REVOLUTIONS IN PARALLEL:
THE RISE AND FALL OF DRAWING IN ARCHITECTURAL DESIGN

by

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ABSTRACT

This dissertation examines how the foundational principles of architectural design are influenced and reflected the discipline's conceptual media. The first section explores the transition to drawing as architecture's conceptual medium. Arguing that the use of drawing within masonic traditions of the Gothic period was not the same as its use during the early Renaissance, this work maintains that the simultaneous employment of plan, section and elevation (i.e. triadic form) was key to changing how drawing was understood and utilized in design. Examinations of Strasbourg Plan A (c. 1260) and the Milan Cathedral Plan and Section (c. 1390) demonstrate how drawings that appear orthographic may not indicate the use of orthography to prefigure forms in space. The examination of Raphael's interior drawing of the Pantheon (c. 1509) further demonstrates that more than just a technical hurdle, the use of triadic form indicates epistemic shifts in both the understanding of design as a human rather than exclusively divine activity, and in the elevation of form as the primary quality of architectural contemplation.

The second section of this dissertation examines the transition to computation as the medium of design. Through an exploration of Peter Eisenman's House VI (c. 1975), this section demonstrates that the shift towards process-based (as opposed to form-based) thinking isn't dependant on computation as a medium, and yet the medium of drawing constrains the ways in which process can contemplated. Further, this section suggests that rather than being a twentieth-century development, a turn to process is evidenced during

the nineteenth-century by emerging fields like morphology, biology and genetics. Gehry Technologies' project for the Yas Island Formula-One Hotel and Evan Douglis' project for Choice Restaurant (both 2009) demonstrate how the focus on process and the use of computation as a medium impact both the practice and aesthetics of architecture.

Tying these sections together, the over-arching argument of this work is that these two shifts in medium are similar in scope and impact for the architectural discipline. Like the transition to drawing centuries before, today's shift to computation imbricates both technical and epistemological developments for the representation, design and practice of architecture.

CHAPTER ONE:

INTRODUCTION

> Linguists, historians, etymologists and other scholars have studied the changes in language usage, vocabulary, rhetoric, and writing style as it is related to intellectual history, uncovering startling revelations about the way language has influenced thought throughout history….Architectural historians and theorists have yet to look with similar depth at the history of architectural drawing as a medium of thought.[1]

Foundations

The dissertation considers the varying influences exerted by both drawing and computers within the process of architectural design. In a sense the topic emerged because of questions I had early on that were inspired by the work of Frank Gehry. Once it had become clear to me that the formal expression Gehry achieved at his New Gugenheim Museum in Bilbao, Spain, had become a kind of signature style, I began to wonder what differentiated the buildings he created in this style. Was the New Guggenheim aesthetically any different than, for example, his Disney Concert Hall in Los Angeles? What did it mean that I found the two building to have overly similar, or better, nearly equivalent expressions and 'looks'. [See Figure 1]. Was it possible to refine such forms? Did the Disney Hall represent such a compositional refinement? Were such questions about formal refinement even relevant to buildings like Gehry's and if not, why not? What was this new aesthetic?

[1] Mark Hewitt, "Representational Forms and Modes of Conception: An Approach to the History of Architectural Drawing," *Journal of Architectural Education* 39, no. 2 (1985): 3.

As one means of answering my questions, I was directed to a recorded talk by Jim Glymph, partner at Gehry Partners and co-founder of Gehry Technologies.[2] Glymph's talk inspired me to write a brief meditation on Gehry's design process and the incongruence troubling me between what and how Gehry built. Interestingly, it is precisely this conflict between these two aspects of design more generally, between the what and the how of architecture, that is the focus of the extended mediation in this dissertation.[3] The problem presented by such a topic, however, is its newness. Gehry's Bilbao may now be a decade old, but the questions his work raises are continuing. The goal of my project, therefore, was to form an understanding of the near-now, and such an understanding is infamously difficult to achieve. As Hegel wrote in his 1820, *Philosophy of Right*, "the owl of Minerva spreads its wings only with the falling of dusk," and the work I wanted to think about represents the dawning of a period, not its dusk. So rather than thinking I could erase all the questions that Gehry's work managed to inspire for me, rather than thinking I could understand the full-shape and meaning of the aesthetic being formulated as the methods Gehry exemplified percolate through design, I thought, why not write about the long arc of architecture's history? Rather than focusing only on the evolving role of the computer in architectural design, why not focus on the computer's analog by writing about the regime of drawing in architecture? By writing about drawing, I could think about architecture's more distant history, as well as its recent past. In addition to the effects and aesthetic shifts brought about by drawing in the Renaissance, I could also ponder its place in the twentieth century and the various ways that drawing was attenuated, not just by technology, but by the slow series of intellectual victories that

[2] Jim Glymph, "Gehry and Partners/Professional Work," in *Wallenberg Lecture Series* (Ann Arbor, MI: University of Michigan, 2003).
[3] For this full text please see Appendix I

process has made over product throughout the last century and a half. I like to think of this shift generally as the move from the aesthetics of form to an aesthetics of process in architecture.

Essentially, this dissertation argues that when architecture developed, adopted and accepted drawing as its representational system, it agreed that form, which is to say the shape of things, was the paramount quality of architecture. Out of this acceptance, virtuosic formal composition became the marker of architecture. Proportion, geometric wizardry, and the theoretical knowledge to manipulate each became the "stuff" to distinguish the architectural profession. The questions appropriate to architecture were the ones that required formal answers and the continued refinement of such answers meant the continued development of formal aesthetics. By contrast the acceptance of the computer as a medium of design comes with the agreement that a focus on process, which is to say on the means of doing rather than the thing done, on the instructions which inform realization rather than on the unique and precious object realized, is essential for architecture. An architecture based on process may require an entirely different aesthetic than one based on form, and it may even require a different formulation of the profession. Such an assertion does not mean that form disappears. As an embodied practice architecture will always have form, but the emphasis on form as an end in itself shifts when architecture orients itself to process.

While it was associated with drawing, architecture maintained and valued an expression of formal transparency as one of its foundational principals—what was drawn was what was built was what was imagined. This transparency pact privileged

certain shapes, mainly eidetic ones, over others because they moved from abstraction and symbol to materialization with ease. Modernists like Le Corbusier reflected this privileged status in his rally against that use of forms that did not result in the instant and pleasurable recognition afforded by platonic shapes.

> Our eyes were made for seeing forms in light; shadow and light reveal forms; cubes, cones, spheres, cylinders, and pyramids are the great primary forms that light reveals well; the image is clear and tangible for us, without ambiguity. That is why these are beautiful forms, the most beautiful forms. Everyone is in agreement about this[4]

In process centric architecture, however, form becomes an index. It must be read and deciphered. The act of fully experiencing a building becomes similar to the experience of a detective story.[5] A building rewards the attentive visitor who labors to solve its mystery of formation with a narrative of its logics and processes of generation. Such a story stands side by side with the architect's actual process of generation, and this being the case, process-centric design has a tendency to de-emphasize the singular output associated with form-focused artistic practices. In fact, a focus on processes that inform becoming tends to undermine not only the object but the very value of the "one-off". Process-oriented design erodes the emphasis on autographic creation and the place such creations have held for so long as the dividing line between custom and mass-produced objects. Instead of focusing on the object, in a process-centric practice architects focus on the instructions that give rise to the object. One designs a series of potential objects, not a single unique one. Similarly, when design's purpose is the creation of a process, there is a pressure to see all acts of design as similar. It is no coincidence that we now speak of a computer's architecture

[4] Le Corbusier, *Toward an Architecture*, trans. John Goodman (Los Angeles: The Getty Research Institute, 2007), 102.
[5] Cynthia Davidson, ed. *Tracing Eisenman: Complete Works* (New York: Rizzoli,2006).

or of software designers "architecting" a program. If the object of design is process, there is little difference in the designing of one set of instructions versus another.

In his pivotal text on complexity, *The Sciences of the Artificial*, Herbert Simon writes that there are two fundamental modes of comprehending our experiences: either through state description or through process description.[6] State descriptions categorize the world based on our senses. They provide criteria for identifying objects, often by modeling the objects themselves. According to Simon, blueprints, diagrams and chemical formulas are all state descriptions. On the other hand, process descriptions characterize the world as acted upon. They provide instructions for generating objects with desired characteristics. Recipes, computer programs and DNA can all be understood as process descriptions. Either type of description can be used as a means to reproduce an object, but one's grasp of that object is profoundly altered depending on the type of description. Simon's explanation of how things are described, and how the essential nature of description is transferred onto our understanding of the object is an uncanny reflection of the conclusions I've drawn from this study. This dissertation seeks to make sense of and document the switch from one mode of comprehending our experiences to another. From the Renaissance until recently, architecture has been fathomed through state descriptions, and doing so was a reflection not just of architecture, but of how our culture understood the meaning of our own acts of creation. To the extent that we model our own processes of creation on what we understand of the world and its processes, we reflect not only cultural values but scientific ones. We are now in the process of altering all of these understandings as we reinterpret the world and our own creative acts based on process descriptions rather that state descriptions. As Simon's text implies, such a switch

[6] Herbert Simon, *The Sciences of the Artificial*, 3rd ed. (Cambridge, MA: MIT Press, 1996), 210-13.

implicates a profound change in how we grasp the world, and by extension, what we value in our own creations.

Therefore, this dissertation begins with a the belief that the profession of architecture has been historically shaped by the products and aesthetics dictated by mode of design, and that such methods are not a-historical givens natural to the process, but are instead culturally produced in response to the most basic understanding of what it is that defines a building. Such a definition, in turn, reflects the technological state of a culture and the basic tenets of what constitute its knowledge. It follows, therefore, that architecture, the discipline and not just its buildings, can itself be interpreted as an historical document of the culture in which it exists. Thus a chain of reflections can be formed from buildings and the architect; to the discipline and its responsibilities, aesthetics and means of working; to the technological and scientific advances that mark a culture; to the way such advances reflect how a culture understands itself in relation to the larger world and universe.

Outlines

Approaching architecture with these beliefs and assertions in mind, this dissertation examines two historical moments when new modes of design were and are being created and adopted. These two moments are defined historically by the transition from the Gothic to Renaissance periods in Western Europe, and by the more recent transition from the Modern to Post-modern periods. Chronologically, the periods I look at range from the late thirteenth to the early sixteenth centuries and from the early nineteenth to the early twenty-first centuries. These moments capture major

epistemological shifts in the sciences, the arts and culture. Unlike many narratives that view these transitions as periods of advancement, improvement and progression, this dissertation maintains the view that such transitions are not easy, nor are they the triumphant victory of an inherently better way to understand or be in the world. They are moments fraught with sacrifice, doubt and resistance in the face of the seemingly ineluctable march of change. And while it is easy to gloss over the conflict inherent in such shifts when speaking of them in the abstract or from a viewpoint centuries later, by tunneling into the meaning that such shift held for a single discipline like architecture, the full effect of such ground shaking change can be illustrated. The lens that will allow me to examine architecture in this way is drawing. I will be looking at the moments surrounding the adoption and rejection of drawing as architecture's primary tool of design.

"How do architects use drawings?" My assumption throughout this work will be that from the late 16th century until very recently, drawing has been the primary medium for architectural conception. Or, as Robin Evans asserts, "for architecture, the principal locus of conjecture is drawing."[7] Drawing has been able to shape this space of architectural imagination because, throughout the later fifteenth and early sixteenth centuries, an emerging class of Humanist practitioners navigated a new set of definitions for architecture, the architect and architectural design. These artists, many of whom rose from artistic traditions outside of building, formed a new basis for design, one grounded in visual knowledge and based on the aesthetics of drawing. In the following chapters I

[7] Robin Evans, *Translations from Drawing to Building and Other Essays.* (Cambridge, Massachusetts: MIT Press, 1997), 154.

will be exploring these new definitions and practices through an examination of what I call the "Birth of Drawing's Reign" within architectural design.

Related to my question, "How do architects use drawing?" is another: "How do architects use computation?". Answers to this question are only recently beginning to take form. In its early phases within architecture, the use of the computer relied on that new medium to imitate the old one. Early programs like MacDraw and AutoCAD duplicated the drawing board, its tools and its products. More recently, however, computational design has started to come into its own. Design is beginning to ponder the result when computational logics are used as a starting point rather than realization tool. Like the similar question about drawing, the paths delineated by the adoption of computation lead architecture away from its current professional and aesthetic definitions. In Chapters Four and Five I explore these new pathways in what I call the "Birth of Computation's Reign".

Both of these sections, and both of these questions share an understanding of the role that both drawing and computation hold in relationship to architectural design. In both instances I assume that by speaking of drawing or computation, I am speaking of a seminal aspect of architecture and its definition. In neither case do I discuss a mere tool or technique for the realization of pre-conceived and prefigured idea about what a design is or what architecture is, more generally. Like buildings and building types, there is nothing natural or given about architecture's boundaries. It is a cultural construct and therefore mutable. Both drawing and computation are facilitators not only of the outcomes of architectural design, but of these boundaries and, therefore, of architecture itself. They lend their forms to architecture's products, definitions and professional

outlines. In other words, they are the "primary conceptual media" of architecture. They form not just what can be thought about a building during its design, but the categories that one uses when understanding a building, the architect and the discipline. By conceiving of drawing and computation as architecture's "primary conceptual media" I intend to demonstrate the full breadth of influence that any dominant media holds over the discipline.

Therefore, my use of historical methods is complex. My intention is to use the current transition away from drawing and the intellectual awareness it empowers to expatiate on both the instability of the now and of the past, instability that is a result of the adoption of new technologies whether these involve geometry and paper or computation and processors. Because our current period is unsettled it forms a better lens or a better set of assumptions from which to read the similar process as it occurred in the Renaissance. Because we are at a moment when drawing's hegemony is cracking we can see outside of its definitions and paradigms for architecture. Until now, drawing had been such a strong medium it carried with it a set of blinders that prevented the understanding it as something negotiable. It had ceased to be an historical product and had become a truth. From within the system that drawing created, architectural drawing had no moment of creation. It had no origin, but simply was. Most histories which attempted to account for drawing reflected this biased understanding.

And yet, now that we are emerging from drawing's dominance, it is possible to recognize that drawing was created, that it isn't an a-historical given. We recognize and can accept what some historian's have concluded over the last century: that there **can** be building without drawing-that entire traditions are based on it. Because previous

histories have been written from the location of the "victorious" paradigm of drawing within architectural design, the histories thus far have not seen the "loser" forms of drawing. We have not been in a position to fully see or understand the modes of drawing that were rejected or the ways that drawing was negotiated. Because drawing's conventions transformed architecture, they have made the preceding architectural design process and its related forms of aesthetics seem irrelevant and even nonsensical. In response, when we looked at these earlier periods we had no other sense-making option but to force the modern position of drawing onto them.

We can see this intellectual imposition now because we are in that precious moment in which drawing has fallen, but the use of its replacement conceptual medium is still being negotiated. Architectural design is without a dominant paradigm, without a stable definition of the architect, without a stable definition of our aesthetics, and in this moment we can recognize similar moments of instability. Because the birth of a new medium is inherently an unstable place, a place of experimentation where options and choices multiply, to characterize such a moment historically we must be in a position slightly outside the trajectory that emerged from it. In essence, I am saying that because we have emerged from the unity of an architectural methodology dominated by drawing into a volatile moment in the practice of architecture, we have acquired a certain flexibility within our intellectual categories that allow us to more accurately see a moment when architecture's definitions were similarly uncertain. The specific conditions of our current moment form an ideal lens to look at the origins of our previously dominant paradigm of drawing. We can then use the historical picture this lens helps to form to refine our categories, to make them robust and useful sense-making tools. These

can then be turned back on to our own period in order to understand what it means for architecture to be destabilized. These are the broad outlines of my historic project.

Categories and Terminology

When understood as architecture's primary conceptual medium, drawing gives shape to the questions that can be asked and the answers that can be offered. It allows for the analysis and contemplation of a design's formal and spatial qualities. With it, the architect does not just document or communicate a design, but can test, probe, develop and finalize it. She can preconceive its shapes and forms in advance of construction. Drawing can fulfill this role in design because during the sixteenth century a new graphic methodology was developed and adopted: drawing's triadic form.[8] As implied by the name, this form of combined orthographic projection uses three drawings: the plan (concerned with the horizontal or ground plane), the elevation (concerned with the exterior vertical plane), and the section (concerned with the interior and usually opposing vertical plane). These three drawings function as a systematized unit, reconciled through the rules of orthographic or parallel projection. Most often, they represent x,y, and z axes in space, and in this way triadic form is similar to descriptive geometry, as it locks the architect's drawings to the three dimensions of space.[9]

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[8] The term "triadic form" was offered to me by Anatole Senkevitch who believed it originated from the work of James Ackerman. I have not been able to find this term used in relationship to drawing in Ackerman's work, but Christoph Frommel discusses "the triad" in his article Christoph Luitpold Frommel, "Reflections on the Early Architectural Drawings," in *The Renaissance from Brunelleschi to Michaelangelo: The Representation of Architecture*, ed. Henry A. Millon and Vittorio Magnago Lampugnani (New York: Rizzoli International Publications, 1997).

[9] "From the perspective of the history of mathematics, the new method in question is nothing but descriptive geometry in an early—actually in its first—but nevertheless manifest stage of development." Wolfgang Lefèvre, *Picturing Machines 1400-1700*, Transformations: Studies in the History of Science and Technology (Cambridge, Mass.: MIT Press, 2004), 226.

The definitions I have provided for both "triadic form" and "primary conceptual medium" are important because they help to disentangle the origination narratives for architectural drawing, which are often contradictory largely due to a less than precise understanding of drawing's role within design.[10] Authors often provide roots for our modern system of architectural drawing in the Ancient, Gothic or Renaissance periods. This confusion stems from the existence of isolated examples of some drawings resembling modern ones in each of these periods. In addition, the fundamental role that drawing plays in architectural design today colors the interpretation of these early drawings. These two qualities have often prevented historians and scholars from seeing that the existence of building plans in ancient Mesopotamia, for example, does not mean that a system of architectural drawing at all like our own was in place then. Further, these historians, as a result of drawing's current hegemony over design, have marginalized evidence of design methodologies very different from our own, methodologies that demand that we interpret historic architectural drawings differently. In other words, drawing's role today has cast an interpretive fog on our ability to recognize that drawing is part of a historically variable process of design.

As a representational system triadic form demands adherence to its own internal structures in order to function. Used more generally, drawing can convey different kinds of information. As an isolated image, a drawing may take on many variations of hybridized technique. If a drawing's role is simply to convey information that its creator finds relevant, different techniques may find their place as part of the bricolage of visual data that imaging through drawing can communicate. However, if drawing is to be

[10] Scholarship by authors like James Ackerman, Robin Evans and Wolfgang Lefevre has been essential to the deconstruction of drawing's hegemony over design.

understood as part of a system of projection, as is the case in triadic form, each drawing must be regulated by this single system. As a refined, conventionalized set of drawings within such a system, the internal logic of triadic form is derived from the interrelationships orthography creates between drawings. This system demands that a drawing serve its role within a structure that anticipates corroboration with other drawings. Therefore, the most important trait within each individual drawing is its geometric coherence. The anticipation of corroboration and the demands it makes on the geometric coherency of the system override any artist's desire to communicate something outside the system. Within the systematized unit of triadic form, a plan must be correct, accurate, and complete because parts of it inform the elevation and the section, and vice versa. These relationships justify the logic of each drawing and each part of the system, and excuse its shortcomings. When used together this systematized rigor allows the drawings to form an analytical tool for representing and understanding formal and spatial compositions in three-dimensions. In short when triadic form is used, drawing is transformed from imaging technique to conceptual medium. Although other kinds of drawings are still used outside this system, individually or as partialities, just as they were before the sixteenth century, the development, use and understanding of the triadic relationship between the plan, section and elevation was the key to drawing's evolution as the primary conceptual medium for architecture.

When understood as architecture's "primary conceptual medium," computation also gives shape to the questions and answers available from architecture. It allows for the contemplation of the origin of a design. It enables the architect to plunge not just into a formal transformation or analysis, but formal generation. As genetics did for evolution,

so computation does for architecture. It allows one to address actual formative processes rather than only the transformative ones. But, what is the difference between using the computer, using software and computational architecture? Computational architecture is more than just using the computer. Architects have been using the computer for a long time without doing anything that would qualify as "computational architecture". In the 1960's, they used cards and the computer to do calculations, and in the 1990's they used CAD to produce drawings, but computational architecture goes beyond doing calculations and beyond drawing. Even when new software programs are developed and used to mimic former media, there is little change in the labor that defines architecture. In other words, for the most part, the point of many of these programs is to automate drawing, but whether executed with mouse or pencil, the medium referenced is still drawing.

With computational architecture, however, the computer is still used to labor, but the labor is of a different sort. It is intellectual rather than manual, as its focus is the crafting of the code. It is a shift akin to the tending of the factory rather than the operation of an individual machine. Computational design can involve the use of parametrics or Building Information Management (BIM) or coding. It is distinguished not by the flavor of its algorithms, but by the nature of algorithmic thinking, tout court. It is the creation of an abstract diagram of logic and information. As a result, rather than designing a single building, one designs a whole range of potential buildings by creating the rules and relationships of things rather than by continually refining the things directly. Computational design is best seen as an extension of the industrial revolution, but rather than creating objects one designs the procedures of creation.

Trajectory

Historically, the processes of design and their respective media demonstrate long periods of continuity, which allows for the possibility of a comparison between drawing's role and influence in architectural design, and computation's. Such a comparative study would focus on the roots of architectural form, rather than its symptoms and would provide a new lens through which to understand the links and influences between various architectural periods. Further, such a study has the potential to provide insight and understanding into the relationships and references inherent in the architectural process. These connections transform all architectural design into a fundamentally rich form of cultural expression. The adoption of computation signals our entry into a moment of discontinuity within architectural design, and therefore a study of drawing's rule offers uncertain insight into our current moment. For this reason, with this project I am focused on the period before drawing finds its place within the design process. In what follows, I will look not at drawing's rule, but at its rise within architectural design. I am interested in the competing priorities that precede conventionalization. This historical period of discontinuity, because it is similar to our current one, provides a lens with which we can better see and understand the rapidly shifting priorities of today's architecture. Therefore, I similarly look not to the triumph of computation within architecture, but to the consequences and struggle for its adoption.

CHAPTER TWO:

THE ADOPTION OF DRAWING

Drawing's State of Affairs

One of the goals of this dissertation is to resist the easy essentialization of the shifts in the conceptual medium of architecture that I intend to explore. If the shifts themselves are complex, then the cultural changes that encourage or attenuate them are equally so. Too often the histories that have been written to account for the Renaissance shift to drawing have sought to devise a simple narrative. Many uses of drawing are often lumped together in these accounts, or conversely a single aspect of the shift is made to stand in for what is a multiplex series of changes. Technology is most often given credit with the force to shift paradigms, but as technology is itself the product of a culture, it seems that many cultural shifts must first lay the groundwork for any such innovation to take hold. That said, it is also often the case that technological adaptations are necessary to broadcast intellectual breakthroughs into the real workings of a culture, its professions and institutions. Similarly, the evolution of a discipline can expose gaps and encourage new ways of thinking. In other words, it is commonly the case that what we think of as a change is not one large movement occurring instantaneously, but instead a collection of small but related shifts that stretched out over a series of smaller moments. The mirror of history distorts the shape and pace of these changes because we tend to order such narratives based on their ability to explain how something evolved. This drive tends to

erase the false starts and incremental steps involved in a paradigmatic shift in favor of a clearly defined moment of origin, an instant which allows us to say after "this" the world had changed.

Having qualified the kind of attention I would like to give to the shift to drawing in architecture, and the kind of simplification I hope to avoid, I must acknowledge the power of a common feature to many of the histories of drawing. Generally, these agree that a significant break with earlier, mediaeval, design traditions in architecture occurred during the Renaissance. If the shift that occurred in this moment is to be distinguished from the other imbricated shifts, I add my voice to Wolfgang Lefevre's to contend that this origin then denotes the adoption of triadic form, or as he calls it "combined orthographic projection," as the primary conceptual medium for design.[11] Distinguishing the correlated use of plan, section and elevation from orthogonal drawing in general is very helpful in the disentanglement of a Gothic versus Renaissance origin for architectural drawing. The debates about the origins of architectural drawing stem, in part, from Wolfgang Lotz's assertion that that orthogonal projection was a convention established by the Renaissance. [12] The problem is that orthographic drawings clearly exist before Alberti advocates for their usage by architects. In fact it is clear that existed for a very long time before the fifteenth century. The existence of these early examples has caused many historians, including Christopher Frommel, to make statements like the following: "Architectural drawing is as ancient as monumental architecture…The practice of making ground plans—as documented, for example, by the Carolingian plan for St. Gall—but also elevations and sections, could not have been completely lost during

[11] Lefèvre, *Picturing Machines 1400-1700*, 209-45.
[12] Wolfgang Lotz, *Studies in Italian Renaissance Architecture* (Cambridge, Massachusetts: The MIT Press, 1977), Chapter 1.

the time prior to the beginning of the Gothic."[13] Frommel is clearly opposing Lotz, but the real problem, here, is a lack of refinement within the categories that each side is using. While Gothic examples of orthographic drawing do exist and demonstrate an increasing understanding of the principles of orthography, as I will substantiate later in this chapter, their use of drawing does not reflect a complete understanding of its projective structure. While they do demonstrate a high degree of sophistication in what Lon Shelby calls "constructive geometry," or the use of advanced projective techniques to solve problems that occur during building, they did not access this same degree of sophistication in their drawings.[14] The development of drawing's potential to reflect and create an understanding of an object in the three-dimensions is a Renaissance development.[15]

Alberti is often credited with calling for the use of orthographic drawing in architecture, although he only specifically mentions plans and elevations. Triadic form was specifically called for as early as 1519, in Raphael's letter to Pope Leo X, but there are no examples of its use in his hand. There are, however, two persons who are credited with the first full use of this new triadic form drawing within design.[16] The first is Antonio da Sangallo the Younger (1484-1546), and the second interestingly occurred

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[13] Christoph Frommel and Nicholas Adams, eds., *The Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture*, 2 vols., vol. 1 (Cambridge, Massachusetts: MIT Press,1994), 6.

[14] Lon R. Shelby, "The Geometrical Knowledge of Mediaeval Master Masons," *Speculum* 47, no. 3 (1972).

[15] Also see Lefèvre, *Picturing Machines 1400-1700*, Chapter 7.

[16] As Raphael's letter suggests, it is likely that triadic form was in use before being demonstrated by either of these artists. Sketchbooks from Bramante's circle like the Taccuino Senese suggest projective pairing of plan and elevation, but we don't have purely orthographic examples that unite all three drawings until the work of these two men. Christoph Frommel suggests that that this "first" should instead be attributed to Cronaca, who Frommel asserts, "was a pure architect" and therefore unbothered by the "artless" nature of the technical drawings created through orthography. Again, however, any extant examples of Cronaca using triadic form do not exist. Frommel and Adams, eds., *The Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture*, 7.

outside of the circle of the Italian Renaissance in the figure of Albrecht Dürer (1471-1528).[17] Both produced images that unite plan, section, and elevation into a system that clearly demonstrates the reliance of each drawing upon the other. In Dürer's case, this drawing appears in his *Etliche underrrict zu befestigung der Stett Schllosz und flecken*, published in 1527. In the case of Antonio da Sangallo , the combination occurred sometime after 1509 in his work for St. Peter's. Whether because of the work of these artists or coincident to them, drawing's place as the primary conceptual medium grows quickly from this period. By the later part of the sixteenth century, orthographic projection is established as *the* professional mode of representation for architecture, indispensable for the realization of an actual building.[18] By 1570, for example, Palladio not only demonstrates a thorough understanding of plan, section and elevation, his work resonates with the geometries of orthographic projection. His designs are imbued with the rules of drawing, and they, therefore, present themselves so well through drawing that his book transports his architecture and his fame throughout Europe.[19]

Prior to this sixteenth century "moment" of triadic form's adoption, design was not reliant on drawing for its development.[20] Instead, nearly all design decisions were

[17] Interestingly, most scholars tend to focus on Antonio da Sangallo the Younger as the first to make extensive use of triadic form. This accreditation and emphasis is likely due to the thousand-plus extant drawings that were generated as part of Antonio's architectural "office."
[18] Lotz, *Studies in Italian Renaissance Architecture*, 32.
[19] For a more thorough explanation of the link between the development of architectural drawing and Palladio's work and subsequent fame, please refer to James S. Ackerman, *Palladio (Architect and Society)* (New York: Penguin Books, 1974).
[20] For a general description of Gothic design methods please see Francois Bucher, "Design in Gothic Architecture," *American Society of Architectural Historians.Journal* 27, no. 1 (1968). Also, ———, "Medieval Architectural Design Methods, 800-1560," *Gesta* 11, no. 2 (1972). For a discussion specific to theoretical and aesthetic issues see James S. Ackerman, "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan," *Art Bulletin* 31, no. 2 (1949). For an exploration of builders and building techniques see Roland Recht, ed. *Les Batisseurs Des Cathedrales Gothiques* (Strasbourg, France: Editions Les Musees de la Ville de Strasbourg,1989)..

based on typology and the process of construction.[21] Within the Gothic tradition the master mason coordinated work with a general plan in mind, but most design decisions were left to unfold throughout the building process.[22] And yet, drawing was used during the Gothic period, but the extant examples prove that it did not function to prefigure design in advance of construction as it did in the later sixteenth century, or as it does today. That said, in order to understand the sixteenth century changes in drawing practices it is essential to have some sense of the types of drawings that existed and their functions before this shift occurred.

For the purposes of this explanation, medieval architectural drawings can be divided into three classes, all of which emerged during the thirteenth century.[23] The first of these is the full-scale tracing or épure. [Figure 2]. This drawing type resembles a modern plan or elevation except that rather than being executed on paper, épures were engraved into a hard, flat surface such as a stone or plaster floor.[24] Although épures appear to be very large versions of our own architectural drawings, they are distinguished from them by a set of limitations. While they are consistently elevational, which is to say

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[21] Mario Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography and Printed Images in the History of Architectural Theory*, trans. Sarah Benson (Cambridge, Massachusetts: The MIT Press, 2001), Chapter 3.

[22] See note 11, but also Robert Mark's work that demonstrates how the structural daring of Gothic architecture was based on the use of the building itself as a kind of funicular model to reveal and accommodate stresses as the building was erected. See Robert Mark, *Experiments in Gothic Structure* (Cambridge, Massachusettes: The MIT Press, 1984). Also ———, *Light, Wind, and Structure: The Mystery of the Master Builders* (Cambridge, Massachusetts: The MIT Press, 1994).

[23] Bork notes that while drawing may have, in fact, been in use by Gothic masons before the 13th century, the increasing reference to drawing as well as the increase in drawings still in existence from this period seems to point, if not to the development of scalar drawing during this period, than to its increased prestige and use during construction. Robert Bork, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," *Journal of the Society of Architectural Historians* 64, no. 4 (2005): 442 and Note 3.

[24] Scholarship of the Gothic épure and its function is relatively extensive. See John H. Harvey, "The Tracing Floor at York Minster," in *40th Annual Report of the Friends of York Minster for 1968* (York: 1969). Robert Branner, "Villard De Honnecourt, Archimedes, and Chartres," *The Journal for the Society of Architectural Historians* 19, no. 3 (1960). Francois Bucher, *Architector : The Lodge Books and Sketchbooks of Medieval Architects*, ed. Anonymous (New York: Abaris Books, 1979). Also Jr. Carl F. Barnes, "The Gothic Architectural Engravings in the Cathedral of Soissons," *Speculum* 47, no. 1 (19772).

that they do not contain elements of perspective, they only express building details, not whole buildings. As such épures are focused only on the micro-scale of architecture and construction. They are not drawings concerned with design on a level beyond detail. Further, the needs of engraving, and the precision of line it requires, make it unlikely that these drawings were much involved with design at all. At most épures suggest that certain set and interlocking proportioning systems like *quadrature* and *triangulature*, common keys for Gothic design, were being applied within the drawing.[25] Rather than documenting the searching for and development of a design solution, they appear to communicate a finished design in order to direct and facilitate construction. Épures were used as a kind of model or layout template for the builders or masons. They functioned similarly to the *modani* or full-scale models of the molding profiles that the masons used.[26] After the master mason inscribed the épure, other masons could bring their stones to it in order to compare their work with this master model, thus ensuring their conformation with it and with one another's work. Therefore, although épures do share some traits with modern elevations, particularly in their ability to fulfill the outwardly-communicative role for drawing that we understand today, they do not seem to have a role in the internal dialog between the master mason and the design, where drawing is used as the medium of architectural design.

The second class of drawings to emerge during the thirteenth century is the documentary sketch, or more precisely the sketchbook. [Figure 3]. Only one example of a

[25] For more on these techniques see Paul Frankl, "The Secret of the Mediaeval Masons," *The Art Bulletin* 27, no. 1 (1945). Erwin Panofsky, "An Explanation of Stornaloco's Formula," *The Art Bulletin* 27, no. 1 (1945). Also Shelby, "The Geometrical Knowledge of Mediaeval Master Masons."
[26] Henry Millon, "Models in Renaissance Architecture," in *The Renaissance from Brunelleschi to Michaelangelo: The Representation of Architecture*, ed. Henry Millon and Vittorio Magnago Lampugnani (New York: Rizzoli International Publications, Inc., 1997), 70.

sketchbook exists from the 1200's, that of the Villard de Honnecourt (*Wilars dehonecort* [fol. 1v]; *Vilars dehoncort* [fol. 15r]). After Villard, we must advance two centuries to find another such compilation of drawings.[27] Alternately called a lodge clerk, a metal worker, a mason, a draftsman, and architect by scholars, we cannot be certain about Villard's background.[28] The subject matter of Villard's sketchbook includes architecture, machinery, animal and figure drawing, and a variety of subject matter that has added to the enigma about his professional role. He writes (fol. 1v) that his book contains "sound advice on the techniques of masonry. . . and the techniques of representation."[29] If not a mason, Villard was granted access to the Masonic workshop, so his sketchbook represents a great, though often frustratingly incomplete, source of information on thirteenth century architectural design practices. Amongst his architectural studies are drawings that modulate between those concerned with detail and those concerned with building wholes. Though it is illogical to assume that Villard is the source of this multiplicity of drawing technique, his are the first examples we have of conceptual drawings for actual buildings.[30] [See Figure 4]. Villard's engagement with this sort of representation depicting whole facades or projecting whole plans for buildings still under construction, speaks to a different scale of thinking than that demonstrated by épures. However, it must be noted that his sketches are often tiny, mere schemata of buildings

[27] The next sketchbook of which we have record is the Hans Boeblinger Leaf Pattern Book from 1435, a volume which does not contain the breadth of Villard's. Thirty-five years after Boeblinger's pattern book, Filarete creates his *Treatise on Architecture* ushering a new Humanist tradition for the architectural sketchbook.
[28] Jr. Carl F. Barnes, "Villard De Honnecourt," in *Macmillan Dictionary of Art* (London: Macmillan, 1996).
[29] Theodore Bowie, *The Sketchbook of Villard De Honnecourt* (Bloomington, Indiana: Indiana University Press, 1959).
[30] The so-called "Plan of St. Gall" may be considered an earlier example of a conceptual drawing, but this drawing deals only with an ideal model or schema for any monastery, not an actual or realizable monastic plan. Walter Horn and Ernest Born, *The Plan of St. Gall*, 3 vols. (Berkeley, California: University of California, Berkeley Press, 1979).

rather than drawings that convey the any real sense of the building's individualized design.[31] Alongside épures, however, Villard's architectural drawings form endpoints along a continuum of drawing types and functions, the first concerned with the micro scale of building design, the other with the macro scale.

The third type of drawing to emerge in the 13th century is the architectural project drawing. The early versions of these drawings are all elevations and seem to naturally unify the understanding of elevational techniques seen in the épures and the conceptual thinking demonstrated in Villard's sketchbook. [Figure 5]. Like some of the architectural sketches in Villard's sketchbook, project drawings represent large portions of building facades or towers. Like épures, they also adhere, for the most part, to the rules of orthographic projection, although there are anomalous areas that will be addressed later in this chapter. However, unlike either of the previous drawings described, project drawings are scaled allowing the contemplation of larger design issues to occur with the precision necessary to begin to resolve and direct the solutions.[32] At the same time, the purpose of these drawings is somewhat a subject of debate. According to Kletzl, their purpose was to explain the intricate decorative system that could not be understood

[31] This observation is reliant on and indebted to Gombrich's distinction between the schematic and the particular. It is logical that if Villard's drawings are capturing an early state in the development of architectural representation, than his drawings would focus predominantly on the schematic rather than the particular level. E.H. Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation.* (New York: Bollingen Foundation, 1961).

[32] The scale of theses drawings was likely based on the use of a gridded paper, rather than on measurement by measurement conversion as is done today. Therefore, "to-scale" in this case must be more accurately conceived as approximately-to-scale, or perhaps accurately proportional. There is agreement that these drawings were not intended as a source from which builders could take measurements. For more on the Gothic use of measurement and drawing see Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography and Printed Images in the History of Architectural Theory*, Chapter 3. Also Howard Saalman, "Early Renaissance Architectural Theory and Practice in Antonio Filarete's Trattato Di Architecttura," *The Art Bulletin* 41, no. 1 (1959): 103.

through constructive proportioning system or through verbal description.[33] Other scholars contend that the drawings predominately served to communicate the look of the designs to the patrons.[34] None of the designs seen in extant project drawings are executed according to the drawing; nonetheless, they provide clear evidence of the early contemplation of design through drawing. These early project drawings also provide a record of drawing's limitations both as a tool for communication and design during these early stages. These limitations will be dealt with later in this chapter, but until the late fifteenth century when the Italian tradition of architectural treatises and sketchbooks begins, all of the extant architectural drawings derive from the Masonic traditions. And yet, these drawings have a different character and sensibility than what develops out of the emerging Italian Humanist movement. It is impossible to simply connect the two traditions as one connects dots.

A Conflict Emerges

How did the Humanist architectural practitioners resolve the conflict between their changing intellectual and artistic traditions and those represented by Gothic drawings? Interestingly, it seems this transformation may have occurred through their adaptation of the model provided by Villard de Honnecourt, one that was later made a standard part of the Masonic tradition, the documentary sketch. One of the major developments within fifteenth century Italian thinking is the growth and reliance on the visual as a source of knowledge and experimental truth. This shift results in a desire to

[33] Saalman quoting Otto Kletzl, *Plan-Fragmente Aus Der Deutschen Dombauhütte Von Prag in Stuttgart Und Ulm: Kritische Ausgabe Von Otto Kletzl* (Stuttgart: F. Krais 1939).
[34] Sergio L. Sanabria, "A Late Gothic Drawing of San Juan De Los Reyes in Toledo at the Prado Museum in Madrid," *Journal of the Society of Architectural Historians* 51, no. 2 (1992): 162.

provide a visual, rather than merely written, record of the great antique architectural models. As a result, the Humanists refined the earlier practice of the documentary sketch to suit their own different sensibilities.[35] As techniques were adapted and created in order to "explain" the ancient models, their purpose was also transformed from a purely documentary desire to one in which restored or imagined buildings could also be captured. If the migration between documentation, reconstruction and design seems like a natural, if somewhat teleological progression, the history is much messier. As James Ackerman has asserted, from the very early stages, architects have combined the use of drawing for both the recording and planning of a building.[36] Raphael captures this imbrication of documentation and design in his summary of Pope Leo X's request.

> Your Holiness commanded that I draw ancient Rome, or as much of it as one can know from what can be seen today, with those buildings which show sufficient preservation to enable infallible reconstruction on true principles of their original state, making those elements which are entirely ruined or barely visible correspond to those still standing and visible.[37]

Raphael's shift from drawing "what can be seen" to making the "entirely ruined" visible seems to present little difficulty to his definition of documentation, even if it does to our own.

Further, scholars like Linda Pellecchia, Louise Brown and Diana Kleiner each point to instances when "documentary" efforts also encompassed the extensive use of design, as drawings were likely to record imaginative reconstructions rather than simply

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[35] Carol Cable has argued specifically that the demands of building documentation were the basis for a method of architectural representation that was subsequently adapted to design. Carole Kay Law-Gagnon Cable, "From Documentation to Design: Trends in Architectural Representation During the Italian Renaissance" (Dissertation, University of Texas at Austin, 1983).
[36] James S. Ackerman, Disscussion Session on the Origins of Architectural Drawings, April 5 2006.
[37] I. D. Rowland, "Raphael, Colocci,Angelo, and the Genesis of the Architectural Orders," *Art Bulletin* 76, no. 1 (1994): 83.

the existing conditions.[38] In this way, Richard Krautheimer's work, which allowed for a more flexible understanding of Medieval imitation in the case of the Holy Sepulcher, may be seen to extend to Renaissance version of mimesis.[39] Even if a drawing was understood to document an ancient building, the need for that drawing to be accurately depict or be similar to the building's remains did not always exist. Although today we would expect efforts at documentation to offer formal fidelity to existing conditions, it is clear that neither the Medieval nor the Early Renaissance cultures shared these goals when they attempted to make such records. Instead, Renaissance artists of the late fifteenth and early sixteenth-century artists imagined buildings reconstructed and designed buildings that had never been seen in their efforts to "document" antiquity. This different sensibility makes it necessary to also look at the recording techniques, that is the drawings that serve the documentary role, in order to understand the issues at play as drawing develops into the medium of design. By looking at the struggles of these humanists to capture the essential nature of a building, we can see the questions that were of concern for design drawings, as well.

The Drawings Explored

Therefore, the focus of the next pages will be on three drawings whose dates span 250 years. Although discussion of this period will weave around these representative drawings, it is the general window they provide that motivates my interest in these

[38] Beverly Louise Brown and Diana E. Kleiner, "Giuliano Da Sangallo's Drawings after Ciriaco D'ancona: Transformations of Greek and Roman Antiquities in Athens," *The Journal of the Society of Architectural Historians* 42, no. 4 (1983). Also, Linda Pellecchia, "Reconstructing the Greek House: Giuliano Da Sangallo's Villa for the Medici in Florence," *The Journal for the Society of Architectural Historians* 52, no. 3 (1993).
[39] Richard Krautheimer, "Introduction to an 'Iconography of Mediaeval Architecture'," *Journal of the Warburg and Courtauld Institutes* 5 (1942).

particular examples. My intention is not to focus on a single drawing or the development of a particular drawing type, but the adoption of drawing as part of the architectural design process. Specifically, with this chapter I will explore the Medieval and Early Modern technological advances in drawing and the corresponding epistemological breakthroughs that developed it into a medium for architectural thought. Put more simply, this chapter will be exploring the struggle to develop drawing as the primary conceptual medium for architecture.

The intention in exploring this great span of time is to define the period of drawing's rise and to discern within it the meaning of these drawings. Consideration of this formative period will move between drawings that served a role in the pre-figuration of new buildings and ones that served to document existing buildings. Three paradigmatic examples illustrate drawing's use to project design, to document design and to do both simultaneously: Strasbourg Plan A from 1260, the Plan and Section of Milan Cathedral from 1390, and the Pantheon interior drawing circa 1505. The latter was originally authored by Raphael and subsequently copied by several Florentine architects in drawings that will also be brought into the discussion. The section on the Pantheon drawing will also address the extensive debate that has waged over this series of drawings, questioning the identity of the original's author and even suggesting the possibility that the prototype for this series of drawings has been lost to time. The Strasbourg Plan is an early example of projective drawing, an elevational design for a facade not begun when the drawing was executed. The Milan Plan and Section presents a hybrid case, some areas of the plan in existence when the drawing was made, but the remaining portion of the plan and section offering a projective vision for the building.

Finally, the Pantheon drawing presents a purely documentary attempt to capture the interior of the Pantheon.

Changing Lines and Changing Drawings

It is interesting, and perhaps counterintuitive, that over the 250 years represented by these three drawings, there is an increase in the documentary role of drawing, as opposed to an increase its projective role for design. However, I would argue that a different and equally essential change is occurring alongside this progression from documentation to design. Although documentation would seem like the less creative act, the quality of the line in the Renaissance version of these drawings demonstrates a change in technique that implies a similar change of purpose for their creations. Where the Strasbourg Plan A demonstrates "the confidence and precision of the draftsman," the Pantheon series of drawings even reproduce the *pentimenti*, that is the areas of correction and tentativeness. This shift signals a change in the purpose of drawing from the presentation of a preconceived solution to the documentation of the search for that solution, indicating the transformation of drawing into the medium of architectural design. Before this shift, drawing does exist, and it serves important roles in the communication and execution of a building's design. But until drawing is used to probe, test and analyze design, it is not architecture's conceptual medium.

Ernst Gombrich similarly characterized this developmental schism:

> To the Middle Ages the schema is the image; to the postmedieval artist, it is the starting point for corrections, adjustments, adaptations, the means to probe reality and to wrestle with the particular. The hallmark of the medieval artist is the firm line that testifies to the mastery of his craft. That of the post-medieval artist is not facility, which he avoids, but constant alertness. Its symptom is the sketch, or rather the many sketches which precede his finished work and, for

> all the skill of hand and eye that marks the master, a constant readiness to learn, to make and match and remake till portrayal ceases to be a second hand formula and reflects the unique and unrepeatable experience the artist wishes to seize and hold.[40]

The change that Gombrich describes between sure and the tentative is exactly the change in line-quality that marks the transformation of drawing into the medium of architectural design. It is a shift from drawing as a tool for communication that emanates outward to a tool for inward communication, a move from external to internal dialog. The renegotiation of drawing's position was a result of many influences, but one that is rarely discussed is the rise and spread of papermaking in Europe.[41] Before paper, architectural drawings occurred as carvings in stone or as ink on parchment, and even though parchment looks a lot like paper, the process of drawing on it is closer to that of stone engraving than the process we imagine today. The root of this similarity lies in the practice of incising the drawing into the parchment with a stylus before inking.[42] This procedure ensured precision and durability but it also severely limited drawing's spontaneity. Like those drawings that were engraved into stone, drawing on parchment required a design was, to a large extent, finalized before the image was made. This technique did not allow for the tentative or searching drawing we think of today as part and parcel of the design process. As a result, the process drawings that we are so dependent upon, those drawings through which we experiment and develop ideas, are simply not present before the mid-fifteenth century. It is not only that we lack extant examples from the Romanesque and Gothic periods, but that this type of drawing simply did not exist.

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[40] Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation.*, 173.
[41] Ackerman.
[42] Stephen Murray, "The Gothic Facade Drawings in The "Reims Palimpsest"," *Gesta* 17, no. 2 (1978): 53.

This shift need not only be inferred from the drawings. Humanist authors also wrote about their changed conception of drawing. Alberti reflects this sentiment in a short passage from his treatise on architecture.

> But I say this of myself: I have often conceived of projects in the mind that seemed quite commendable at the time; but when I translated them into drawings, I found several errors in the very parts that delighted me most and quite serious ones; again, when I return to drawings, and measure the dimensions, I recognize and lament my carelessness; finally, when I pass from the drawings to the model, I sometimes notice further mistakes in the individual parts, even over the numbers.[43]

Alberti is describing an activity that places the act of drawing within the process of design. Drawing is clarifying, informing and developing Alberti's own understanding of his conceptions, not just communicating a complete and finalized preconception. In other words, Alberti is using drawing as a medium for design. Without a part in this internal dialog of the architect, drawing simply cannot be the conceptual medium of architecture. Following Gombrich, the symptom of this paradigm shift is the transformation from the firm line to the searching one. This transformation of line-quality is evident in the drawings documenting existing buildings produced during of the late Quattrocento.

This timeline highlights another interesting gap between the emergence of triadic form in the early sixteenth century and the prototypical use of drawing as a conceptual medium as early as the mid-fifteenth. Alberti is often credited with calling for the use of orthographic drawing in *De re Aedificatoria*, although his text does not indicate the use of triadic form.

> The difference between the drawing of the painter and those of the architect is this: the former takes pains to emphasize the relief of objects in paintings with shading and diminishing lines and angles; the architect rejects shading, but take his projections from the ground-plan and, without altering the lines and

[43] Leon Battista Alberti, *On the Art of Building in Ten Books*, trans. Joseph Rykwert, Neil Leach, and Robert Tavernor (Cambridge, Mass.: MIT Press, 1988), Book IX-10, tr. pg 317.

> by maintaining the true angles, reveals the extent and shape of each elevation and side—he is the one who desires his work to be judged not by deceptive appearances but according to certain calculated standards.[44]

His description of the architect taking "projections from the ground plan…to reveal the extent and shape of each elevation and side" clearly calls for the use of a projectively aligned use of plan and elevation, but Alberti's description omits the section, an important part of the interlocking system of triadic form.[45] More than additional façades, the section is necessary to provide both the opposing dimension in space to the one pictured by the front façade, but also to lock together the interior and exterior portions of a building. The section is a drawing which requires a great deal of creativity in order to conceive. Its development is less than automatic from plan and elevation, and its inherent vagaries may add to the relevance of Alberti's omission. Wolfgang Lotz, in the article aptly titled "The Rendering the Interior in Architectural Drawings of the Renaissance," was the first of several scholars concerned with the section within the development of architectural drawing.[46] None are more adamant than Jacques Guillerme:

> section is, by its very essence, associated in architecture with verticality…the vertical is imperative in that it divines and divides the forces of weight, weight

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[44] *Inter pictoris atque architecti perscriptionem hoc interest, quod ille prominentias ex tabula mostrare umbris et lineis et angulis comminutis elaborat, architectus spretis umbris prominentias istic ex fundamenti descriptione ponit, spatia vero et figuras fronti cuiusque et laterum alibi constantibus lineis atque veris angulis docet, uti qui velit non apparentibus putari visis, sed certis ratisque dimensionibus annotari.* Ibid., Book II-1 tr. pg 34.

[45] Ideas that Alberti's text relied on Vitruvius' similar passage in Book I, 2 have not clarified which drawing Alberti means by "side." Vitruvius did name three drawings in this treatise: *ichnographia, orthographia and scaenographia.* While the first two of these have been consistently translated as plan and elevation, *scaenographia*, though usually translated as perspective, was changed to "section" in Daniele Barbaro's translation, to which Palladio was a contributor. See Alberto Perez-Gomez, "Architecture as Drawing," *Journal of Architectural Education* 36, no. 2 (1982).When these ideas are read next to Alberti's advocating for the use of models in the following paragraph of Book II, Chapter 1, and the scholarship on the *quatrocento* interchangeability between model and perspective, the only thing that is clear is that there is a great deal of ambiguity about what drawings the authors of these text had in mind.

[46] Other authors who have problematized section include Ibid., J. Guillerme and H. Verin, "The Archaeology of Section," *Perspecta-the Yale Architectural Journal*, no. 25 (1989). Cable, "From Documentation to Design: Trends in Architectural Representation During the Italian Renaissance", esp. Chapters 5,7 and 8. Also Frommel and Adams, eds., *The Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture*, 15.

> being an invariant parameter of all constructive practice, par excellence. If sections in architecture have diverse functions for the choices of building elements' disposition, they are *also* the necessary referent of all anticipation of construction; they determine in the most immediately visible way the relationship between forms and forces.[47]

Guillerme believes that section is absolutely necessary for the pre-figuration of architecture through drawing, and that without it, construction cannot be contemplated. In the fifteenth century artists like Leonardo da Vinci and Piero della Francesca also clearly recognized the value of the section for increasing the understanding of three-dimensional form, even if their explorations of section via anatomical structures lacked Guillerme's sense of architectural statics.[48] As I will point out later in this chapter, in fact, sections of varying degrees of sophistication do exist from the thirteenth century onwards. It is clear, however, that the Renaissance use of section seems to be the missing piece that, once found, allows triadic form to become the new conceptual medium for architecture. Or, as Howard Saalman hypothesized, plan, section and elevation may have become the accepted mode of architectural representation "only at the beginning of the sixteenth century when the old architectural system no longer functioned effectively."[49]

That said, there is no reason to believe, pace Guillerme, that the section is actually necessary for the process of design during the Renaissance. The joint use of plan, elevation and model seems to create a technique that would accomplish many of the same goals as the section. Alberti himself documents the use of models alongside drawing in

[47] Guillerme and Verin, "The Archaeology of Section," 238.
[48] In fact, Martin Kemp attributes Leonardo with the invention of both the solid section and the exploded view as representational forms. Martin Kemp, *Visualizations: The Nature Book of Art and Science* (Berkeley: University of California Press, 2000), 20.
[49] Saalman, "Early Renaissance Architectural Theory and Practice in Antonio Filarete's Trattato Di Architecttura," 105.

both the previous quotation from Book IX, and more extensively in Book II where he writes of the benefits that a model provides:

> It will make it possible to examine clearly and consider thoroughly the relationship between the site and the surrounding district, the shape of the area, the number and order of the parts of a building, the appearance of the walls, the strength of the covering, and in short the design and construction of all elements.[50]

He goes on write that models provide a surer method of estimating costs since they allow the number, the thickness and the quality of materials to be understood. Further, Alberti claims that once constructed a model allows the designer to easily make alterations and new proposals until "everything fits together well and meets with approval."[51]

Numerous other sources also testify to the essential nature of the model, without which "structures could not be clearly understood."[52] In fact, Carol Cable argues that this hybrid use of plan, elevation and model are absorbed in the efforts to document buildings of the time, thus contributing to the development of a Renaissance understanding of section. Citing several early documentary drawings, she contends that though they appear to be building sections, they are, in fact, drawings of the models which were often built to allow the building to be "opened up" in order to visualize the interior.[53] Cable's ideas collapse the mutually creative acts of designing, drawing and developing graphic connections in a very suggestive way, and her theory, though perhaps unorthodox, does

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[50] Alberti, *On the Art of Building in Ten Books*, II-1 tr. pg 34.
[51] Ibid.
[52] Richard Schofield, "Leonard's Milanese Architecture: Career, Sources and Graphic Techniques," *Achademia Leonardi Vinci* 4 (1991): 124. For more information on the use of models during the Renaissance see Millon, "Models in Renaissance Architecture," 19-74.
[53] Cable includes in this set several studies by Giuliano da Sangallo's that are part of the Barberini Codex, folios 59v, 74r, 16r. Cable, "From Documentation to Design: Trends in Architectural Representation During the Italian Renaissance", 93, 97-99.

seem to resonate with the interdisciplinary nature of inquiry at this time.[54] The increasing number of extant sections from about 1525 onward does seem to coincide with the eventual standardization of the use of models. It is logical that section's rising popularity, and by extension the use of triadic form to contemplate design, may be linked to the expense and labor involved in the production of detailed models. Eventually, model making would be reserved for presentation purposes or to serve as a part of the final design's contract.

The Stage is Set

It is at the moment of this historical hinging that drawing comes into its own within architectural design. With the adoption of section, drawing's triadic form is established as the primary conceptual medium for architecture, and its role becomes very stable. From this point at or around 1530 until the twenty-first century, drawing maintained its role as architecture's primary conceptual medium. Although developments of new drawing types have emerged and influenced architectural aesthetics, triadic form has remained the core of design development and analysis. The initial conception for a design may occur in many ways, but the translation of that concept into architecture, its development and refinement, in short, the work of design, relies on the analytical power of architecture's triadic form of drawing. The changes to the architectural discipline that drawing allows, namely the separation between design and building, facilitate the

[54] Further, this link between the development of the section as a type of drawing and efforts at documentation has been seen by others. "The problem we would like to address here is that of retracing the steps by which inventive citizens, from the reasoning artisan to the curious philologist, were able to translate the "natural" images of breaks in ancient ruins into stable schemata of sectional contours in the documents made by the traveler as well as the projects made by the artist. To put it another way, we would like to glimpse the many stages where the acute and questioning gaze of technicians paused to contemplate in order to transform the observation of archaeological remains (trace) into the observance of architectural diagrams (tracés)." Guillerme and Verin, "The Archaeology of Section," 226.

architect's development of an entirely separate kind of knowledge from that of the builder. Instead of being master builders, architects like Alberti, or even better like Sabastiano Serlio, become masters of Humanist theory. They understand the techniques and procedures of building, but are no longer builders in their own right. This shift in the architectural knowledge base allows architects to refocus their attention and expertise on other areas. The emphasis that drawing places on the shape of a thing, on its abstract forms, reinforces the development of an aesthetic based on proportion, and architects become the experts of these new and developing aesthetic theories. The new architect works with his mind not with his hands. The importance of this shift to our understanding of the architect can hardly be underestimated. Once the essence of architectural training switched from Masonic to Humanist traditions, once the architect became a scholar rather than a builder, there would be no recovery of lost traditions. In this way drawing reigns over architecture for 500 years, uniting the architects of the Renaissance with those of today.[55] As Frommel wrote, "The study of architectural drawing now reveals that there had never been such continuity [in the methods of architectural design] between antiquity and the Renaissance."

Although with hindsight it is possible to see that our modern techniques have their roots in the 250-year period explored in the following pages, during these early stages drawing's role remained tenuous. Although the techniques we use today were being developed, their use remained, to a great extent, disconnected from our own. This conclusion is supported by a close examination of the drawings. Details within the three primary case studies, and within those drawings introduced as contrasting examples, demonstrate techniques that contradict our contemporary understanding of what drawing

[55] Frommel, "Reflections on the Early Architectural Drawings," 101.

is and what drawing means. The series of three drawings that I will interpret over the next pages will illustrate the different aspects of drawing's growing role within architectural design, including the development of the projective relationships between drawings types (plan, section and elevation), the use of drawing to correlate interior and exterior elements of a building, and the difficulties in confining architectural drawing to specific, conventionalized form. These developments set the stage for drawing's adoption as the primary medium of architectural conception. From this point to that of the late twentieth-century, drawing's use will wax and wane within architectural design, but its primacy will go unchallenged. In other words, the period I will explore through these drawings lays out the rise of drawing within architectural design.

The Milan Drawings

It is no coincidence that the drawing towards which this chapter now turns is of Milan Cathedral. The drawing depicts that building's plan and section, and is currently housed in Bologna at the Museo di S. Petronio, Archivio della Fabbrica di San Petronio. [Cartella 389, no. 1, Cat. No. 6. See Figure 7]. Just as my project seeks to better understand transitional periods in architectural design practice, Milan can, in many ways be considered a transitional city. The location of Milan is important because it was an area of interchange between the North and the South. Christoph Frommel claims that Milan was the only city in Italy where Northern European Architecture gained footing and that it was a city where Northern European architects were often called in for new tasks.[56] James Ackerman, whose article "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan," is a seminal work on the Milan drawing, says

[56] Ibid.

that it was made in a workshop "where a war over theoretical and structural principles was waged vehemently between transalpine and Italian masters."[57] From 1390-1400, a series of French and German master masons were brought to Milan in order to inspect the cathedral and provide "engineering" expertise. Although the grand vision and aspiration for a Cathedral of monumental size required that the Milanese seek this assistance to determine if their project would be structurally sound, the opinions and advice of the Northerners clashed so much with Milanese sensibilities and aesthetics, many of them stayed longer than a year.[58] Later, Italian architects including Bramante, Leonardo and Francesco di Giorgio would be engaged in the completion of the cathedral, and the "correction" of what was deemed the "less competent" work executed by these Northern architects.

The Milan drawing dates from 1390, the early period of this architectural interchange, when Antonio di Vincenzo, the architect of San Petronio in Bologna, traveled to Milan to inspect its cathedral in advance of beginning his commission at Bologna.[59] During his visit he drew the plan, and according to Valerio Ascani, upon returning home he added the section drawing.[60] The drawing is important because, as Ackerman elucidates, it provides an early visual record of the state of construction and planning at Milan's cathedral. When placed in dialog with the *Annals of the building of Milan Cathedral*, the drawing helps to clarify the theoretical debate that occurred over the cathedral design.[61] However, my interest in the drawing lies predominately outside of this context. For this

[57] Ackerman, "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan," 43.
[58] Ibid.: 88.
[59] The date for Antonio's drawing was established in 1887 by Luca Beltrami who based the date on a notice in the records of San Petronio which establish Antonio's departure from Milan in February of 1390. Ibid.: Note 14.
[60] James S. Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* (Cambridge, Massachusetts: MIT Press, 2002), 46.
[61] Ackerman, "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan," 85.

study, I will be exploring the Milan Plan and Section because the drawing presents the earliest extant example of a full-building plan united with a full-height section.[62]

The significance of this combination requires some explanation. Plan drawings are the earliest to appear in the record of architectural drawing, some dating to the third millennium B.C., hence the appearance of a plan is not particularly remarkable in 1390. Further, a section drawing of Reims Cathedral can be found in the Sketchbook of Villard de Honnecourt predating the Milan drawing by over 150 years.[63] What makes the Milan drawing unique is that in its unification of the two drawings, it forces a contemplation of the entire building section—not just the ground plane. The drawing demands that the whole building be synchronically understood. This kind of prefiguration is not in evidence in the earlier drawings. Evidence in the *Annals* actually demonstrates that the Milan building section was not determined until well after the foundations were laid and the walls of the cathedral had started to rise.[64] While this reversal of our own procedure may seem incredible, other Gothic buildings, like Metz cathedral, whose upper proportions are stretched from the classic 3:1:3 ratio, suggest that a certain flexibility for the building profile existed more generally during the period. "That the mediaeval builder frequently began operations with little else pre-arranged than the general scheme of the building, may be quite safely affirmed."[65] Therefore, Di Vincenzo's drawing is interesting because it illustrates an attempt to prefigure a solution to the design of the

[62] Although the point was rhetorical, Wolfgang Lotz has suggested the importance of this drawing through his assertion that if the Milan drawing had been used as an example, Alberti's description of the difference between the drawings of painter and architects could be interpreted as providing theoretical justification for a practice already long in existence. Lotz, *Studies in Italian Renaissance Architecture*, 4.
[63] The date and identity of Villard de Honnecourt is the subject of debate. Generally, scholarship accepts him as a Picardy artist, perhaps a lodge clerk or architect, who produced the sketchbook in the 1220's and 1230's Carl F. Barnes, "Villard De Honnecourt."
[64] Ackerman, "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan," 89.
[65] Francis B. Andrews, *The Mediaeval Builder and His Methods* (Ottowa: Roman and Littlefield, 1976), 2.

cathedral, and significantly, this attempt at prefiguration is made through drawing. Experimentation is shifted from the construction process onto paper. Furthermore, Antonio's pairing of the plan and section demonstrates a clear understanding of the projective relationship between the drawings. The significance of these traits are best highlighted through a comparison with the earlier section of Reims cathedral found in Villard's sketchbook. [See Figure 8].

Although several scholars have written extensively on the sketchbook, Ackerman is likely the most thorough in detailing the "errors" of the Reims Section. He writes that it demonstrates "the extent to which the fundamental elements of contemporary drafting have already been worked out." [66] However, I believe that any conceptual deficiencies the drawing exhibits are important keys to understanding what was still not understood. One of the most glaring of these conceptual difficulties is the rendering of the roof plane, which is shown to intersect the lower passage of the intermediary buttresses. Nearly all but the earliest scholarly presentations of this drawing note this difficulty, likely because such an intersection would make passage impossible. But further, this area of the cathedral is actually not under roof. It stands in open air making the need for such a passage questionable as one might simply walk around the buttress. It is doubtful that the masons would undermine the structural soundness of the buttress with an unnecessary passage. This error seems to be more than the oversight of a neophyte. As pictured the drawing demonstrates a fundamental misunderstanding of this area of the building. The forms and spaces are simply not resolved in the drawing.

As is typical for Villard, the aisle vaults below the buttresses are also not drawn with precision, but filled in with a wavy-line notation intended to indicate generally that

[66] Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* , 36.

vaulting is or will be present. He deviates, however, from this convention for his depiction of the springing of the main vaults on the interior of the choir, but here is another error. Villard pictures the vaults springing from the height of the lower flyer when they should have been shown to spring closer to the base of the window.[67] The location he chooses instead is where the window arches spring, but rather than depicting these as arches, they are replaced with tall colonnettes which stretch to the height of the widow apex, in effect replacing the arched window opening with a square one.[68] Finally, the "cut" areas of the section, those depicting the form of the mass that is cut through by the section plane, are very confused. At the top of the drawing molding lines end abruptly without a clear distinction between what is cut and what lies in the background. The same misrepresentation occurs at the base of the drawing. The result is an M.C. Escher-like effect: depending on where you begin to look, the same plane will be part of the cut plane one minute, part of the background elevation the next.

Although Villard's section demonstrates confusion at the section-cut areas, its engagement with this feature is still noteworthy. Subsequent drawings that might also be thought of as sections, that is drawings that attempt to render the interior, or both interior and exterior conditions simultaneously, place much more emphasis on their elevational portions than their sectional ones. With its sectional difficulties, Villard's drawing is better understood within this context, rather than as a drawing whose purpose it is to solve or contemplate the wall profile. In fact, interpretively, it is helpful to see Villard's drawing as an extension of his contemplation of interior to exterior elevational correspondence, a relationship with which he demonstrated engagement in Plate 61 of the

[67] Ibid.
[68] Ibid.

sketchbook. [See Figure 9]. In this drawing, Villard has placed two elevations of Reims, one interior and the other exterior, in dialog with one another. According to Christoph Frommel, this graphic convention is original. "No one had ever tried before to find the correspondence between the outer and inner construction and to bring into close relations all the single elements of the body of the building by means of visual axes and cornices."[69] Rather than concentrating on conditions at the wall (one of major functions of a section), these types of drawing explore the relationship between interior and exterior design (another major function for the section). Seen in this light, Villard's section, and its deeper, more resolved treatment of the elevation, begins to reveal some of the early priorities for this kind of drawing. The fact that, after Villard, most drawings that contemplate the interior tend to omit any serious contemplation of the wall section, suggests that his early attempt was truly pioneering.

What, if anything, do all of these conceptions, including those we would label misconceptions, of Villard's suggest? Most authors have overlooked them, discounting their significance in favor of the overall appearance of refinement that the Villard section conveys. As a result, many authors have used the Villard drawings as proof that the triadic form of plan, section, and elevation existed as far back as the early thirteenth century. Frommel writes that, through his drawings, Villard found "correspondence between the outer and the inner construction" and that in Villard's time, "Everything could be represented through an orthogonal projection."[70] He concludes in later texts that Gothic architects had perfected orthographic projection, and that Villard's sketchbook

[69] Frommel, "Reflections on the Early Architectural Drawings," 101.
[70] Ibid.

"presents the broad spectrum of possibilities in drawing during the thirteenth century."[71] I believe, however, that the Villard section demonstrates that the understanding of drawing as a technique was extremely incomplete. The sheer number of inconsistencies only makes sense if we acknowledge that the drawing is, in fact, *not* orthographic, and set aside expectations that the drawing does not fulfill.

The Villard section is not an internally coherent section showing a view taken from one location, from one imaginary cut through a wall. Instead, it is a layering of many impressions in an attempt to capture the whole. As drawn, that whole is made up of many parts and is very informative, but those parts do not necessarily form a coherent system. They are not part of the regular geometry of orthographic projection in which one drawing informs and resolves the other. The Villard section is an important drawing, and it does demonstrate a kind of sophistication, but its refinements are not orthographic. Claims that the drawing falls into this system confuse our understanding of how drawing was used during this early period with how we use drawing today. In particular, the attribution of orthography to the Villard section masks the development of, and the inevitable difficulties with, a projective system of drawing that develops over the next 300 years. Further, only by understanding the actual state of drawing, and by acknowledging what had and what had not developed in the relatively few examples we have, can the importance of each drawing be understood. It is only in this light that the significance of the Milan drawing, and its combination of plan and section, can be revealed.

[71] Frommel and Adams, eds., *The Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture*, 6.

In many ways the Milan drawing appears to be less sophisticated that the Villard section. [Figure 7]. The relatively small scale of the Milan plan, though it does capture the entire building plan, prevents a highly detailed exploration. The piers in the choir are delineated plainly as a circular shaft with attached colonettes. At the transept and nave these piers are replaced with simple circular ones. The colonettes are not shown in plan, nor are they shown in the section drawing. It is difficult to determine, assuming the section drawing was indeed executed when Antonio returned to Bologna, if this difference represents a change in the design for Milan or simply an alteration in Antonio's memory. The exterior walls are represented using a double line convention, and yet the thickness indicated is too thin and invariable to be more than a notational convention. Although exterior buttresses are indicated where the piers are engaged with the wall, very little of the wall condition is actually explored. At the bottom of the drawing, details pertaining to the nave piers give way to the section drawing of the nave and side aisles. As was the case with the Reims section, in many ways the Milan section is more concerned with providing details for a hidden elevation, than in it is with the exploration of the actual section (i.e. in those areas that would be cut through by the picture plane). The pier bases and capitals are rendered with a sketch-like quality somewhere between perspective and elevation, and the three single line vault profiles give the only the slightest indication of what the intended building section may have been.[72] The drawing conventions and the overall detail of the Milan plan and section make it appear to be a relatively simple drawing. Conceptually, however, it represents a great leap forward from the Villard section.

[72] Here, I refer the reader again to Ackerman's article "Ars Sine Scientia Nihil Est" for a detailed analysis of the proportions of the Milan section and its implications for our understanding of Gothic theory. Ackerman, "'Ars Sine Scientia Nihil Est' Gothic Theory of Architecture at the Cathedral of Milan."

Even without the attempts seen in the Villard section to delineate areas where the picture plane has cut through the building, the Milan drawing should be understood as representing a more cohesive sectional drawing than the Villard section, and a highly evolved state for architectural representation. The key advance can be found in the portrayed relationship between the plan and section which, in the Milan drawing, is clearly a projective one. Unlike the drawings in the Villard sketchbook, the plan and section in the Milan drawing are aligned in such a way to allow the plan to inform the section. The location and width of the piers in section is clearly coming from the plan drawing. At the pier capitals the projective lines determining pier width from their respective plans are evident. [See Figure 10]. At the pier bases the projected width of the pier shaft is drawn to the ground plane, and the pier bases are then added to this projected width. The solution seems tentative, and the details of the bases are not shown in plan as one might expect in a fully evolved drawing set. However, as the height of the bases is shown with a single horizontal line that crosses all the piers, it seems likely that either Antonio was filling in these details on his own, or from his memory of design decisions for the pier bases that were only just beginning.[73] These instances of projection, and the interaction between the projection of known attributes from the plan with design experimentation in elevation, demonstrate a kind of thinking which is not present in the Villard section. In other words, the Milan drawing demonstrates a conceptual breakthrough for architectural drawing: the beginnings of drawing being used as part of a interlocking projective system, a system through which design decisions can be tested.

[73] My conclusion is supported both by the fact that these bases were not the ones finally built, and by the debates regarding the pier capitals and base proportions to be found in the Annals of the building of Milan Cathedral. Ibid.: 97-98.

Because the Milan plan and section clearly represents a conceptual change in drawing technology, it is logical to assume that this intellectual development has occurred between the Villard sketchbook and this drawing. Although it is possible to view Villard, as some authors have, as someone unfamiliar with drawing conventions who likely copied rather than devising his own images. I believe that the errors he demonstrates are difficult to discount as solely attributable to his replication methods. It is unlikely that if he were granted access to the Masonic workshops and such drawings that he would have been as ignorant of Masonic techniques, as some other authors have suggested. As a result of some of these ideas about Villard, the question of how the projective relationship between drawings gains influence, and from where this leap in drawing technologies may have emerged, has been cloaked by the assumptions about the early sophistication of Gothic drawing. If one assumes, however, that the projective relationship between various drawings is developed sometime between the mid-thirteenth and late fourteenth centuries, greater analysis becomes possible. There are two drawings suggestive of an such a transitional source within the Masonic traditions of épure drawings. They are the wall épure at Reims Cathedral [Figure 11], and the South Tower drawing at Bourges Cathedral [Figure 12]. Because the drawings are very similar conceptually, discussion here will focus on the earlier and more provocative of the two, the épure at Bourges.[74]

The South Tower drawing can be found in the crypt of Bourges cathedral, in the fifth apsidal bay. It is a large shallow drawing measuring five meters by twelve meters

[74] The Reims épure is very similar to the one seen at Bourges, and may in fact detail a nearly identical technique, however, the drawing has not been featured as an object of study in itself and the only images of it are currently found in the book Cathedral and Castles. These images feature what I assume may be a simplified version of the drawing making detailed analysis impossible. Alain Erlande-Brandenburg, *Cathedrals and Castles : Building in the Middle Ages*, Discoveries (New York: H.N. Abrams, 1995), 78.

with engraved lines of one millimeter or less.[75] By using the construction timeline and molding profiles for the cathedral laid out by Robert Branner, the drawing can be dated to 1230-1240.[76] Although the drawing is a rich source of information on Gothic design procedure, for the purposes of this argument, the South Tower épure is significant for one reason: at the base of the elevation molding profiles have been indicated in plan directly below the corresponding moldings in elevation. [Figure 13]. Is this an early demonstration of projection? The answer is both yes and no. It is difficult to see definitive evidence that the extents of the molding plans are being projected up into elevation. Some misalignment occurs on both the left- and right-most profile sets, and the center moldings are not complete. Only the secondary center under the right quatrefoil seems to fully articulate the molding in elevation from the contours shown in plan. Alternatively, the molding plans could merely be intended to signal to the masons which molding template is to be used in each case.[77] It is my belief that such a possibility introduces a physical, kinetic parallel to the mathematical understanding of projection implied in the drawings. The haptic process of using the molding template to check the profile of the tracery respond involves lifting the template of the molding over the contour of its elevation. This physical movement mirrors the intellectual movement of projecting an elevation from its plan. Furthermore, this sort of constructive process serves as the predominant means through which Gothic masons understood the geometry they

[75] Kristina Luce, "Gothic Drawing, the Neglected Set and the 14th Century Tower Epure at the Cathedral of Bourges" (Masters, Miami University, 1996), 65.
[76] Robert Branner, *The Cathedral of Bourges and Its Place in Gothic Architecture* (Cambridge, MA: The MIT Press, 1989), 18-64. And Luce, "Gothic Drawing, the Neglected Set and the 14th Century Tower Epure at the Cathedral of Bourges", 65.
[77] Explanation of the importance and use of templates by Gothic masons can be found in John James, *The Template-Makers of the Paris Basin* (Leura, Australia: West Grinstead Publishing, 1989).

used in proportioning and constructing their buildings.[78] I believe that it stands to reason that their understanding of orthographic projection might be equally rooted in a physical manipulation rather than a theoretically-based understanding of the geometric principal. If the Masonic understanding of projection was initially based on this haptic, rather than a geometric, understanding of projection, it makes sense that a drawing such as the Milan Plan and Section, one which demonstrates an understanding of projection on the conceptual level, would not appear until many decades later. It also helps to explain why Villard's sectional drawing of Reims might capture the appearance of an orthographic drawing without adhering to the requirements for consistency needed in orthography. This empirically-based understanding of projection may also help explain the anomalies in other drawings created between those of Villard and Antonio.

Strasbourg Plan A

Strasbourg Plan A is a proposed elevation design for the west façade of the cathedral dating from around 1260.[79] [Figure 14]. Though this drawing has been examined before, most recently as part of Robert Bork's assessment of the mathematical relationships between the cathedral and its various design drawings, my exploration will focus on types of projective understanding that the drawing demonstrates. It is very interesting that even though the drawing predates the Milan Plan and Section by over a hundred years, on first inspection it appears to be more accurate and sophisticated representation than the Milan drawing. Where the Milan drawing's sketch-like qualities give it an air of naiveté, the Strasbourg drawing's firm and precise line make it seem

[78] Frankl, "The Secret of the Mediaeval Masons," 50, 57-60.
[79] Bork, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," 443.

authoritative. Yet, this aura of certainty masks some interesting graphic solecisms, particularly in the case of the portals and pinnacles.

It may seem picayune to draw attention to these areas of, perhaps, minor detail within the overall scheme of the façade design. In many ways Strasbourg Plan A is an astounding drawing, but for all of its beautifully rendered tracery and careful draftsmanship, the design being shown is, in fact, quite flat. It presents few challenges to making a drawing in elevation. Nearly all the exploration of depth that does occur in the design does so on parallel receding planes. Even on the upper portions of the design, those areas most likely to introduce angled surfaces, Strasbourg Plan A remains, for the most part, flat. In projective terms means that the various planes, at various depths, can be easily rendered as if they existed on the same plane. Because the surfaces are all co-planar, in elevation, their measurements will be all equally undistorted, their true shape and extents conveyed.

Only with its pinnacles does the design finally introduce oblique planes, and in these areas of the drawing some difficulty is demonstrated.[80] While the majority of Strasbourg Plan A adheres to the laws of orthographic projection, in areas where planes angle to the back or to the front, the drawing is not correctly resolved. Note in particular how the octagonal pinnacles above the pier buttresses show three equal sides. If accurately drawn in elevation, the center one should be wider than the two on the outside. This small difference in width accounts for the fact that, in plan, these sides of the octagon are at 45-degrees to the picture plane and should appear more narrow. If drawing the pinnacle today, we would derive these different measurements by projecting lines

[80] In fact, the portals, with their flared sides, also introduce oblique surfaces, but these are not subject to the kind of rotating evolution of design based on the process of quadrature that is seen in the pinnacles. For this reason, I have limited my discussion to these areas where the design procedure necessities oblique planes.

upward from the plan of the pinnacle at this level. By using this projective technique the proper diminishment of the sides would be evident. In the Strasbourg drawing, however, all three sides are depicted equally. No direct projection from plan is evident.

It is also interesting that the octagonal buttress pinnacles terminate in a pyramidal roof with sides parallel to the picture plane. This arrangement is exceedingly odd. It is much more likely, based on the rotating geometry below, that these pinnacles would terminate in an octagonal faceted cone. In fact, I suspect, that these pinnacles were intended to be octagonal, but that the details were omitted because of the difficulty in determining the projection. Although from our perspective, all that is missing are two lines from corners of the octagon below to the apex of the peak, in fact conceptualizing the orthographic representation of this plane is difficult because it introduces a second oblique or double angle. At this point the facets of the pinnacle are rotated in both the horizontal and vertical dimension. If the masons could not be sure of how to determine locations along this doubly oblique plane, they may have chosen to omit the details all together.

The problem of oblique planes within early Gothic drawing is something that Wolfgang Lefèvre points out in his article on combined orthographic projections. He argues that early elevations appear virtuosic, when their accuracy is, in fact, confined to those surfaces parallel to the picture plane.

> …it is not clear whether these architects had command of a general technique of construction elevations, or only a of a partial one that was restricted to the case of parallel surfaces….What I am claiming exactly is that such a general technique was not part of the professional skills of architects before the sixteenth century.[81]

[81] Lefèvre, *Picturing Machines 1400-1700*, 214.

Lefèvre provides further evidence that Strasbourg Plan A avoided the resolution of its oblique planes in the similar techniques found in the later drawings of Strasbourg and in those of Ulm, Cologne and Frieburg-Munster Cathedrals. These later Gothic examples also deviate from the consistent adherence to orthographic projection by using one of two techniques to fill in the detail on oblique planes. The first is omission. For example, the tower elevation and ground plan of Freiburg Münster from 1380, omits the detail from the oblique planes in a similar manner as the Strasbourg Plan A pinnacles. [Figure 15]. In this drawing only the parallel front plane of the octagonal upper tower is depicted. It is, however, difficult to determine if even these details are accurate. At first glance they appear to be incorrect as the tracery divisions actually grow longer from the base to the top of the pinnacle. However, this expansion may, in fact, be an optical "correction" to the design. The goal may be that these divisions would appear equal from below. Without other drawings of this area, it is impossible to determine if this area is accurately portraying design or if it further reveals the limits of representational techniques. While these front panels of the tower feature the details of the tracery design, both the singly oblique sides of the tower, and the doubly oblique sides of the pinnacle are without detail. Although the omission of these details gives the drawing an overly solid and planar impression, one that is incongruous with the likely intentions of the design, as a rendering technique it is a consistent, if incomplete, version of orthographic projection.

The alternative Lefèvre demonstrates to the omission technique is the use of "cropped slide translation."[82] This convention gives drawings like those of Ulm and Cologne, and the later tower drawing of Strasbourg [Figure 16], a sense of completion and a more accurate impression of the sense of a design without the complex double oblique angle projection being worked out. Rather than leaving large portions of the drawing blank, in these designs, which replicate the same the tracery pattern on multiple faces, the tracery is drawn on the front plane and then exactly replicated for the oblique ones. These oblique planes, which have been accurately diminished, have less width than the front plane, so the "excess" tracery is simply cropped off. This technique is a little shocking to our modern sense of the fidelity required by this kind of drawing. Although cropped slide translation may give a better overall impression of the design, it certainly breaks with the projective consistency of the drawing. However, it also reveals the likelihood that at least one of the main functions of these drawings was to give patrons a sense of the design. The use of cropped slide translation eliminates the need for patrons to imaginatively fill in the missing details, a skill which may have been in short supply. Overall, the technique, though inaccurate in our eyes, may have been a preferred solution because it provided a more accurate skeletal impression than the solid one provided by the technique of omission.

Lefevre reasons that these two conventions may be solutions to the same technical problem, a lack of projective understanding for the case of oblique planes in elevation. But, what solutions do the methods of omission and slide translation really provide? Are these drawings produced only to convey design ideas to the patrons? Or do they fill other

[82] This term is my own. Lefèvre talks about the tracery being "sliced", but it is more descriptive to understand what is happening in the image as a two part process: first the transposition of one area of the image onto another and then the cropping or slicing off of the excess.

roles? It is worth noting that, for the purpose of construction, projective accuracy in these details is often unnecessary. Between the proportional rules dictated by processes like *quadrature* and the fact that oblique planes occur most often in features like a tower, features which replicate the same design on four or eight sides, a single representation of the design on the side that is coplanar suffices to communicate intentions. The idea that these details are, at least on some level, unnecessary is reinforced by their omission as one of the drawing conventions.

In cases where a correct projection required the resolution of a compound angle, the demands of representation may have actually out-stripped the representation's usefulness. Particularly this occurred when, even without an accurate drawing, such features were still buildable. When necessary, masons were capable of resolving complex geometric conditions as demonstrated by the increasing complexity of vault patterns. Techniques like *Bogenaustragung*, better known as the "Dresden Method" of vault projection, existed specifically to solve difficult projective problems when such solutions were necessary for construction.[83] Strasbourg Plan A demonstrates that a basic understanding of projection existed in the thirteenth century, and later drawings like at Frieburg-Munster and Strasbourg show that the projection of singly oblique surfaces was possible, at least where the complexity of the representation was minimal. It appears, however, that projectively sophisticated drawings were limited in their application to construction. Perhaps, the need for a project drawing that was projectively accurate simply did not exist.

[83] This "Dresden Method" is outlined in the *Dresden Sketchbook of Vault Projection* housed in the Oesterreichische Nationalbibliothek in Vienna. Additionally, *The Lodge Book of Wolfgang Rixner, Jorg Reiter and Others* housed in the Albertina Graphic Collection in Vienna also contains practical information on the projection of vaults. For more information see Bucher, "Medieval Architectural Design Methods, 800-1560."

In fact there is some indication, that although projectively inaccurate, techniques like slide translation were working to communicate more to the builders than is immediately apparent to us. It is possible that roots for slide translation may, once again, filter back to the techniques seen Villard de Honnecourt's sketchbook. In his drawing of the tower at Laon, Villard struggles to portray an area of decidedly un-flat architecture. [Figure 3]. If you constrain your view to the bottom of this drawing, it appears to be an elevation, but as Villard attempts to capture the complex tower geometry with its progression of 45-degree rotations, his image becomes increasingly convoluted. It is apparent that he is dissatisfied with the way the lowest elevational portion of his drawing masks the different planes of the tower. In his attempt to capture the 45-degree rotation of these planes further up the tower, Villard is forced to move from elevation into a quasi-perspectival mode of representation. This hybrid form has the advantage of allowing the complex moves of *quadrature* with its subtractive 45-degree rotations to be expressed, but while Villard's technique succeeds at conveying the tower's geometric complexity, it also creates a serious issue with his rendering of the tower arches.

Because Villard's graphic method involves coding those areas that project at 45-degrees by elevating them to the point that the drawing practically conveys their plan rather than their elevation, and because he does not allow these areas to occlude other areas as would occur in a naturalized perspective, column bases that should be at the same height are portrayed at different levels in the drawing. This feature combined with Villard's consistent maintenance of the height of the colonettes forces the arches to be portrayed as strangely lopsided whenever they occur on oblique planes. Alternatively, this asymmetrical rendering of the arches might be interpreted as the drawing of the

arches having been cropped. This observation bears striking similarity with those later drawings that obviously used a cropping technique.

Villard's drawing is often seen as a crude attempt at perspective. Instead, given the elevational aspects at the drawing's base, combined with the consistency with which he renders the dimensions (heights) of the columns, and his use of a nearly 45-degree angle to indicate those areas where this angle occurs in plan, this drawing should be more accurately characterized as an innovative resolution between plan and elevation. Cropped slide translation may have been used in drawings, like the elevation of the Strasbourg Tower, to portray a more complete impression of the design, and perhaps to continue a previous graphic technique which integrated aspects of plan and elevation. Although a depiction the plan is omitted in favor of a more consistent impression of the elevation, it is possible that slide translation developed into a notational tool for the masons who could interpret the degree to which the design was cropped as an indication of the angle at which the plane was oblique. In other words, the proportion of tracery omitted (a third, a quarter, et cetera) could suggest what was occurring on the level of the plan, and such a proportional judgment is actually made easier against the reticule provided by slide translation.

Even if this suggestion of a possible deeper meaning for the conventions of slide translation is rejected, the technique's use is suggestive of the growing desire for a complete and coherent drawing. Such an expectation seems, itself, to be driven by the existence of new intellectual or theoretical constructs that demand that the whole of a building be pictured in a unified mathematical system. Drawing techniques like triadic form exhibit such autonomy, but the same demands simply did not exist within the

Gothic tradition. When both design and designer were still so intimately linked to the act of building, what would the purpose of such systematic representation be? Because design was based on a known transformative procedure, this kind of detailed visual instruction was unnecessary. In fact, some scholars like Howard Saalman have claimed that the strong typological basis for Gothic design, eliminated the need for nearly all drawing and measurement.

> In fact, once the size of the main crossing square has been decided upon and the proportions to be used for the nave and crossing arches have been selected from the small repertory, the masons could proceed to build without further instructions and actually without plans and measurements.[84]

Within such a system of design it is hard to imagine why Gothic drawings would resemble our own, at all. The completeness of a drawing and its adherence to a regularized system of spatial representation speaks to a conception of its use that did not exist until the sixteenth century. This conception is part of the humanist project, not the Gothic one. Techniques like slide translation are less indications that Gothic masons were incapable of sophisticated projective techniques, and more indications that the uses to which projectively accurate drawings were put, did not require their consistent production. For Gothic masons, the need for fidelity between the drawing and the design, a trait whose necessity we assume because drawing is used to document or direct building, was simply unnecessary when depicting oblique elevational details.

Interpretively, then, Strasbourg Plan A, and the relative flatness of its design makes this drawing a very interesting document. In comparison to other façade designs contemporary to it, Strasbourg Plan A seems anachronistic. Its flatness and relative simplicity make for a beautiful drawing, but not one that reflects the increasing

[84] Saalman, "Early Renaissance Architectural Theory and Practice in Antonio Filarete's Trattato Di Architecttura," 93.

complexity of Gothic design during the later half of the thirteenth century. Might the design's anachronism be related to a growing conventionalization of the drawing techniques available to Gothic masons? Robert Branner hypothesized that mid-thirteenth century Rayonnant styles were likely indebted to the development of scalar drawing during this period.[85] Branner saw a relationship between the emphasis on linearity during the Rayonnant and the embedded linearity of scalar drawing. Christoph Frommel takes this idea further asserting that later painterly devices like the use of color and chiaroscuro allowed priority to be given to the surface.

> The graphic technique corresponded to the character of the project here as it had done with the Gothic style: instead of a filigree skeleton there was a stereometric body; in the place of abstract lines, there was the precious materiality of a consistent surface.[86]

It is not, then, a large stretch to allow that an increased flatness within the façade design of Strasbourg Plan A, that is, a resistance to planes oblique to the main plane of the façade, may also be a response to the structures inherent within this early use of drawing.[87] It seems logical that early attempts to convey a design through these limited drawing techniques may have resulted in flatter designs. And yet, masons were capable of building much more dynamic structures than the ones they drew. It is not surprising that Strasbourg Plan A is cast aside when construction on the actual cathedral façade is begun in 1277. Nor is it surprising that the built design, for all of its "calligraphic"

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[85] Robert Branner, "Villard De Honnecourt, Reims and the Origin of Gothic Architectural Drawing," *Gazette des Beaux-Arts* 6, no. 61 (1963).
[86] Frommel, "Reflections on the Early Architectural Drawings," 102.
[87] Through its reliance on parallel projectors that intersect the picture plane and ninety degrees, orthographic projection favors the parallel alignment of façade and the picture plane. Oblique planes are in conflict with the inherent structure of orthographic drawing and the ability to use the drawing media as both a thinking and communication tool in these areas is compromised. Designs that respect this parallel relationship avoid a conflict between the structures of the drawing and that of the design. Cite evans here…I think it's the Eva Blau book

beauty, explores the depth of the façade through a layering of parallel planes, rather than one which explores depth through rotation and angled or curved surfaces. [88]

Although sophisticated projective techniques existed for Gothic masons, these techniques were generally tied to the process of construction. Because design was more closely tied to the building process and drawing was most often used as part of this construction, two problems presented themselves when drawings of the entire building design were made. The first of these was a reversal of the design process. Because design was a process of evolution that unfolded through time and through the process of construction, the making of a detailed drawing of the design for an entire building façade was, in many ways, akin to putting the cart before the horse. The demands of rendering to-scale an entire façade and its iteratively proportioned sizes and parts, reverses the working method of the early designer that dictated that design move from parts to the whole.[89] The second problem was one of drawing technique. Project drawings often required laborious projective solutions to represent certain areas. These representational solutions served little purpose within the Gothic mode of design. The problem solved by their resolution provided no corresponding solution for the actual construction of the design. As a result of the combination of these difficulties, the degree to which drawing could serve the Gothic designer was constrained.

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[88] Bork, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," 442. The following description of the design of the Strasbourg cathedral façade also comes from Bork, "the rapid development of architectural drawing in the city has produced an even more radically calligraphic style, seen both in Plan B and in the lower zone of the cathedral's façade." ———, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," 442.

[89] This movement was, of course, guided by a general typological schema, but such a regulating form did not encompass building details, nor was it unusual that changes to the initially conceived schema were made. As John James wrote, "the design is not a well controlled and harmonious entity, but a mess." John James, *Chartres: The Masons Who Built a Legend* (London: Routledge & Kegan Paul, 1985), 9. Also, David Turnbull, "The Ad Hoc Collective Work of Building Gothic Cathedrals with Templates, String, and Geometry," *Science, Technonlogy, & Human Values* 18, no. 3 (1993): 316.

The Pantheon Drawings

An intriguing series of five related interior perspectives depicting the Pantheon, each copies of a single master drawing, was made in the early years of sixteenth century.[90] Two of these drawings (U 1950 A r [Figure 17] and U 4333 A r [Figure 18]) are by the artist that Gustina Scaglia calls Anonymous I not Jacopo Sansovino.[91] The one in the Codex Escurialensis is attributable to the anonymous author of the second portion of that manuscript [Figure 19]. The two remaining drawings (U 164 A r [Figure 20] and Salzburg H 193/2 r [Figure 21]) were authored by Raphael.[92] The Pantheon was, of course, one of the most revered and studied buildings of antiquity by Renaissance architects, and it was common that artists would make copies of one another's drawings. Other drawings of the Pantheon's interior, such as the ones by Francesco di Giorgio and by the author of the Codex Coner, certainly exist and testify to this trend. However, Raphael's interior view of the Pantheon stands out as an especially distinguished

[90] Three of these are now housed in the Uffizi, (U 1950 A r, U 4333 A r, and U 164 A r), one lies at the Universitätsbibliothek in Salzburg (Salzburg H 193/2 r), and the last is folio 30 r of the Codex Escurialensis housed at the Biblioteca, El Escorial (Cod. Inv. 28.II.2). A sixth drawing from the *Mellon Codex* held at the Pierpont Morgan Library in New York (42 r) seems to be inspired by these drawings taking the same compositional structure and viewpoint for the scene. However, this drawing seems to have been constructed independently of the others, taking its own measurements and details. The Mellon Codex drawing may have been motivated by the others, but is not a copy from them. Gustina Scaglia, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings," *Architectura-Zeitschrift Fur Geschichte Der Baukunst* 25, no. 1 (1995): 23. See Figure 22 for a summary of these drawings, their authors, dates and current locations.

[91] The rather awkward "not Sansovino" attribution is Scaglia's attempt to correct a historical error in the drawing's attribution. P. Nerino Ferri first attributed U1950A r to Sansovino in his book *Indice geografico-analitico dei disegni di architeturra civile e militare esistenti nella Galleria degli Uffizi.* Roma (1885), and Sansovino's influence was perpetuated by Hubertus Günther's correction of the attribution as "Sansovino-group" in his article "Werke Bramantes in Spiegel einer Gruppe von Zeichnungen der Uffizien in Florenz." *Müncher Jahrbuch der bildenden Kunst* 33. (1982): 77-108. Scaglia wants to make clear that Sansovino played no part in the crafting of these drawings, hence the "Anonymous I not Jacopo Sansovino" reference. Ibid.: 9.

[92] For the Codex Escurialensis attribution please refer to Hermann Egger, *Codex Ecurialensis: Ein Skizzenbuch Aus Der Werkstatt Domenico Ghirlandaios*, 2 vols. (Wien: Alfred Holder, 1905). The attribution of the other two drawings to Raphael is generally accepted, and reinforced by Scaglia through handwriting analysis. Scaglia, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings," 9-10,13.

representational archetype because of the degree to which it was copied, and the fact that as one of the most prominent artists of the time, Raphael produced two versions of it.

Scholars of the past and present have long been fascinated by this set of drawings, and their work has gone a long way to establish their provenance and genealogy. The question of dates, and by extension, the establishment of a model for this series drawings, was first raised by Wolfgang Lotz in his article "Das Raumbild in der Architekturzeichnung der italienischen Renaissance."[93] The question was taken up again by John Shearman in his article "Raphael, Rome and the *Codex Escurialensis*," and most recently by Gustina Scaglia in her article, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings."[94] Lotz proposed that Raphael was the designer of the drawing, but Shearman's article demonstrates that the date of the *Codex Escurialensis'* arrival in Spain makes it nearly impossible for Raphael to have constructed the model given our current understanding of his arrival date in Rome. Scagllia pushes Shearman's argument even further. Basing her thinking on the level of detail in the *Escurialensis* version, she argues that the *Escurialensis* version served as model for the other drawings. Her assertion relies on the *Escurialensis* version's full-column fluting. This feature, she contends is later abbreviated in the other drawings. Although Shearman notes that the same feature demonstrates that Raphael actually matched the drawing to the Pantheon since what Scaglia understands as an abbreviation actually captures the Pantheon's cabled or belted

[93] Lotz, *Studies in Italian Renaissance Architecture*. translation of "Das Raumbild in der Architekturzeichnung der italienischen Renaissance," *Mitteilungen des Kunsthistorischen Institutes in Florez* 7 (1956), pp. 193-226.
[94] John Shearman, "Raphael, Rome, and the Codex Escurialensis," *Master Drawings* 15, no. 2 (1977). And Scaglia, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings."

columns. After examining the actual drawings in the Uffizi, and high quality facsimiles of the drawings in Austria and Spain, I tend to believe that U 164 A r was the model for the other drawings. If the entire composition is not original to Raphael, I believe that Raphael drew his version in tandem with visits to the Pantheon. His drawing alone seems to engage in a process of sketching and correction as he matches the image to his conceptions. Other drawings seem to replicate his *pentimenti* and even attempt to resolve the ambiguities. The left-most aedicule is one area where these features are apparent. In the end, the other versions, including Raphael's copy of his own work in Salzberg, appear as simplified versions of Uffizi 164 A r, and given this observation, I believe logic dictates that Uffizi 164 A r should be considered to be the model.

These debates are beneficial to this study because they provide important groundwork for understanding circumstances behind their production and their individual significance. However, my approach to the Pantheon drawings diverges from this more historiographical one. I will not be focusing on the serial nature of the drawings, but on the significance of their graphic structure.

In terms of graphic structure, U164 A r is the most important since as the above evidence demonstrates, it was the model drawing for the others[95] When so many images of the Pantheon were available, what was it about this one that made it the subject of so

[95] Scaglia asserts that although the various drawings do differ from one another on the level of detail, structurally they are nearly identical. She claims that the gross measurements between the drawings differ by only millimeters, although my own examination of the drawings leads me to question the basis of her claim. For example, it is quite obvious that the not-Sansovino artist attempts to alter the centralized feeling of the image by significantly increasing the depth of the foreground and the extent of the baseline curve. The *Escurialensis* drawing similarly changes the impression of the image by cropping out significant portions of the drawing on the top and right. Scaglia, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings," 10.

many studies?[96] Was there something about the particular way this drawing was constructed that the copyists were imitating?

In his article Lotz states that the drawing's importance stems from its mediation between the forms of perspective and section.

> The Uffizi drawing … stands, so to speak, halfway between the perspective image of the interior and the orthogonal projection of the inner wall [section], as defined in Raphael's letter.[97]

Lotz's assertion and his definition of liminally-positioned drawings can begin to explain the significance of both this particular drawing, and the general process of drawing's rise within architectural design. This section will begin with his assertion while examining how the Pantheon drawings occupy this middle ground, and why this liminal position is significant.

The hinge piece of Lotz's claim is his idea that drawings with multiple viewpoints stand between those with a single viewpoint (perspective) and those with no or an infinite viewpoint (section, as well as all orthographic projection). Or as Ackerman says, "Orthogonal projection might also be described as perspective with an unlimited number of vantage points."[98] As a contrasting example of a liminally-positioned drawing, Lotz analyzes Uffizi 131 by Giuliano da Sangallo. [Figure 23]. In this drawing, identified as a project for Saint Peter's, each of the three bays depicted has its own central vanishing or viewpoint. These separate views are held together with a common elevational framework,

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[96] In his answer to Egger's question "Why did the model, now presumably lost, become so famous and so frequently copied?" Egger, *Codex Ecurialensis: Ein Skizzenbuch Aus Der Werkstatt Domenico Ghirlandaios*, 37ff. Lotz replies "The reason may very well lie in the fact that at the time it was considered a masterpiece of applied perspective and that therefore it was used as an example in the teaching of perspective drawing…The rendering of the interior, the main orders, the upper story, and the base of the dome must have been considered an extraordinary achievement at the time." Lotz, *Studies in Italian Renaissance Architecture*, 25. Pace Lotz, the Pantheon drawing deviates from any consistent perspective construction, as I will further explain later in this section.

[97] Lotz, *Studies in Italian Renaissance Architecture*, 26.

[98] Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* , note 72.

and knitting together of these multiple viewpoints into a single drawing produces a final image that has qualities of both perspective and orthographic projection.

It is curious that Lotz attributes the significance of the Pantheon drawing to its liminal position when, clearly, Uffizi 131 already accomplishes this goal. We saw earlier how Strasbourg Plan A achieved its appearance of technical sophistication in part because the building's design did not pose a challenge to the graphic conventions. Similarly in Uffizi 131 the nature of the architecture being depicted makes knitting together the three bay views quite unproblematic. The additive structure of the repetitive bay system allows these three separate perspectives, each with its own vanishing point, to be placed into a fairly simple orthographic framework made up of the bay-dividing columns, impost blocks and barrel vaults. This framework occupies the foreground of the picture and the three self-referential, single-point perspectives that are inserted into that frame make up the background. This structure mirrors that of the actual design where the overall form of the church would create a unifying whole into which individual chapels could be inserted at each bay. In this way the form of the architecture pictured is in line with the geometry of the representational process. Although, like the Pantheon drawing, Uffizi 131 is made up of perspectival and orthographic features, the sympathy between the geometry of the design and the geometry of the representation in Uffizi 131 makes it much easier to resolve the drawing into clearly defined orthographic and perspective areas.[99]

[99] Only the cut line at the peak of the barrel vault suggests that this drawing is a section and not an elevation. While this sectional detail is minor, when it is used in tandem with the coffers that correctly become compressed as the barrel vault becomes more horizontal, it does solve the problem of how to depict vaults within orthographic projection, a puzzle that took decades to solve during the Gothic period. The reader may recall the wavy-line convention Villard used, and his difficulty drawing the vaults in his section at Reims. See pages 25-29.

Further, it is clear that in addition to that in Uffizi 131, other alternative approaches existed and were even more common during the time when the Pantheon drawing was made. Such an approach can be seen, for example, in the Codex Coner's drawing of the Belvedere, interestingly labeled as an example of "*orthografia*." [Figure 24]. In this image the bays are similarly held together by an orthographic frame, but this time they are united by a single perspective structure. Even though the hierarchy created by this form is not reflected in the architecture, this composition with its single vanishing point places emphasis on the middle bay while it conceals many details in both the left and the right bays. Da Sangallo's method in Uffizi 131 counters the tendency of perspectives like the Belvedere to occlude surfaces on either side of the vanishing point. Much like Villard's drawing of Laon Tower, discussed in the earlier section, Uffizi 131 allows the viewer to see around objects that would otherwise be concealed. It also replaces the architecturally arbitrary emphasis on the center bay which results from a unifying vanishing point in drawings like the Belvedere, with a technique that equalizes the emphasis on each bay. This change in what the drawing prioritizes is particularly appropriate for images of long, repetitive spaces.

The existence of these two drawings, and the other drawings like them, visibly demonstrates that it was not the liminality of the position between orthography and perspective that was at stake, but a debate over what kinds of priorities were activated by the different forms of picturing. The inflection Uffizi 131 provided to previous representational techniques, such as the one demonstrated by the Belvedere drawing, suggests that finding the appropriate mode of representation for specific types of buildings, that is drawing techniques where geometric priorities harmonize with the

architecture being represented, may have been a concern during the early years of the sixteenth century.

In other words, drawings like that of the Belvedere or Uffizi 131 already occupied, in a very sophisticated way, the liminal position Lotz claims for the Pantheon drawing. Why, then, were they not copied the way the Pantheon drawing was? While these drawings provide evidence for Lotz's theory that between perspective and section is a method with multiple viewpoints that unites the two forms, it is not really the unification that is at issue in these drawings. Instead, the debate that these various methods articulate can be seen as one of priorities: which priorities should representational techniques emphasize and what kinds of resonance will different techniques encourage with design?

Further, this debate is not wholly new during the Renaissance. Drawings which sought to unite multiple points of view, multiple drawing forms, or as Lotz calls them at one point, "impossible perspectives," can also be found within the Gothic tradition.[100] These drawings also engage in their own discourse on representational and architectural priorities. Once again, it is possible to turn to the sketchbook of Villard de Honnecourt's drawings of the interior and exterior of the central apsidal bay of the choir at Reims Cathedral to find such an example and see early roots for the explorations that came after. [Figure 25]. Unlike Strasbourg Plan A, or the later tower drawings of Strasbourg or Freiburg-Munster, the Reims choir drawings do not adhere to any set conventions, but instead they suggest a new, and likely experimental, form of depiction. Like other experimental images such as Uffizi 131, Villard's drawing captures the renegotiation of the priorities between those granted by the geometry of the drawing techniques typical in

[100] Lotz, *Studies in Italian Renaissance Architecture*, 26.

his time and those he wishes to emphasize. Of Villard's Reims drawings James Ackerman has provocatively written that images seem to portray an "orthogonal drawing made on a flat surface which is then bent into a semi-cylindrical form."[101] In other words, the images suggest a fiction in which Villard drew elevations for the each side of the chapel, fused them into a ribbon and then bent them into a schematized form that suggested a naturalized impression of the space. While the drawings do depict a form of recession, like Villard's Laon drawing, it is a form that does not adhere to a uniform mathematical or optical perspective structure.[102]

Because of their unique spatial depiction, both the Reims interior and exterior drawings are intriguing, but it is the interior drawing that is particularly illuminating of the issues that were at play in the drawings of the sixteenth century. In the interior drawing, Villard still gives the impression of a fused elevation. But where the exterior drawing only included three sides or elevations of the chapel, the interior drawing also fits in other surfaces. Along the wall both sides of the projecting piers have been shown in order to portray both openings of the passage that penetrates through them (the thick, dark lines on either side of the piers). At most only one of these should be visible, the other occluded by the illusions of parallax. In all, Villard's drawing fuses nine different elevations within the single spatial schematic he draws. The successful revealing of all these surfaces into a unified, if quirky, spatial structure is remarkable, and surprisingly, in addition to exposing multiple surfaces, this very unperspectival structure also maintains many features of an elevation within those surfaces. As is the case with many of Villard's

[101] Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* , 34.
[102] In fact, the base of Villard's drawings appear to project rather than recede because he is not actually making use of an optically-correct perspective structure. Instead the spatial illusion equivocates between an outward and inward projection from top to bottom, almost prefiguring the types of images created by M.C. Escher or El Lissitzky's Proun Room.

"perspectives," the relative dimensions of similar elements are largely preserved. For example, in this drawing identical colonettes are of equal size in his drawing.[103] The negotiations necessitated by this technique inevitably produced some areas where the system could not be maintained and features had to be distorted, as is the case with the apices of the pointed arches on either side of the choir.[104] And yet, while the drawings also distort the overall sense of space, in their creative solution to the representational problem, Villard's drawings adhere better to Alberti's fifteenth century specifications that architectural drawings preserve size and shape than many of the drawings produced during that theorists time.[105]

While Villard's drawings of Reims are commonly interpreted as crude attempts at perspective, in fact he is offering a different kind of fidelity to the experience of the building. Villard gives priority to the depiction of individual surfaces and individual elements rather than the depiction of space. These are presented in a way that allows the maximum number of elevations to be presented while maintaining their proximal relations and the sizes of their individual elements. In other words, the Villard drawings do something very similar to what is accomplished by Sangallo's drawing for his design for Saint Peter's. Both techniques unite elements from various representational structures, and both play within the combination in order to reinforce the aspects of the discipline they considered important. Rather than three perspective views united into one section, Villard's drawing of the interior at Reims presents three elevations (nine, if one includes

[103] Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* , 35.
[104] Ibid.
[105] Alberti, *On the Art of Building in Ten Books*, II:1, tr. pg 34, Ackerman, *Origins, Imitation, Conventions: Representation in the Visual Arts.* , II:1.

each of the revealed sides of the piers) united into single perspective-like structure that suggests a schematized equivalent of the space depicted.

Although it may tempting to dismiss Villard's drawings as isolated examples of a rare technique, his are not the only Gothic drawings to demonstrate this assemblage of surfaces into an interpretively complex spatial representation. There is another Gothic example which similarly bridges between the concerns demonstrated both by Villard's drawings of Reims and by Renaissance examples like Uffizi 131 or Raphael's drawing of the Pantheon. This drawing is the interior "perspective" of the church of San Juan de los Reyes in Toledo, Spain, dating from 1480. [Figure 26]. Executed by Juan Guas, one of the master masons for the church, this image was likely intended as a project drawing made previous to the church's construction, perhaps as a means to persuade patrons to build the design.[106]

Like Villard's drawing of the interiors at Reims, the Guas drawing also struggles to avoid concealing surfaces. This drawing, however, seems to simultaneously recognize the benefit of a more perspectival depiction of space. It depicts a portion of the church encompassing the transept and sanctuary, and although the plan of this area does not deviate from the typical Latin cross configuration, the drawing gives the design a surprisingly centralized feeling. Whereas the Reims drawings gave the impression of a series of elevations that had been wrapped around a cylinder, this drawing initially gives the impression of a perspective. But on closer examination it is more accurate to describe the structure as an assemblage of elevations that have been pleated into place, unfolding to reveal surfaces whenever possible. The resulting implied geometry may be closer to

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Alberti, *On the Art of Building in Ten Books*. Sanabria, "A Late Gothic Drawing of San Juan De Los Reyes in Toledo at the Prado Museum in Madrid," 162.

that of actual plan than a cylinder, but not by much. The depiction of the vaults creates the illusion of these having been tipped backwards to reveal more of their surface. The rear transept walls actually angle backwards in the space in order to allow the front wall of the transept to be unfolded and partially seen. The same is true of the clerestory windows where the front-most jambs and their sculpture are visible. Sergio Sanabria, described this drawing as having been treated as a "fish-eye photograph." The artist, Sanabria claims, "unfolded the horizontal plane to allow all walls to be seen frontally without overlaps."[107] Like Villard's drawings of Laon and Reims, this technique allowed some mirco-scale distortions to be eliminated, but on the macro-scale, fidelity to either the visual experience or the actual form was compromised. Sanabria describes the effects of the San Juan de los Reyes drawing as follows:

> The total space does not read as a unit; rather, there is a succession and articulation of parts, connected by the viewer who process nearsightedly through them.[108]

In other words, like Villard's drawing, Guas' drawing is suggestive of an attempt to harmonize a certain mental habit, the tendency to conceive of a building as a series of discrete surfaces knit together into a whole, with the representational conventions of their time.

Interestingly, this mode of thinking and this form of representing reverses the priority evident in drawings like that of the Belvedere or Uffizi 131 where instead the emphasis is given to the form of the whole into which are fitted individual elements or surfaces. In the Gothic tradition the consistent trait is towards revealing many surfaces, subordinating the structure of the architecture so it could be manipulated in ways that

[107] Sanabria, "A Late Gothic Drawing of San Juan De Los Reyes in Toledo at the Prado Museum in Madrid," 168.
[108] Ibid.

promoted this exposure. In the Renaissance however the disposition of the individual elements is manipulated and is, therefore, subordinate to the structure of the whole. Yet, in every case these drawings occupy a liminal position. They are not pure representations of elevation, section, or perspective, but instead are attempts to communicate a different set of priorities from what is possible within the conventional forms of representation.

Given the genealogy of the liminally-positioned drawings and the graphic debates they represent, what does Raphael's drawing attempt to prioritize? To answer this question a few initial observations are essential. Perhaps most obviously, if ever the drawing was intended to convey any sort of archaeological documentation of the Pantheon, it is grossly in error. In its approximate 200-degree sweep, the drawing captures the Pantheon from the altar-niche on the left to the vestibule on the right, and between these two are depicted three aediculae and two recesses. [109] However, in the actual Pantheon, as the Renaissance artists knew, there are four aediculae and three recesses. [Figure 27]. These are arranged so that there are eight major features: the vestibule, the altar-niche, two circular recesses and four rectangular recesses. The circular recesses form an axis at 90-degrees to the vestibule/altar-niche axis while the rectangular recesses create a secondary set of axes at 45-degrees separating these four major features. The aediculae further subdivide the wall and are topped on either side of the circular recesses by segmental pediments, and on either side of the vestibule and altar-niche with triangular pediments. Raphael's drawing of the Pantheon, with its omission of one tabernacle and recess, can reflect the idea of this rhythm, but not its careful, hierarchical structure.

[109] Lotz, *Studies in Italian Renaissance Architecture*, 26.

As an explanation for these omissions Shearman offers an interesting theory that Uffizi 164 A r as it stands now is an extension of Raphael's original drawing, which was not in error. By identifying differences in the quality of ink and line, Shearman hypothesizes that the right most tabernacle and vestibule portion of the drawing, among other features, are later additions that sought to transform Raphael's working drawing into something that resembled a *vedute*.[110] The reduced angle of view that results from these omissions potentially eliminates much of the perspectival irregularities that are apparent in the final drawing. This later artist responsible for extending Raphael's drawing, Shearman believes, had not seen the Pantheon, but had in his possession another view that overlapped Raphael's but captured the right-most two recesses and the vestibule. When fusing the two drawings together, the artist assumed that each drawing showed the same recesses, rather than there being only one recess in common.[111] The resulting drawing frames an interior view of the Pantheon with only two recesses between the altar-niche and vestibule. Shearman's theory also explains the incorrect rhythm of the tabernacle pediments depicted in the final drawing. If the artist did indeed work with two overlapping drawings as Shearman thinks, the belief that only two recesses existed would consequently eliminate one of the segmental pediments, thus producing the incorrect alternating rhythm that Uffizi 164 A r demonstrates.

I find Shearman's theory intriguing. Particularly because, through logical extension, it establishes that Uffizi 164 A r was the model copied by the other drawings since the other drawings demonstrate only one state, not the two that Shearman sees. However, Shearman fails to acknowledge the copy of Uffizi 164 A r found in Salzberg.

[110] Shearman, "Raphael, Rome, and the Codex Escurialensis," 111.
[111] Ibid.: 114.

Scaglia quite convincingly argues that the Salzberg drawing is also authored by Raphael.[112] Such an assertion complicates Shearman's theory because even if a later artist altered Raphael's original version of the Pantheon interior, Raphael saw fit to make a copy of these alterations. There must have been something compelling about the new construction that made it worth recording, even in light of its documentary errors. One can only conclude that the drawing was not copied for its documentary value, but that there was another motivation. Further, as I mentioned previously, my own observations of Uffizi 164 A r revealed none of the breaks in line-work or layered deposits of ink that one would expect to find had Shearman's theory been correct. The only logical conclusions are that Uffizi 164 A r is the model drawing, and that an accurate depiction of the Pantheon's formal arrangement was not what Raphael prioritized in its making.

One possible conclusion from these solecisms is that the drawing, like the drawings of other Humanists, was more concerned with communicating the spatial whole of the Pantheon and therefore subordinated the accuracy of the constituting elements to this overall impression. And yet, what spatial impression does the drawing convey? The Pantheon's grandeur? Its centralized plan? Raphael's drawing conveys neither of these qualities, which are arguably the Pantheon's most powerful. Instead, the architecture appears flattened. The shallow sweeping curve at the base of the wall is more suggestive of a wide ellipse rather than the circular plan of the Pantheon's ideal architecture, and the dome above seems to have been similarly flattened onto the drawing's surface.[113] This observation is key to placing Raphael's] drawing in dialog with other earlier ones.

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[112] Scaglia, "11 Facsimile Drawings of the Pantheons Vestibule and the Interior in Relation to the Codex-Escurialensis and Sangallo, Giuliano, Da Libro Drawings," 13.

[113] The spatial composition of the Pantheon is sometimes referred to as an "ideal dome." This arrangement perfectly nests a complete sphere into a cylinder whose height matches its radius allowing the base of the sphere to be exactly tangent to the base of the cylinder.

Because the Pantheon interior is a very flat drawing of a circular space, it seems to portray a schema or code for the shape of the Pantheon rather than a re-presentation of its appearances. In other words, the structure of the Pantheon drawing is based on a spatial contrivance into which it was possible to place individual elements like the aediculae and recesses without incurring an excessive degree of recession. In this structure, like-objects are depicted as such rather than being arbitrarily prioritized solely on the basis of a strict representational framework, as would have been the case with perspective.

Yet, the geometry of the Pantheon resists being conceived as an additive multiplicity of elements or surfaces. This condition is arguably true of any centralized space, but is particularly the case within a rotunda's continuity of interlocked relationships. The Pantheon cannot be made to subordinate its whole to a series of parts. In other words, the flattened geometry of the Pantheon in Raphael's drawing places it in line with drawings like Uffizi 131 which sought to curb the unwanted hierarchies incurred by perspective. Because of its distortion of the Pantheon's spatial configuration it can also be read within the Gothic tradition of subordinating the architectural whole to the accuracy of its individual elements. Therefore, the Pantheon drawing negotiates between both graphic traditions. Because of the Pantheon's centralized geometry, Raphael's drawing struggles between its engagement with the surface and the space.

If the Pantheon interior appears to walk the line between representational conventions and priorities, perhaps it is because Raphael was illuminating the ways in which certain representational priorities may lend themselves inadequately to certain types of buildings. In such situations the architectural priorities cannot be harmonized with the representational geometry. Unlike the interplay between Uffizi 131 and the

Belevdere drawing where a series of representational options nuance the interaction between the architecture and its image, a dissonance occurs between the mental understanding of the Pantheon's schema and the experience of the image that attempts to capture it. In Uffizi 131 the geometry of the drawing is linear, but so was the architecture of Sangallo's proposal. The drawing could resonate and reinforce the mind's experience of the space. In the case of the Pantheon, however, a logical and geometrically sympathetic representational framework cannot be provided by either perspective or orthography.

Initially it may appear that this resolution would not be so problematic. Why not, for example, simply unroll the wall of the Pantheon creating an elevation whose length matches the circumference of the circular plan? While seeming to provide a simple orthographic framework that accurately conveys the forms and proportions of the enclosing wall, this solution would actually redefine the projective relationship between the elevation and the plan. It would require that the plan be rotated, and the elevation only connected by a point of tangency. This rotation would be at odds to the parallel geometry of orthography. While the flatness of Raphael's drawing seems to suggest this vein of thinking, it appears that Herman Vischer did exactly this in his slightly later drawing from 1515. [Figure 28]. This interior elevation records a portion of the Pantheon wall as if it was flat. However, just as the drawing's relationship with its plan is difficult, so the resolution of the dome, which introduces a doubly curving geometry, becomes impossible. Vischer omits this portion of the drawing in its entirety. In the end his drawing gives the impression of having been abandoned before it was finished, and it is not difficult to imagine that upon discovering the difficulty of maintaining the

proportional accuracy of the wall as its moves into the dome, he gave up on the image. Although neither Vischer's drawing nor Raphael's can resolve the disharmony between their representational conventions and the geometry of the Pantheon, their drawings do indicate that a graphic discourse was taking place: that options for a form of picturing that would resonate with their architectural priorities for the centralized forms idealized during the Renaissance were being sought.

In other words, the Pantheon drawing captures the struggle in which the Renaissance architects were engaged regarding the appropriate relationship between architecture and its representation. It demonstrates that the explicit goals of the elevation drawing as stated by Alberti were not something natural and inevitable, but in fact, that they could be the source of conflict when the geometry of the object conflicted with that of the representation. Alberti stresses that the architect "takes his projections from the ground plan and, without altering the lines and by maintaining the true angles, reveals the extent and shape of each elevation and side."[114] It is true that when the lines and angles achieved through projection are maintained the extent and shape of objects are often revealed. But this is only true when the object's geometry is aligned with geometry of orthographic projection. Such a harmony requires that an object's form reinforce the rectilinear projectors and 90-degree angles of orthographic projection with its own parallel lines and 90-degree angles. When planes occur at oblique angles, or worse, when they are round, the "ideal" representational space of orthographic projection is compromised. As a centralized space the curves of the Pantheon distort the true shape and width of every element along the wall when depicted in elevation. If such a drawing fails to capture the correct forms and their proportional relationships, or even the spatial

[114] Alberti, *On the Art of Building in Ten Books*, 34.

impression of the space, what would be its purpose? In other words, given these observations, it seems that the Pantheon drawing picks up on some of the same debate about the representation of oblique surfaces that can be seen in the Gothic drawings like Strasbourg Plan A and the later Gothic drawings that make use of cropped slide translation.

> Raphael spoke of this very problem in his letter 1519 Letter to Pope Leo X:
>
> > And in such drawings, whether the building be round or square, it is not made smaller at the edges in order to make it show two sides. Because the architect cannot take an exact measurement of the reduced line, it is necessary that a device which seeks the actual complete measurements be drawn with parallel lines, not with those that appear equal and yet are not. If the exact measurements of a round form are foreshortened or diminished on the plan, this is quickly discovered in the drawing of the plan, and those things that are foreshortened in the plan, such as domes, arches, triangles, are rendered more perfectly in his direct drawings.[115]

In this letter Raphael clearly identified the need of a drawing to function as part of a system to explain space rather than to function individually just as a simple image of it. As Lotz noted: "This means that the ground plan, elevation, and section of such buildings are in some cases ambiguous by themselves; only a comparison of these three projections can result in a correct image.[116] In his drawing of the Pantheon, a drawing made approximately fifteen years before he would write these words, Raphael seemed to be struggling with these very representational conflicts. These conflicts exist when architectural images are created outside of synthetic systems that force a single drawing to do all the work of representing. These tensions can be noted in the interplay between

[115] Andrea Palladio, Vaughan Hart, and Peter Hicks, *Palladio's Rome : A Translation of Andrea Palladio's Two Guidebooks to Rome* (New Haven: Yale University Press, 2006), 188.
[116] There is some dispute as to whether this description of perspective, which is only found in the Munich copy of the letter, was actually authored by Raphael or was a later addendum by another author. I tend to think that the Pantheon drawing, which seems to problematize this very issue, makes a strong case for this thought being Raphael's even if it only made it into one copy of the letter. Lotz, *Studies in Italian Renaissance Architecture*, 29 and Note 77.

the Belvedere drawing and Uffizi 131, but the extent of the conflict is brought to a head by Raphael's drawing of the Pantheon. Although the drawing demonstrates an attempt at commensurability with the equivalent weight it places on each of the recesses and aediculae, in order to give equal emphasis to each of these, the drawing must minimize recession. Graphically, this goal requires that the spatial impression of the Pantheon be compromised by making it much flatter, which, in turn, undermines the spatial experience of the Pantheon as a whole. In fact, this distortion is so extreme that the image created virtually anticipates the spatial experience of Boromini's San Carlo alle Quattro Fontane more than it captures the monumental cohesive impression of the actual Pantheon.[117] In other words, this drawing simultaneously tries to convey an understanding of the Pantheon as a whole as well as an understanding of its individual elements, but the difficulty is that neither perspective nor orthography offers a system that harmonizes geometrically with architecture. Both priorities are at odds to the representational scheme.

While the Pantheon drawing may not have provided an answer to the question of how or what to depict of oblique or curvilinear surfaces within an architectural drawing, it certainly made the problem clear. No graphic solution existed to successfully harmonize the geometries of this kind of architecture and its representation. Unfortunately, spatial frameworks like those of Guas and Villard involve the use of approximations. Though these drawings strike a compromise in that they preserve a sense of commensurability, no actual measurements can be taken from the drawing. Within a

[117] In light of Wolfgang Jung's argument about Borromini's "Anarchy of Imagination," this observation provocatively hints at the Pantheon drawing as a source for this later Baroque form of centralized architecture. See James Ackerman and Wolfgang Jung, eds., *Conventions of Architectural Drawing: Representation and Misrepresentation* (Cambridge, Massachusetts: James Ackerman,2000), Chapter 5.

Gothic system of design, a system that functions without the need of a universal measure, this type of image conveys what is necessary. For the Humanists, however, measurement was important. As Wolfgang Lefevre explained such an approximation reduces the power of the plan to that of a picture, thus limiting the power of the image to resolve and inform issues of design and construction.[118] While Raphael's Pantheon demonstrated the need to reconsider the spatial frameworks for the depiction of centralized churches, his provocative drawing was not an image that offered a solution for architectural representation.

Graphically speaking, the Pantheon poses a difficult problem. If Uffizi 131 is a successful demonstration of a technique for interlocking two forms of representation so that the geometry of the image reinforces the actual geometry of the architecture and how it is perceived, perhaps the ease with which these two systems came together made Uffizi 131 less interesting to the sixteenth century Humanists. The question it posed had been both asked and answered. However, the Pantheon drawing offers no such resolution. Its representational system does not promote an understanding of the geometry of the architecture, and it may have been for this very reason that the drawing was copied. The space resisted a graphically sympathetic construction. Much like an unsolvable riddle, the drawing may have been copied not for the answer it offered but because the question it posed remained both relevant and unanswered.

While drawings like Villard's and Guas' may have been successful tools for understanding space as the Gothic masons conceived it, they prioritized a very different sense of building design. Just the same, we must conclude that for the Gothic artists,

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[118] Wolfgang Lefèvre, Jürgen Renn, and Urs Schoepflin, eds., *The Power of Images in Early Modern Science* (Basel: Birkhäuser Verlag,2003), 85.

these images conveyed what were, for them, the essentials of the buildings. Their images were successful conveyors of the representational priorities of the time. Similarly, during the Renaissance, design techniques were available to fill in any gaps that drawing did not come to occupy. In particular, model-making often substituted for a systematized method of representing space through drawing. Yet even within these methods, it is clear that drawing's potential as a more spontaneous, varied and versatile tool for creative reflection was intriguing to the Humanists. They engaged drawing and pushed its use forward to unprecedented modes of expression within design.

When we look back on these drawings, the dissonance between our esteem for drawings like Sangallo's and its Gothic counterparts has more to do with the pictorial continuity within architecture throughout the last 500 years than it does with a lack of sophistication or merit within these other techniques. We read Sangallo's drawing as a development because we see our own system within it, since the conventions he worked out in Uffizi 131 were adopted, resolved and perpetuated. Simultaneously, we have forgotten our understanding of the Gothic conceptions of space and how to read its representations to such an extent that we can hardly make sense of Villard's or Guas' priorities. We fail to see that the development of our own system was not a linear progressive march, but a messy process of negotiation, development, application and rejection. The Pantheon drawing captures a picture of this process. It does not present a solution, but a snapshot of questions and indeterminacies. It was a representational experiment that adapted new technologies to newly preferred spatial configurations. Uffizi 164 A r presents a glimpse into a dialog that over the last 500 years, we have forgotten ever occurred. If Raphael and his colleagues recognized the drawing as an

important drawing because of the eloquence with which it revealed a geometric disjunction between representation and architecture, it is significant today because it exemplifies the complex nature of the interactive forces involved in a transitional moment within the medium of architectural design.

Confronted with a drawing like Raphael's I believe that our difficulty as historians stems from our failure to recognize the nature of the problem. It is because Raphael's image captures this complexity, a complexity we have learned to disregard due to the hegemony of drawing, that we see his drawing of the Pantheon as opaque. We read back our prejudices for drawing and cannot see the Pantheon drawing outside our own standards. It is for this reason that we herald the drawing as a masterful perspective, when there is hardly anything perspectival about it, or that we claim it accurately captures the space when it is clearly in error here, as well.[119] In our recognition of the drawing's importance we struggle to see it as important within our own system, when its significance likely stems from the part it played in our system's development, the conventions for which would not be set until at least ten years later. In other words, we have misinterpreted Raphael's image of the Pantheon because triadic form, the graphic system which Raphael argues for in the next decade, subsequently achieves such success and dominance that it has obscured our understanding of its developmental context.

The Fractures

From the examination of these three drawings I believe it is possible to form a characterization drawing's rise within architectural design. Contrary to much of what has

[119] Shearman notes P. Fehl's comments in particular who believes that the Pantheon drawing demonstrates "views which make the austere splendor of that work comprehensible to us remarkably better than even the cleverest photograph can." Shearman, "Raphael, Rome, and the Codex Escurialensis," 141.

been written about architectural design and the role of drawing within it, architectural drawing conventions are not self-evident. Their development and adoption is part of a creative historical process that was established over many centuries and finally implemented as a conventional practice during the cinquecento. Throughout the centuries between the (re)emergence of drawing within Gothic architecture until this moment in the sixteenth, drawing's role in design steadily grows, but its exact place is found through a process of negotiations, advances and retreats that makes its final adoption a less than inevitable result.

Drawing, as it is used today, emerged from its part in the process of Gothic construction. Here, drawing was indispensable to the resolution of problems in construction, those stereotomic problems whose geometric solutions were only accessible to the Gothic mason through the use of drawn geometric operations, or what Lon Shelby has called "constructive geometry."[120] These operations and the knowledge of them defined the Gothic mason as geometer. Masons used drawing as a surrogate for geometric theory, and the solutions they provided, though approximate, were often more expedient than the route provided by a more generalized and universal mathematic theory.[121] Unfortunately, the rote nature of their knowledge in this area also limited the emergence of new techniques.

Through the Gothic use of templates, it is also possible to imagine an empirically-derived understanding of how a plan may project its structure in elevation; just as a template used to carve individual stone moldings projected and unified the final outline of an arch. This understanding may have driven a transformation of drawing's role from

[120] Shelby, "The Geometrical Knowledge of Mediaeval Master Masons."
[121] Turnbull, "The Ad Hoc Collective Work of Building Gothic Cathedrals with Templates, String, and Geometry," 326-29.

its direct use in the process of construction to its use in the approximately scaled elevations that emerged around 1260. These drawings were likely used as communication tools to provide a vision of the project, rather than being used to inform construction. And yet, as this new graphic convention took hold, it is possible that the drawings may have informed other purposes than solely a means to communicate with the patron.

Additionally, masons made use of documentary sketches, particularly within their creation of "model books" which they used to record significant buildings, a thorough knowledge of which may have provided later solutions to architectural problems. Nested as they were within the process of construction, many of these drawings served as graphical keys that could be decoded into a building's specific version of interdependent proportional rules, rather than the kinds of building sketches we think of today. However, among these drawings there are also attempts to capture and explain certain buildings visually. These sketches may seem very opaque to modern sensibilities, but they offer us a wealth of insight into the Gothic priorities for representation.

Yet, within all of these representational innovations, a certain limit existed for drawing's role. A technological evolution is apparent within the progression of drawing's use as part of the rule-based procedures to determine the results of geometric problems, to the limited forms of drawing that were used to communicate design particulars to other masons, and eventually, the use of drawings to present or obtain approval for the design from patrons, but this developmental pathway is limited. While the geometric basis for orthographic projection was less complex than many of the stereotomic techniques that were used by the masons, the empirical form through which these techniques were known

prevented a generalization of such mathematical knowledge.[122] The Masonic knowledge of mathematics was frozen within their techniques, not adaptable to new or emergent problems.[123] Although a more generalized or theoretical knowledge of mathematics was available during this period, a division between it and the practice of its principles through craft existed. But perhaps more significant than this division, drawing's root in the process of construction or the limited understanding of its geometric principles, the *ad hoc* design procedure that evolved rather than prefigured design simply placed little developmental pressure on drawing.

With the rise of Italian Humanism during the fifteenth century, however, a change occurred within the person of the architect and within the process and purpose of design. Rather than solving those problems that were unapproachable to the Gothic mason, however, the Humanists switched the foundations of those problems, and rooted their thinking in a different aesthetic basis that further inverted how a building was conceived. Drawing and its new forms are fully imbricated in these changes. A cementing of the division between mason and architect occurred. While the beginnings of this division were already apparent in the late thirteenth century, the transformation from master mason to architect would mark the final schism.[124] In this role the architect was no longer

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[122] These techniques involved the use of extensive graphic approximations for stereotomic calculation, leading some scholars to acknowledge that "An exact solution [to the problem of stereotomy] was beyond the ken of most masons even after the availability of printed editions of Euclid in Latin after 1482 and in vernacular translations after 1543." Sergio L. Sanabria, "From Gothic to Renaissance Stereotomy: The Design Methods of Philibert De L'orme and Alonso De Vandelvira," *Technology and Culture* 30, no. 2 (1989): 271.

[123] For a discussion of the transmission of knowledge within the Gothic tradition of masonry and specifically the idea of the mason's techniques as frozen knowledge, see Turnbull, "The Ad Hoc Collective Work of Building Gothic Cathedrals with Templates, String, and Geometry," esp. 328.

[124] In a famous thirteenth century sermon, Nicholas de Biard complains that the "masters of the masons, carrying a baguette [measuring rod] and gloves ordered others to 'cut it there fore me,' and worked not at all, although they received a larger payment [than the other masons]." Teresa Frisch, *Gothic Art 1140-C.1450: Sources and Documents* (Toronto1987), 55. And yet, this division does not mirror our

a mere craftsman but could also be a theorist, writer, cartographer, painter, sculptor, geometer, inventor and engineer.[125] The knowledge embodied by such a person was not only empirical, but also general and theoretical. The role of the architect was no longer one that required training as a mason, but instead scholarly study and aesthetic expertise.

Further, while Gothic drawings tended to conceptualize the whole as an accumulation of its parts, their Humanist counterparts as the designers of buildings, rather than their evolvers, inverted this relationship both in their drawings and in their conception of the buildings.[126] The Renaissance acquired a cohesive image, it was an object like the ancient monuments of Rome, an object to be contemplated and captured as a whole, not as an ad hoc assemblage of parts. [127] This conception of both the building and its image was governed by a new and evolving theory of *all'antica* aesthetics reliant on a new kind of proportioning system which related the elements to the whole of a building rather than to the next chain of iteratively proportioned elements.[128]And it was this series of altered definitions and priorities was entangled in the fundamental changes that occurred within architectural representation. These new conceptions of about architecture required a new forms of representing it, and drawing became a means for "geometers and physicists" to rationalize building practices to their own models and

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understanding of the architect, as during the Gothic period "no individual designer *qua* architect was existent and *per se* he was not necessary." Andrews, *The Mediaeval Builder and His Methods*, 8.

[125] Schofield, "Leonard's Milanese Architecture: Career, Sources and Graphic Techniques," 112-20.

[126] Filarete stands out as a hinge-like exception to this division. As Saalman claims, his treatise is related to both that of Alberti and that of Vitruvius, but is utterly different from them. It is more down to earth, and also more reflective of the processes used by early Renaissance architects like Brunellschi, a process that is "inextricably tied to preceding Gothic theory and practice." Saalman, "Early Renaissance Architectural Theory and Practice in Antonio Filarete's Trattato Di Architecttura," 88.

[127] While Gothic buildings also appear as wholes initially, this impression belies the consistently variable nature of their parts. By nature of their proportioning systems both Classical and Renaissance buildings are cohesive. The use of an order guarantees this systematization from their holistic impression to the constitutive parts.

[128] Saalman's work on Filarete is also an excellent source for more on the break between the proportioning systems between the Gothic and Renaissance periods. Saalman, "Early Renaissance Architectural Theory and Practice in Antonio Filarete's Trattato Di Architecttura."

principles.[129] Within the sketchbooks of the Humanists, techniques seem to first emulate and then transform those types of image that had been in use during the Gothic period. The new demands for proportion, that is the valuing of a Humanist definition of proportion, were at odds to the Gothic methodology that did not require commensurability between the drawing and the building. Without a system that could accurately convey the true shape and extents of objects, how could the new Humanist proportional system find its way into building? If designs become less typologically based, and if what typologies do exist for the new designs are not as familiar to the builders as they are to the designers, architectural representation must become more complete. It must communicate more about the intended design. In other words, if, as Reginald Blomfield asserted in 1912, the architecture of the Renaissance emerged out from the realm of builders and fell under the purveyance of scholars, then the new types of design "had to be explained, down to the minutest detail."[130] Thus the techniques and conventions that had developed for architectural drawing had to be reworked. These changing priorities united with the different training that the Humanist architect received, created both the representational problem and the means to solve it. From these forces triadic form emerges as the new conceptive medium for architecture.

Thus the picture of the Rise of Drawing is one in which there is a convergence of two parallel tracks of knowledge. On one side is the track of the masons whose experimental knowledge produces graphic techniques for geometry. On the other is the track of the scholars who have a generalized knowledge of theoretical mathematics and geometry. For the Humanists the rejection of the tactile and haptic knowledge of building

[129] Guillerme and Verin, "The Archaeology of Section," 240.
[130] Reginald Blomfield, *Architectural Drawing and Draughtsmen* (London: Cassell & Company, Ltd., 1912), 17.

frees them to unite the graphic and theoretical forms of thinking. In the Humanist period these tracks merge creating a single person with both forms of knowledge, but who leaves the handiwork of building behind.

CHAPTER THREE

THE RISE OF FORM

Techniques, Ontologies and Design

In the previous chapter I looked to three historic architectural images in order to understand drawing's changing role within design. My explorations were centered on the Milan Cathedral Plan and Section, Strasbourg Plan A, and the Pantheon interior drawing: three drawings which spanned in time from the mid-thirteenth through the beginning of the sixteenth centuries. Although this extended time frame limited the degree to which I could explore any single drawing or moment, its expanse has allowed me to draw some distinctions about drawing's technical development and adoption that have not previously been made. Therefore, in this chapter, I will attempt to make some bolder links: connections that may work to reconcile the conflicts between the earlier attempts to narrate the history of architectural drawing.

To these ends, this chapter will explore the history of drawing's technical advancement alongside the cultural shifts that catalyzed drawing's role finally resulting in the profession of design and the role of the architect. These developments are, in fact, all correlative. For although drawing's role within the practice of architectural design was fundamentally changed during the Renaissance, the drawing techniques that were used

were, in fact, largely continuous with those of the mid to late-thirteenth century.[131] In other words, it was not so much a lack of technical understanding as it was a missing cultural will that prevented drawing's expansion during the Medieval period. A meaningful place was not found for drawing within the building process until design became an act separate from it.

Although the fifteenth and sixteenth centuries did make technical contributions in the form of the systematization of drawing, that is to say they united the drawing forms of the preceding centuries into a system of combined orthographic projection, the thirteenth century provided many of the core techniques. That period originated the elevation and section, provided the first consistently scaled version of architectural drawings, produced refinements such as the alignment of plan and elevation, and offered a workable solution to the "problem" of depicting of oblique planes. To this extent, then, authors like Christophe Frommel who write that elements of orthographic projection had been "perfected" during the Medieval rather than Renaissance periods, were correct in their assertions.[132] But with the exception of those instances where drawing played an

[131] My own understanding of this period is most closely allied with that of Wolfgang Lefevre. He writes that: "On the other hand, the modern techniques of constructing plans were actually invented—albeit rarely employed—in just this period [the thirteenth century]. This chapter, therefore, has two goals. It tries to show that Renaissance (and Gothic) plan construction was not based on a technique that is essential for present-day plan construction, namely the combined views technique. Furthermore, it tries to show that this technique was invented at the turn of the fifteenth century and introduced to architecture by Antonio da Sangallo the Younger and Albrecht Dürer in the second decade of the sixteenth century, and that it took the entire sixteenth century before it became a standard technique in architecture." Lefèvre, *Picturing Machines 1400-1700*, 210.

[132] According to Frommel, "Architectural drawing is as ancient as monumental architecture. But only in the course of Antiquity did the methodology known to us from Vitruvius's treatise come to maturity. The practice of making not only ground plans—as documented, for example, by the Carolingian plan for St. Gall—but also elevations and sections, could not have been completely lost during the time prior to the beginning of the Gothic. Villard de Honnecourt's builders' lodge book presents the broad spectrum of possibilities in drawing during the early thirteenth century, which included the complementary representation of interior and exterior walls. Thus it is not very credible to argue, as has repeatedly been done, that Gothic builders has largely dispensed with the aid of drawing. After the artistic means for representing spatial depth had mostly been forgotten, Gothic architects perfected above all purely orthogonal, geometrically constructed methods of designing." Frommel and Adams, eds., *The*

indispensable role, as was the case with vault projection in which graphic techniques were used to resolve precise stereotomic problems, drawing's role within the Gothic tradition drawing never became central to building.[133]

To find this sea change we must move forward, retreating from Gothic processes and crossing into the emerging Renaissance design tradition. While the previous chapter touches on that moment when triadic form became conventionalized, my analysis of Raphael's drawing of the Pantheon documents the point at which conditions tipped towards it. Uffizi 164 A.r. set the epistemological stage for the acceptance of orthographic drawing, and it can be no coincidence that as Raphael's assistant and youngest colleague at Saint Peter's, Antonio da Sangallo the Younger, is often credited with the first consistent use of combined orthographic projection.[134] It is clear, however, that it was Raphael whose work validated orthographic drawing as architecture's new heuristic, clearing the way for the acceptance of Sangallo's drawings.[135] To this extent, then, authors like Robin Evans are also correct when they insisted that orthographic drawing was not actualized within design until the sixteenth century.[136] Yet both authors

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Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture, 6.

[133] For further information on techniques like vault projection please see Bucher, "Medieval Architectural Design Methods, 800-1560.", and Branner, "Villard De Honnecourt, Archimedes, and Chartres."

[134] As Frommel has convincingly argued, "The body of extant drawings suggests that Antonio da Sangallo the Younger, Raphael's youngest colleague at St. Peter's, was the first to make consistent use of the correct orthogonal projection when representing an interior by means of a section….Sangallo, the craftsman, must have recognized [orthogonal projection's] advantages of grater clarity and readability. He must have welcomed it also as a final solution to the problem of representing an interior by means of a drawing and therefore adhered to it consistently…In my opinion it is most probable that Sangallo, as Raphael's assistant, cooperated in developing the orthogonal projection." Frommel and Adams, eds., *The Architectural Drawings of Antonio Da Sangallo the Younger and His Circle: Fortifications, Machines, and Festival Architecture*, 31.

[135] This lineage is also acknowledge by Wolfgang Lotz asserted "Antonio da Sangallo may be considered to have developed the genre of the architect's drawings in the narrower sense as defined by Raphael's letter." Lotz, *Studies in Italian Renaissance Architecture*, 32.

[136] Robin Evans, "Architectural Projection," in *Architecture and Its Image: Four Centuries of Architectural Representation.*, ed. Eve Blau and Edward Kaufman (Cambridge, MA: MIT Press, 1989), 25.

are also wrong, because they did not pay sufficient attention to the intertwined and dependent nature of these two trajectories. Alone, neither moment could fully actualize a mode of design rooted in drawing. Therefore, in my attempt to reorient our perspective of drawing's rise within architecture, I will take both moments into account.

The drawings I have examined layout an entwined and sometimes conflicted path of technical innovation and practical upheaval which defines the rise of drawing and the making of its reign over architecture.[137] In other words, to deal with this history, it is necessary to contend with both the technological and ontological trajectories of drawing's development, both the evolution of drawing techniques and the related but separate advancement of its place within design. Along this complex journey the architect, as we understand the role today, comes into being, thus inextricably tying the definition of architecture to drawing. This chapter will attempt to tell this chronologically and thematically layered story. At the end of the chapter I will also discuss the role of Classicism, or how the goal of an architecture *all'antica* worked to bridge and resolve many of the contradictions and difficulties involved in moving from a tradition of architectural design based on building to one based on drawing.

One clarifying note: while it may be possible to develop a strong history which accounts for each technical and cultural advancement leading to drawing's current use, such an investigation is beyond the scope of this chapter and this dissertation. Instead, my

[137] Mario Carpo writes of a similar ambiguous causality during this period, as the changes seen in architectural form also lack the accompanying changes in materiality or construction technique that are often associated with moments of fundamental shift. "Allowing for slight variations according to chronology and location, in the period falling between the end of the Middle Ages and the beginning of the Renaissance, the architectural forms being built throughout Europe changed in a sudden and radical way—but without any corresponding change in either materials or construction procedures." Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography and Printed Images in the History of Architectural Theory*, 5. My similar assertion is that alongside the changes in architectural form are changes within design procedure, and these changes occur, notwithstanding a great degree of continuity in representational technique.

goal will be to shade in our understanding of certain developments and conditions that were key to drawing's adoption as design's conceptual medium. To a great extent, my work is synthetic. Both technical and epistemological aspects exert a distinctive influence on drawing and imprint their pattern on many of the later aesthetic explorations possible within architecture. I will attempt to pull these aspects together, making their influence visible. Such a picture of history is helpful because the issues I will discuss continue to structure and circumscribe the legacy of drawing throughout its five hundred year reign. In sum, this section is an attempt to unpack the ways in which our use of and thinking about drawing are never fully independent but are always developments on and reflections of these early points of origination for our techniques and our profession.

Gothic Moments of Origination

From our contemporary perspective in which drawing is prefigurative, which is to say that it is viewed as part of design and thought to occur before and in order to direct construction, the idea of drawing as construction probably seems illogical. And yet, this is exactly the role that drawing held for hundreds of years within the masonic tradition. Drawing, or perhaps it is more precise to say graphic geometric operations, were used to solve the stereotomic problems that arose during the process of building. Robert Branner argued for this kind of operative drawing in his analysis of the Archimedes spiral discovered at Chartres.[138] In this particular case, drawing was used to determine the proper form of an arch's keystone by graphically calculating the correct radii. In other words, drawing was brought to bear on an operation where an exact pre-figured form was necessary for construction. While these operative uses can be called pre-figurative, in that

[138] Branner, "Villard De Honnecourt, Archimedes, and Chartres."

they were determining the solution of a problem in advance of its execution, the solution they provided immediately preceded its execution. In other words, drawing only pre-figured architecture on a micro-level and its role was always part and parcel to the act of building. There was no intellectual distance between drawing and constructing.

Effectively within this role, drawing was not used in the same manner as it is today. Defined within a constructive rather than prefigurative process, drawing was not the generator of a holistic, governing image for the building. Instead, construction was carried out with a much more vague sense of what a building would eventually become. It seems tremendously foreign to our sensibilities that it would be possible to construct without a thoroughly understood concept of a building's shape, and yet this is exactly what occurred within most, if not all, pre-Renaissance contexts. Full-scale templates directed the shape of molding profiles, and by recording the paths of these templates, full-scale *épures* traced the deployment of such curves and moldings for minor formal compositions as in the case of window or wall traceries. In most other cases, however, design was guided by typology, and prefigurement was limited to the footprint of the building. The foundations were laid and construction continued upward following their form. Essentially, drawing was only used for the full-scale communication of design specifics, and these specifics formed only a small picture, a portion of the total building form. For other aspects of building, other forms of ideation and communication existed, and construction could proceed with only a general notion of what a building's final form might be.[139] As Alberto Perez-Gomez has argued, within the Gothic tradition building

[139] What was necessary for building was a sense of its footprint, although this was often highly influenced by previous constructions on the site. This footprint was laid out full-scale on site in order to direct the construction of foundations. In this sense, although the footprint or building plan was designed in much the same sense as we understand the term today, pre-figuration ended at with this very concrete act that

progressed by "rhetoric and geometry raising the elevation from a footprint, while discussions concerning the unknown final figure of the building's face continued almost until the end."[140] In this conservative, typologically based environment where the limited needs for pre-figurement could be fulfilled by reference to prior buildings, design could unfold without much recourse to drawing. As a result, drawing use was restricted to those situations when a visual model was necessary and only for those aspects of building that escaped sufficient encoding through other means.

This point holds interpretive insight because it highlights the opposing nature of the forces under which drawing's use has evolved. Drawing emerged within architecture as a formal tool, a technique that could step in where other modes of communication failed, and yet the need for such a tool was very limited. Only certain moments within the process of construction, and generally only small areas of the building, required that form be made explicit in advance of construction. As a result, the particular graphic techniques that were developed to solve this small and specific problem were equally precise. They were excellent means to determine and transmit form, and they could do so above and even to the exclusion of other properties because drawing held such a limited role. The degree to which Gothic architecture was concerned with this formal task was reflected by the limited use of drawing throughout the period. Even as the technical achievements of drawing expanded, as was the case with the appearance of scalar drawing which allowed

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functioned directly to coordinate construction. This practice, however, provides an interesting inflection for Le Corbusier's famous claims about the plan: "The plan is the generator….The whole structure rises from its base and is developed in accordance with a rule which is written on the ground in plan…The plan is what determines everything; it is the decisive moment." Le Corbusier goes on to insist on the abstract nature of the plan, however Gothic practices are both more concrete and more adherent to Le Corbusier's definition. Le Corbusier, *Towards a New Architecture*, trans. Frederick Etchells (New York: Dover Publications, Inc., 1986), 47-48.

[140] Alberto Perez-Gomez, "The Revelation of Order," in *This Is Not Architecture*, ed. Kester Rattenbury (London: Routledge, 2002), 15.

the imaging of entire building façades, the deployment of these drawings remained limited.

The Strasbourg Drawing, Part II

For example, by returning to Strasbourg Plan A from the previous chapter we can evaluate these limits. [See Figure 14]. Although with the help of Lefèvre's argument, a reasonable case can be made that this drawing served the patron more than it did the mason, it is also possible to read a certain resistance on the part of the masons to graphically stabilize the building's form.[141] Although the building is given an overall shape (it is a three-aisled church façade with a tripartite elevation and western rose-window), this degree of formal definition expounds little upon that dictated by a general sense of the typological form. Further, even as the drawing gestures towards a specific solution for the façade, there is little about this drawing that we can find in the final elevation at Strasbourg.[142] The proportions the drawing expresses (specifically those for the nave and aisle) are not specific to Strasbourg, and while the extensive detailing gives the impression of a solution to made to fit the precise problem presented there, a closer inspection brings even these intentions under suspicion as well.[143]

For example, a reader may notice that the detailed areas presented in Strasbourg Plan A are all highly repetitious. This point is interesting since it starts to speak to the power of drawn pre-figuration to outstrip building. Unlike the slower and more laborious process of building where, for example, tracery forms might drift from one bay to another

[141] Of reduced scale plans like Strasbourg, Lefèvre writes, "But even if one regards some or all of them as working drawings, it has the appearance that their use was not widespread, probably above all because the craftsman were not trained to use them." Lefèvre, *Picturing Machines 1400-1700*, 224.
[142] Bork, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," 442
[143] Bork, "Plan B and the Geometry of Facade Design at Strasbourg Cathedral, 1250-1350," 460-465.

over the extended period of construction, drawing allowed for the evaluation of consistently conceived and executed design gesture. Using drawing, the effect of certain regulating lines or the repetition of a particular piece of tracery repeated across a facade could be more immediately accessed. And yet, in Strasbourg Plan A, there is a certain sophism with which this tracery is marched over the façade. The triforium tracery, for example, is ambiguous about which aspects of the building it should align to. Rather than beginning at the pier buttresses which divide the aisles and the nave portions of the façade, these arcades are slightly offset. To make up the gap, inverted trefoils are inserted, and sometimes seemingly squeezed into place against the wall, thus allowing the arcades to appear uncropped by the pinnacles which rise alongside the buttresses. It is highly unlikely that this was the as-built intention. Gothic arcades were generally sized so that a whole number of arches always fit into the opening. Starting an arcade half-way through an arch would be highly irregular. Drawn as it is in the Strasbourg façade, the tracery acquires the same sense of being filler as when slide translation was used on the oblique planes in the Strasbourg Tower drawing. [See Figure 16]. In essence, Strasbourg Plan A demonstrates a conceit between those areas that appear to have been designed and those that remain empty. While we assume the detailed areas encoded specific instructions about what is to be constructed in those areas, much less seems to actually be conveyed. In sum, the appearance of the completed design is a fiction, not only because it wasn't built in this manner, but because this drawing was never intended to instruct or prefigure what would be built.

Again, this statement will likely strike a reader as nonsense. What other purpose could the drawing serve? Indeed, the drawing seems to be caught grappling with just such

a question. How does a drawing technique designed to inform specific and limited areas of construction grow in its purpose to encompass the prefigurement of the entire building, particularly when, as I will discuss shortly, such a goal is at odds with both the practice and nature of construction? The answer to this question seems to be that drawing's role grows very slowly and in idiosyncratic ways. Drawings growth is not only restricted by its use and purpose within construction, but by other factors as well.

In terms of perceptual logic, Mario Carpo argues compellingly about the inherent disconnect between the unfolding process of construction and pictorial perception: the former occurring linearly and the latter occurring synchronically.[144] In other words, a fundamental disjuncture exists between the process by which construction was traditionally understood and the process by which information is presented in a drawing. Basing his argument on Renaissance treatises Carpo argues that, originally, the orders were understood in terms of their process of generation: each part formed by an action taken on a previous part, each unit nested into the other. This process-based understanding is at odds with the one created by an image where the parts and their proportions are understood numerically and in relation to the whole. These two competing ways of perceiving an order forces a slow transition to occur between the one way of conceiving and seeing the orders to another. Carpo's argument extends, as well, to the earlier contemplations of drawing's function during in the Medieval period. Here, too, we confront a linear understanding, this time within the generation of built form. Within the Gothic tradition, the building was understood in terms of its construction

[144] Here, Carpo's argument parallels that of Michael Baxandall in his book Michael Baxandall, *Patterns of Intention: On the Historical Explanation of Pictures* (New Haven, CT: Yale University Press, 1986). Baxandall's discussion about the experiential differences between looking at and writing about pictures is particularly sympathetic to Carpo's argument.

sequences, not as totalities which had been formally prefigured. Understanding the building in terms of its construction processes is so effective within the Gothic tradition that, as I argued in the last chapter in the case of the depiction of oblique surfaces, it replaces nearly all need for formal determinism. It is easy to conjecture that within such a system drawing couldn't be fully conceived as a set of instructions for building because the formal emphasis and the simultaneity of drawing's presentation of design were at odds with the nested, process-based understanding of Gothic construction.[145]

Where drawing was used in the Gothic period, it was limited to small, discrete areas. This mode of deployment minimized the differences between drawing and oral instruction as a means of direction, but scalar drawing presented a wholly different kind of envisioning: a degree of prefigurement that lay outside an understanding of building as a process that unfolds. Instead, scalar drawing existed, ontologically speaking, alongside existing buildings, as something complete and to be taken in as a relatively simultaneous experience. Such impressions were simply at odds with construction which unfolds part by part.

In sum, the purpose of Strasbourg Plan A, and also much of Gothic drawing in general, is intensely unclear. While we think of it as the presentation of a design, it doesn't seem to imply the same kind of direction that we believe such a drawing would encode. Perceptually, it is not the equivalent to a multitude of *épures* assembled together and scaled down. Even if we assume the drawing functioned in this manner, the contradictions between how Strasbourg Plan A presents tracery and how this tracery would actually be built, demand that we reassess our assumptions. And yet, it is

[145] Mario Carpo, "Drawing with Numbers: Geometry and Numeracy in Early Modern Architectural Design," *The Journal for the Society of Architectural Historians* 62, no. 4 (2003).

tantalizing to note that those areas that have been detailed on the drawing are the very same areas that would have been constructed with the aid of an *épure*. In other words, these areas are portions of the façade that, historically, seemed to have concerned the masons on a formal level, even before the advent of scalar drawing. A link certainly exists between scalar drawing and the épure within the Gothic tradition, but it is not the link we expect, nor one that is easily definable. Were the tracery areas of Strasbourg Plan A explored with an épure, an assumption of their role in construction could be made, but perplexingly little constructive meaning is conveyed in these areas of the drawing.[146] Instead, there is the appearance of formal meaning without any relationship to the practice of constructing these areas.

Imitative Changes

In other words, although formal determinism was absolutely necessary for solving issues of construction during the Gothic period, it was less a concern when it came to imagining what a building would become. Instead, this form of imagining was based on orality and typological imitation.[147] Here, too, we run into an important conceptual difference—this time, in the understanding of imitation. While to us imitation is often judged on the basis of formal similarities, for instance an object imitates another when it looks like the original object, during the middle ages the idea of imitation extended beyond form. As Richard Krautheimer argues in his "Introduction to an 'Iconography on

[146] Interestingly, the areas where detail appears are all such that an épure might have been used to pre-coordinate their construction, areas that a mason may have been comfortable thinking about as a formal problem to be solved graphically, and yet the detail in these areas does not seem to encode the same type of information an épure would.
[147] Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography and Printed Images in the History of Architectural Theory*.

Medieval Architecture,'" an imitation could rely on other *tertium comparationis*.[148] In particular, Krautheimer concludes that symbolic content was more important than visual form as a basis of imitation.

> The difference between such an attitude and a modern approach to architecture is obvious. From Early Christian times and throughout the Middle Ages descriptions, depictions or architectural copies are ...limited to a selected number of outstanding elements; their selection is determined by and their visual aspect subordinated to the hierarchic order of their religious importance. This attitude seems to change gradually after the beginning of the 13th century. Since then...copies, depictions and descriptions strive more and more towards giving a reproduction of the original in its visible aspects....At the same time, however, a gradual process of draining the edifice of its 'content' seems to begin....[by the 19th c.] Architectural patterns are then used regardless of their original significance.[149]

With this paragraph, Krautheimer is filling in with the broadest of stokes some of the transitions that will occur within architecture over the next few centuries. Two of his points are particularly important for my thinking about drawing, however. First, he reinforces the idea that during the Middle Ages the visual aspects of architecture, which is to say its formal aspects, were not prioritized. Second, he suggests that, instead, objects were understood and characterized on the basis of a few key elements that were imbued with potent symbolic content. When imitating another building, the replication of these elements invoked their symbolism and stood in place of an imitation of their visual aspects. For example, Krautheimer argues that, "to Petrarch…it mattered little whether or not a site was commemorated by a monument, or merely haunted by memories. His approach was entirely literary, almost emphatically non-visual."[150] In essence,

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[148] Krautheimer, "Introduction to an 'Iconography of Mediaeval Architecture'," 3.
[149] Ibid.: 20.
[150] Richard Krautheimer and Trude Krautheimer-Hess, *Lorenzo Ghiberti* (Princeton, NJ: Princeton University Press, 1970), 294. Also Mario Carpo, "How Do You Imitate a Building That You Have Never

Krautheimer is thinking about a different aesthetic basis for imitation. Rather than a formally based compositional code governing such things as proportion (as we find during the Renaissance), Gothic architecture was governed by an aesthetic of symbolic or religious content. At times, this aesthetic had formal implications, as in the case of the church crossing. What is really encoded here, however, is a certain symbolic relationship between objects, not the form that these objects might take. This is why, according to Krautheimer, multiple cross forms all invoke the same general meaning, be it a Latin Cross, T-cross or Greek Cross.[151]

And yet, the Gothic reliance on symbolism does not end here, nor does it stop with the building itself. In many ways we can better understand the Gothic act of design if we view it as part of the symbolic process, rather than seeing it from our more contemporary perspective, as the coordination of the building's symbolism. This interpretation helps to make sense of the Gothic conception of design as an unfolding or emergent process rather than a pre-figured one. If design itself was a symbolic act, its processes and outcomes were not fully governed by the designer. Instead, they emerged from what might be thought of as a pseudo-ritualistic code of conduct. There are many texts, both primary and secondary, that support this interpretation of Gothic design, but perhaps Perez-Gomez is the most direct when he says that, "[the] master mason was responsible for participating in the act of construction, in the actualization of the city of God on earth. Only the Architect of the Universe, however, was deemed responsible for the conclusion of the work at the end of time."[152] In this sense the master mason's role

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Seen? Printed Images, Ancient Models, and Handmade Drawings in Renaissance Architectural Theory," *Zeitscrift Kunstgeschichte* 64 (2001): note 6.

[151] Krautheimer, "Introduction to an 'Iconography of Mediaeval Architecture'," 8.

[152] Perez-Gomez, "The Revelation of Order," 6.

was understood as passive. He operated as a kind of vessel or means of transcribing God's vision. In other words, the act of design was not a human endeavor but, instead, a divine one.

This view of the relationship between humans and God was, of course, applicable to a wide range of human endeavors, not just building, extending even to the very conception of self during the Medieval period. Robert Branner wrote that, "[medieval] man considered himself but an imperfect 'refraction' of the Divine Light of God".[153] As typology served as a conservative model for architecture, this conception of self also served to support the socio-political status quo. Like buildings, people were understood as types fulfilling roles or forms given to them by God. As such, it is unsurprising that a transformation of the standing roles and hierarchies was met with great resistance. One instance of this resistance in an architectural environment can be found in the famous sermon of Nicolas de Biard. De Biard derided masters masons for their upward aspirations and their growing cultural stature writing, that the "master masons, with rod and glove in hand, say to the others, 'Cut it for me here,' and do none of the work themselves, although they receive the greater pay."[154] In sum, during the Middle Ages one did not design or *fashion*, to employ one of Stephen Greenblatt's terms, oneself to a personal or idiosyncratic vision, but instead performed the duties of one's type. As de Biard demonstrates, attempts to expand one's own place were seen to be violations of the vision God laid out for you.[155] "Hands off yourself," Augustine declared. "Try to build up

[153] Robert Branner, *Gothic Architecture*, The Great Ages of World Architecture (New York,: G. Braziller, 1961), 10.
[154] Frisch, *Gothic Art 1140-C.1450: Sources and Documents*, 55.
[155] Stephen Greenblatt, *Renaissance Self-Fashioning: From More to Shakespeare* (Chicago: Chicago University Press, 1980). Robert Scheller writes that basis for this thinking is to be found in, "the first chapter of Genesis which states that God created man in his own image and likeness ('imago et similitudo'). This immediately raises the question of the extent to which man is a 'copy' of God". Robert W. Scheller,

yourself, and you build a ruin."[156] If the development of oneself can be viewed as the primary creative act and the basis for all further creativity, here is a model of creativity that is divested of any personal expression, rooted instead in the transcription of a divine design.

An avenue of this thinking that is, perhaps, more clearly applicable to the design process can be found from the late twelfth century, in a well-known story of a Irish scribe's attempts to illuminate a gospel book. The scribe of this story dreams of an angel who shows him a design for the frontispiece for the manuscript. When the scribe says that he lacks the talent, the angel tells him to pray to God with the help of St. Brigid of Kildare so that "God will guide his hand and help him draw correctly ('*ad recte protrahendum manus dirigat*')."[157] In the end, this process brings the book a successful conclusion. "And so, with the angel indicating the design, Brigid praying, and the scribe imitating, that book was composed."[158] Here again we see the creative act defined as transcription. Creativity belongs to the Godly realm (*Deus artifex*) not the human one.[159]

The effect of this conception of creativity or design was to remove nearly all needs for prefigurement. Masons were guided by traditional and sacred rules which dictated a series of unfolding proportions for the building. Practically speaking, these rules ensured stability, but the reliance on them also shifted creative concerns towards process. This process was inculcated with a mysticism and allowed the masons to divest themselves (at least psychologically) of much of the responsibility for the building's

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Exemplum: Model-Book Drawings and the Practice of Artistic Transmission in the Middle Ages (Ca. 900-Ca. 1470), trans. Michael Hoyle (Amsterdam: Amsterdam University Press, 1995), 12.
[156] Peter Brown, *Religion and Society in the Age of Saint Augustine* (London: Faber and Faber, 1972), 30 Augustine, Sermon 169.
[157] Scheller, *Exemplum: Model-Book Drawings and the Practice of Artistic Transmission in the Middle Ages (Ca. 900-Ca. 1470)*, 11.
[158] Ibid.
[159] Ibid., 16.

vision. As a result, the act of construction could proceed with only a minimal sense of what the building's final form would be. Instead, the process itself was prefigured, governed by ritual.

Within this ritualized process of design, it is unsurprising that the form of expression allowed by scalar drawing, and the changes it presented to the process of design, were untenable. Scalar drawing allowed the construction of entire buildings from the micro to the macro scale to be directed by a single vision. It made a place for the single artist to impose his will over all the details of the building. In sum, scalar drawing allowed one individual to appropriate control over much of the building's form, where previously this control had been held by many, with God alone directing the final composition. Although drawing had developed to solve a formal problem, within the Gothic process the extents of this formal problem were limited to very specific constructive solutions. A larger role for drawing was out of place both because within the ritualized design form was not prioritized, but also because the act of prefiguring formal solutions lay outside of the ritualized process. It belonged in the hands of God, not the hands of humans. The very things that drawing empowered, the things we assume define architecture today, were secondary within a definition of the profession which valued imitative symbolism and the transmission of God's message as the act of creation. As Panofsky concludes in his study of Scholastic aesthetics, "the aesthetic views of medieval Scholasticism are no more than auxiliary constructions for theological trains of thought."[160]

From the sum of these contemplations, a picture of drawing's origins emerges in

[160] Erwin Panofsky, *Idea: A Concept in Art Theory*, trans. J.S. Peake (Columbia, SC: University of South Carolina Press, 1968), 40.

which its deployment, though technically quite possible, was restrained by at least four layers of ontology. Drawing's role remains confined because, first, the constructive process was fully-functional without the use of prefigurative drawings; second, because the linear manner in which construction and its processes were understood opposed the perceptual process of a picture; third, because the reliance on symbolic rather than formal aesthetics marginalized what drawing conveyed; and fourth, because their understanding of design placed the responsibility for its vision in the Divine realm. By the close of the thirteenth century, a variety of drawings exist to suggest that, at least in their ur-form, nearly all the techniques in use today including plan, section, elevation and the pairing of interior and exterior views were in place. And yet, the use of these drawing techniques does not appear to truly expand until the fifteenth and sixteenth centuries. Although we see the usefulness of these various drawing techniques and their essentiality to design, the Gothic form of design and understanding of creativity differed from our own to such an extent as to render a larger purpose for drawing unnecessary, or at the very least, indeterminate.

Understanding drawing's limited use at its point of origin is paramount because the circumscribed nature of its early use refined and distilled the qualities of architecture to which drawing could speak. This refinement is both drawing's power and its limitation. Drawing evolved as an operative procedure clearly tuned to the problem of communicating shape, but this shape-problem belonged fully to the process of construction. As a result, the potential of the drawing techniques that emerged was always tied to their ability to instruct building. This visceral and physical connection fully synchronized the logic of drawing with the logic of construction. In other words, the

conditions that fashioned Gothic drawing into such a powerful tool for conveying formal intent to those who would build were the same conditions that limited drawing's role. These origins invest drawing during the Gothic period with an exquisite ability to communicate issues of form in a way particularly adapted to form-centric design, yet as I have just discussed, the ontological environment which produces this mode of drawing has little need for the potential it promises.

Herein lies one of the contradictions of Gothic drawing. Within the rich and fully-functional traditions of Gothic masonry, a (the most?) powerful drawing technique known to architecture was developed, but the same conditions which tailored drawing's efficacy limited its deployment. It would a take the theoretical understanding of orthography, and a transformation of the definition and aesthetic basis for design for drawing to subsume its larger role. Instead, the rather stringent practice from which Gothic drawing emerged produced a mode of visualization that was only *essentially* orthographic. The properties such a system implied were not understood on a theoretical level, but through the physical projection of templates and a direct connection between the linear and built gesture. And yet, had this other, more intellectual understanding existed, the pull to express other graphic priorities would likely have changed drawing's development, creating a tool not so well suited to direct construction from afar. Instead, because drawing was understood and used as a means to direct and coordinate the efforts of multiple workers, Gothic drawing techniques were extremely well suited as a tool for Renaissance artists to when they needed to convey their new form-based *all'antica* designs to builders. Gothic drawing's point of origin makes it the ideal tool to direct

construction. Because it emerged from construction, it paradoxically allows the process of design to become separate from construction.

Drawing's position would eventually expand to encompass the very ideation of architecture, but because little pressure was placed on to what drawing could express until the fifteenth century, initially the limited architectural qualities it captured did not present a problem. Gothic drawing techniques were the quintessential tools for thinking about and communicating formal composition, but adopting these techniques exclusively meant compromising or even sacrificing other types of expression that drawing could achieve. This is, perhaps, another reason why the Renaissance architects were so slow in following Alberti's advice to avoid perspective, and why even though Raphael was the first to call for the exclusive use of plan, section and elevation to document architecture, it was not until his pupil Antonio da Sangallo the Younger that this dictum would be adhered to within architectural design. The very reason Gothic drawing techniques were used (because they captured and could precisely transmit form for constructive purposes) meant that their adoption restricted the architectural qualities they could contemplate to aspects of form.

As a result of the eventual adoption of triadic form, formal fidelity, that is a drawing's ability to faithfully and unambiguously transmit shape, became architectural drawing's essential trait. By extension, form also became the primary trait for architectural contemplation, the new basis of an architectural aesthetic. These two developments are locked together because the double connection between building and drawing, and between drawing and form, established the foundation of drawing's rise in design. Drawing's power is rooted in its ties and equivalencies to construction. When

drawing, specifically when orthographic projection, is adapted to its new uses in the Renaissance, its ability to contemplate and direct form is extended while those features of architecture that lie outside of drawing's purview are defined as something outside the art and contemplation of design.

Renaissance Moments of Expansion

I have already gestured towards the Renaissance changes that allow drawing's role to expand; however, my explanation of these developments needs to be extended. In essence, the Renaissance contributed changes to both the technical and ontological understanding of drawing, eventually allowing its use to be transformed. With this transformation came a changed the understanding of the creative act, a changed process of construction, and the development of the architect's role.

On the technological front, the fifteenth and sixteenth centuries contributed a theoretical understanding of the plan, section and elevation and their interrelationships that fused the drawings into the unified system we understand today as orthography. Of course, these centuries brought with them not only this understanding, but a surging interest in and practice of all projective systems of representation, including perspective, orthography and cartography. Interestingly, these three systems, though easily placed in separate categories today, seem to have been less distinct during the Renaissance. This contention has been thoroughly discussed by recent scholars for both cartography and perspective. Authors like Hubert Damisch, James Elkins and Svetlana Alpers, among others, have demonstrated how in the picturing of various places, representational structures were often combined and multiplied within Renaissance art and the art that

followed. It is rare to find an image executed in that single, coherent, rationalized spatial system that we assume projective systems inculcate.

And yet, this lack of lucid or instrumentalized execution does not mean that the artists were ignorant of the underlying projective theories. It is more accurate to say that the Renaissance practitioner was simply less likely to insist on a single system to govern an entire picture. I argued a similar point in Chapter Two with my discussion of Uffizi 164 A.r. Indeed, expanding on what seemed immediately visible in that drawing, I would argue that the representational goals an artist had for a picture, by which I mean the aspects of the object or space the artist was attempting to portray, were the primary driving force in a picture's creation and different techniques of representation would be combined as needed to facilitate this goal. The goal of the image rather than a consistent structure held sway.[161] In the case of Uffizi 164 A.r. perspective and orthographic systems were fully imbricated in an attempt to capture the Pantheon's centralized space, but as Raphael demonstrated, this process required extensive graphic compromise. Raphael's image achieves neither Alberti's goal of formal fidelity nor the visual fidelity of perspective. It is also possible to argue, however, that Raphael didn't stop with these two systems. In fact he may have been taking cues from another projective system as to how perspective and orthography might be combined. This other system was, of course, cartography.

[161] Which is not to say that a picture cannot contemplate pictorial structure as its subject, but that such instrumentalized explorations may have been limited in number.

The Pantheon Drawing, Part II

As I discussed in Chapter Two, the main representational problem in the case of the Pantheon was the depiction of round or spherical objects so that equivalent objects remained equally commensurable in the image. This challenge was not a subject contemplated by architecture, alone. As a result of the rediscovery, translation and printing of Ptolemy's *Geographia*, it was a subject also pondered by cosmographers, cartographers and choreographers (again, allowing that these distinctions were less than apparent during the early years of the sixteenth century).[162] Just as the Pantheon problematized the projection of a sphere onto paper, so mathematical geography required the globe to be similarly flattened onto a surface. Raphael's strikingly flat drawing of the Pantheon seems to be informed by these contemplations of the globe. Although specific parallels might be drawn to several of these early global pictures, even this early image from Nicolo Todescho's 1482 version of *Geographia* begins to suggest the kinds of conceptual structures Raphael may have had in mind in his projection of the Pantheon. [Figure 29].

Perez-Gomez describes the form of Ptolemy's global projection, writing "Ptolemy's map itself is not a circle as would be formed by a section through the globe, not an ellipse as argued later by Edgerton, but an elongated and curved stretch of land—

[162] In her text on early cartography in England, Lesley Cormack writes, "Ptolemy's *Geographia* was not included in the Ptolemaic *opera* introduced into the West in the twelfth century. It was only rediscovered in the West ca. 1406, when it was translated into Latin by Jacobus Angelus in Florence. In addition to numerous manuscript copies, it appeared in six printed editions in the fifteenth century: Bologna 1462 (1482?); Vicenza, 1475; Rome 1478; Ulm, 1482; Ulm, 1486; and Rome, 1490. It appeared in numerous editions in the sixteenth century in both folio and quarto; twenty in Latin, six in Italian and two in Greek." Lesley B. Cormack, "'Good Fences Make Good Neighbors': Geography as Self-Definition in Early Modern England," *Isis* 82, no. 4 (1991): note 17.

the *oikumene*—whose center of curvature lies at the north pole."[163] This account, and particularly that portion that describes the image as an elongated and curved stretch of land, could apply equally well to Raphael's depiction of the Pantheon. Both drawings demonstrate considerable flattening of their curvatures on the macro-level in order to more accurately portray the relative sizes and shapes of the objects within their projective frameworks. One need only imagine the interior of Pantheon as the interior of a globe or as the celestial sphere, not a large ontological leap given the sensibilities of the sixteenth century, and even the curvature of the world map would then correspond to Raphael's image of the Pantheon, in particular Raphael's treatment of the upper portions of the building.[164]

Further, other images exist to amplify this intellectual reliance on cartography. This image [Figure 30] taken from one of the sixteenth century's illustrated versions of Vitruvius, the *Vitruvio ferrarese*, seems to pull the tensions we have seen in Raphael's (and Vischer's) drawing into projective clarity. In this drawing we find an image of a Pantheon-like building with its interior surface fully unrolled, the missing link connecting the thinking behind Vischer's drawing to images like Raphael's. Unlike Vischer's drawing which omitted the dome due to projective difficulties, in the *Vitruvio Ferrarese* drawing, the dome is projected, broken into a recognizable, cartographically-influenced interrupted surface of four lobes, or gores. This projective technique of using interrupted surfaces for cartographic images is known to have been used as early as 1507 by

[163] Alberto Perez-Gomez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, Mass.: MIT Press, 1997), 95.
[164] Although it changes the status of what we assume was Villard's knowledge of geometry, and according to Cormack, it would have been impossible for such knowledge to be available in the west, it is difficult not to see similarities between the projection methods in *Geographia* and Villard's visually ambiguous spatial contrivance for the Reims chapel drawings. Those structural features that cause the curves of Villard's drawing to create an equivocating spatial illusion, first projecting inward and then outward from the drawing's top to bottom, seem consistent with the application of Ptolemaic projection.

Waldseemüller and 1514 by Da Vinci. [Figure 31]. However, the *Vitruvio ferrarese* image, unlike that of Waldseemüller, does not reconstruct into a sphere or hemisphere. Further, the projection used for the coffers in the *Vitruvio ferrarese* image is not cartographic, but perspectival. It is interesting that Carlo Sgarbi suggests this version of Vitruvius may have been illustrated by an artist from Raphael's circle, since like Raphael's drawing, this image strikes a compromise between Alberti's requirement to convey true shapes and the desire to schematize those shapes into a conceptual analog.[165] As was the case for both Villard's images and Raphael's, such a compromise undermines much of the power inherent in the systems being negotiated. The result in the *Vitruvio ferrarese* image is that, instead of real projective accuracy, there is an illusion of formal fidelity. The reliance on cartography occurs at the level of artifice not projection. Here, even more than was the case with Raphael, we have cartography used as a trope to suggest accuracy rather than as projective system.

So, on a technical level, it is possible to see that orthography, perspective and cartography were each forms of projective structuring that were accessible to artists by the beginning of the fifteenth century. However, rather than functioning as separate geometric models for the ordering of spatial representations, these systems were combined, often in idiosyncratic ways that undermined the geometric accuracy of the projection, to generate other forms of meaning. This argument brings us to the question of accuracy during the Renaissance and what it meant in this period for certain drawings to gesture towards accuracy, or towards an accurate projection, without achieving it. While within the Gothic period such attempts seem to indicate certain exterior pressures (perhaps on the part of patrons) to expand drawing's role, this assessment relies on the

[165] Claudio Sgarbi, "A Newly Discovered Corpus of Vitruvian Images," *Res* 23 (1993).

existence the typological and oral traditions which served as an alternate basis for conveying and constructing design within Gothic architecture. A different process of design and construction is taking effect during the Renaissance, and a different meaning must be sought for drawings like Raphael's or the *Vitruvio ferrarese* image.

The Drawing as Instrument

In part, my work with Uffizi 164 A r has explored this question. I have endeavored to show the complexity of its graphic structure and the allusions it makes to a variety of projective systems, each of which implicated a different level of knowledge creation. Of course, Raphael was not alone in such explorations. Negotiations of this sort were occurring in every type of picturing. Dalibor Vesley has framed these negotiations as a debate between instrumental and symbolic forms of representation, and while his categories are clarifying, during this period it is difficult to establish where and whether a line existed to divide the two. [166] Not only did images commonly unite multiple forms of picturing, thereby imbricating both instrumental and symbolic systems of representation, but even what Vesely would classify as purely instrumental representation carried with it symbolic meaning. Although Panofsky's seminal work *Perspective as Symbolic Form* has, to a large extent, been contested, during the Renaissance and after, part of perspective's authority and appeal was derived from the symbolic meaning of its geometric structure, not just from the meanings conveyed by its subject matter. A further investigation of this point is helpful not only for unpacking the nature of Vesely's

[166] Although Vesely and Perez-Gomez thoroughly discuss the implications and development of instrumentalized representation, I wish to acknowledge Amy Kulper for stressing its conceptual importance to my topic. Dalibor Vesely, *Architecture in the Age of Divided Representation: The Question of Creativity in the Shadow of Production* (Cambridge, Mass.: MIT Press, 2004), Alberto Perez-Gomez, *Architecture and the Crisis of Modern Science* (Cambridge, Mass.: MIT Press, 1983). Amy Kulper, January 12, 2006.

categories during the Renaissance, but also for understanding what was at stake within the negotiated images of the Renaissance. Why were representational systems consistently hybrid rather than pure, and what can this tell us about drawings that gesture towards accuracy without achieving what we expect by that term?

The logical place to locate a further exploration of this thinking is around what we have come to see as the origin of linear perspective but also the origin of representational instrumentality. This origin is to be found with Manetti's chronicle of Brunelleschi's perspective "experiments" from the early fifteenth century. Many authors have worked to reconstruct the exact nature of the experiments based on Manetti's descriptions.[167] There were two such experiment described in Manetti's text, one depicting the baptistery of San Giovanni and the other the piazza of the palace of the Signori, both in Florence. For the purposes of this chapter, it is enough to concentrate on the first experiment. This demonstration involved a small panel on which Brunelleschi rendered the baptistery in perspective from a viewpoint located a small distance inside the Cathedral doors. The painting was pierced with a small hole (the size of a lentil) in the area we now understand as the vanishing point. The viewer was to stand inside the doors of Santa Maria dei Fiori with her eye peering through the hole at the back of the painting such that the actual baptistery was visible. A mirror was then to be inserted into the field of view reflecting back Brunelleschi's image, and by moving the mirror in and out of the field of vision, a

[167] While the panels used in these experiments are now lost, Milanesi identifies them as those described by Vasari in the inventory of Lorenzo the Magnificent. Hubert Damisch, *The Origin of Perspective* (Cambridge, MA: MIT Press, 1994), 72 note 36.Kemp and Damisch both discuss the experiments in detail Martin Kemp, *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat* (New Haven, CN: Yale University Press, 1990). Damisch's list of earlier work is extensive and includes: Alessandro Parronchi "Le due tavole prospettiche del Brunelleschi"; Richard Krautheimer, *Lorenzo Ghiberti*; Decio Gioseffi, *Perspectiva artificialis*; John White, *The Birth and Rebirth of Pictoral Space*; Robert Klein, "Pomponius Gauricus on Perspective"; Samuel Edgerton, *The Renaissance Rediscovery of Linear Perspective* Piero Sanpaolesi, "Ipostesi sulle conoscenze matematiche, statiche e macaniche del Brunelleschi."

comparison between the perspective and the actual view would demonstrate the accuracy of image and its structure. As Manetti describes, when viewing the painting "it seemed that one was seeing truth itself (*pareva che si vedessi; l propio vero*); and I held it in my hands and saw it several times in my own day, and so can testify to it".[168]

Setting aside the issues of the gaze and subjectivity inculcated with our thinking about perspective, if such a thing is possible, the goal of the first experiment was to demonstrate perspective's truth, or as Damisch calls it, its semblance of truth.[169] "The experiment was also intended to reveal," he writes, "by reflectively turning the structural disposition back on itself, nothing less than the premise of its own efficacy."[170] In other words, the experiment was rhetorical, designed to both frame the question and make claims about its accuracy. It offered the viewer a means of reducing or instrumentalizing perception; the purpose of which was to make apparent the formal structure of vision as defined by perspective in the comparison between the image framed by Brunelleschi's peephole and his rendering of that image. To this extent, Brunelleschi's experiment was instrumental. It spoke not only to the image's ability to capture truth, but also about the authority of its truth over the other truths it elided. Samuel Edgerton described a similar effect in his analysis of the *Map with a Chain* depicting late fifteenth-century Florence. The image, Edgerton wrote,

> makes it possible to grasp instantly the overall plan of Florence and its relationship to the surrounding countryside, but forces the viewer to lose tactile contact with the individual details that so delight all the senses when he

[168] Damisch, *The Origin of Perspective*, 116.
[169] Ibid., 140.
[170] Ibid., 119.

> walks through the city. The unity of the Renaissance view has replaced the diversity of the mediaeval one.[171]

While tendency for Renaissance pictures to unite and multiply singular projective or imaging systems undermines somewhat the unity to which Edgerton speaks, Brunelleschi's experiments certainly were a means to codify a certain view of reality.

Brunelleschi's experiment was revolutionary because, at the time, the authority of the image, in general, was suspect. Carpo has discussed at length the preference and need for non-pictorial means of conveying the visual during the fifteenth century, saying that as "everyone knew at the time, drawings could not, and should not be relied upon. In a word, they did not matter. Visual forms were to be described by words, not by pictures."[172] Perhaps Alberti best demonstrates the precarious and contradictory nature of the belief in images during the early Renaissance. Carpo describes Alberti as someone whose trust in images still seemed tentative,

> while advocating the use of drawings for architectural designs, [he] insists and reiterates that his architectural treatise is not, and should never be, illustrated….Alberti himself had, if we believe his word, profusely drawn buildings old and new….But when he conceived of a treatise that was to be transmitted to posterity, and possibly to eternity, he deliberately chose to rely on that good, old, reliable medium of all (historical) times—the alphabet.[173]

Although Carpo's ideas are pragmatically based, as he points to the impossibility of reproducing visual knowledge accurately before the use of the printing process, Edgerton's argument allows that there may also have been a resistance to the essentialization of the image. Here, too, Alberti can be further used to make the point

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[171] Samuel Y. Edgerton, "Florentine Interest in Ptolemaic Cartograpy as Backbround for Renaissance Painting, Architecture and the Discovery of America," *The Journal for the Society of Architectural Historians* 33, no. 4 (1974): 277.
[172]Carpo, "How Do You Imitate a Building That You Have Never Seen? Printed Images, Ancient Models, and Handmade Drawings in Renaissance Architectural Theory," 223.
[173] Ibid.: 225.

because he recommends that architects make use of tools outside drawing, namely models, in order to conceptualize their designs and better estimate the volumes and materials involved. It is the model, Alberti claims, that will allow "one to calculate the width and height of individual elements, their thickness, number, extent, form, appearance, and quality."[174] Models—not drawings—had a history of serving as the documentation and contract for design as was demonstrated by the destruction of all models save the one embodying the approved design for Santa Maria del Fiore in 1368.[175] According to Millon's study on the use of architectural models during the Renaissance, Alberti felt that models were indispensable for the realization of an idea within architecture. For while drawings could refine the idea formed in the mind, the use of a model allowed the drawings to be "studied, assessed and improved…thereby ultimately approaching an embodiment of the idea."[176] Thus for Alberti it was the model even more than the drawing that served as the medium for design. Lotz takes the importance of the model even further concluding that,

> [Alberti's] advice to make a plan and a model can only be interpreted to mean that, in his opinion, elevation and section, though well known to the older practitioners (at least in the North), did not figure among the true forms of representation available to an architect.[177]

This entire discussion speaks to a general opinion existing at that time that what drawing did offer, though possibly helpful, was insufficient for the purposes of architecture. And yet Brunelleschi's experiment fomented a challenge to the opinion that drawing alone was inadequate. By framing the question with his experiment, he was able to demonstrate

[174] Alberti, *On the Art of Building in Ten Books*, 34.
[175] Howard Saalman, "Giovanni Di Gherardo Da Prato's Designs Concerning the Cupola of Santa Marie Del Fiore in Florence," *Journal of the Society of Architectural Historians* 18, no. 1 (1959): 14.
[176] Millon, "Models in Renaissance Architecture," 22.
[177] Lotz, *Studies in Italian Renaissance Architecture*, 21.

how effective perspective could be at capturing reality. His second experiment, which dispensed with the peephole and mirror, took his assertion further by masking those aspects which framed the question in the first place, thereby naturalizing the conclusion that perspective mirrored reality. And yet, the degree to which Brunelleschi was persuasive was a measure of how difficult it was to make the case for perspective. Although the historic view allows us to see Brunelleschi's perspicacity, the role of the image as reality's interlocutor was far less self-evident in the fifteenth century.

The Drawing as Building

Another method of seeing drawing's tentative position during the early Renaissance is to examine some of the designs produced during the time. Wittkower argues persuasively that Brunelleschi's understanding of perspective translated into a governing methodology for design in buildings like San Lorenzo.[178] Christoph Frommel argues, methods like chiaroscuro and perspective, allowed the exploration of depth in painting, thereby opening up new roads for Renaissance artists to investigate the depth and plasticity of architecture.[179] But, to some extent, these arguments project an easy acceptance of drawing's structures and their relationship to the three-dimensional world that does not fully capture the moment. As I have just argued, these relationships were not immediately understood and accepted. And while Wittkower's demonstration of perspectival principles within Brunelleschi's work is convincing, it is also noteworthy that his designs were undeniably planar. Somehow, the exploration of plastic depth Frommel gestures towards was not fully realized. Brunelleschi's designs might even be

[178]R. Wittkower, "Brunelleschi and 'Proportion in Perspective'," *Journal of the Warburg and Courtauld Institutes* 16, no. 3/4 (1953).
[179]Frommel, "Reflections on the Early Architectural Drawings," 101.

best described as the composition of "taut membranes", of architectural surfaces that mirror the canvas, rather than a truly plastic architecture.[180] And he is not alone. Similarly complicating observations can be made about the predominance of *sgraffito* as in the *Palazzo Communale* in Piencza or screen facades as in builidngs like *Palazzo Rucellai*, both designed either by Alberti or by Bernardo Rossellino, one of Alberti's contemporaries.[181] [Figure 32].

In these instances we see architectural design realized in minimal relief. The *Palazzo Communale* uses a common architectural technique of the time where layers of plaster are scratched or carved in bas-relief to realize the design, where the façade of the *Palazzo Rucellai* is rendered in a thin veneer of sandstone. While both techniques certainly had pragmatic factors driving their use (e.g. often such designs were updates to existing façades), it must be noted that *sgraffito* in particular represents the near literal translation between drawing and a mode of construction. A design realized in *sgraffito* certainly didn't require a model to augment the understanding of the design, because the logic of the drawing *is* the logic of the design *is* the logic of the construction method. Any questions about how the structures of drawing or perspectival depth instrumentalize reality can be elided because, here, architecture itself is essentialized to a kind of drawing. The drawing plane has become the architecture, or perhaps better, the façade has become the drawing surface.

This two-dimensional interpretation of design was very common during the early Renaissance, and even when the method of realization was different (when for instance

[180] My thanks again to Amy Kulper for both the term "taut membranes" to describe Brunelleschi's work and for the observation that sgraffito as a technique at Palazzo Rucellai is very akin to drawing. Kulper.
[181] Charles Randall Mack, "The Rucellai Palace: Some New Proposals," *The Art Bulletin* 56, no. 4 (1974).

design was realized in as a stone screen façade rather than plaster), the two-dimensionality was often maintained.

> Precisely because of their less expensive and flexible application, facade graffiti and frescoes allowed house owners to upgrade their residences and to enhance the otherwise whitewashed walls with an almost ostentatious neo-antique veneer. Only a few owners managed to have these ideas dressed in stone - and even they usually did little more than cover the house front.[182]

Within these flattened interpretations of architecture, it is difficult not to see parallels between these Renaissance techinques and the medieval use of full-scale épures. In both forms, the relationships between drawing, design and construction slip. An épure was drawing executed full-scale immediately proceeding construction. Its intellectual distance from the built project was negligible. It did not indicate depth nor did it need to, since it governed what amounted to only an architectural screen (most often tracery). The épure's purpose was to coordinate a process of construction which involved the sculpting of stone and fitting together of the individual masonry pieces. To do this it relied on a one-to-one scale which made the process of construction seem more akin to transcription. In the case of a design realized as a screen façade or in *sgraffito*, a similar constructive literalism seems at play. This illusion is achieved through a procedural parallel between the act of drawing and the act of building. The depth that is explored in the drawing and the design are still limited to the drawing plane. However, where the épure was a full-scale drawing that coordinated construction, design drawing during the Renaissance was executed to-scale (*di braccia picoline*) rather than full-scale (*a braccia vere*). Because of this break in scale, an intellectual distance emerged between drawing and building thereby facilitating the role of a designer whose exclusive role was to prefigure forms that a craftsmen would

[182] Kurt W. Forster, "The Palazzo Rucellai and Questions of Typology in the Development of Renaissance Buildings," *The Art Bulletin* 58, no. 1 (1976): 109.

construct. Before these two roles could become fully distinct, however, the craft process experienced a phase during which its methods directly paralleled those of design. Construction process and design method, that is drawing, mirrored each other. It is as if a point had been set for the level of interpretation necessary to move between the drawing and building, and while the translative act could change in kind, it could not initially change in quantity. During the medieval period drawing was used full-scale as part of the constructive process to govern the masonry construction. During the Renaissance drawing was scaled and its creation separated from building, but the constructive process it governed more closely mirrored the act of drawing.

In sum, what I see both in the deployment of drawing in projects like the Palazzo Rucellai and in the early reliance on models to assist in the creation and refinement of drawing's relationship to design is an early mistrust of the reality or truth offered by an image. So, instead of using drawing to capture and explore three dimensions architecturally, it seems that the world of architecture was reduced to mirror what drawing clearly offered. The most typical examples of drawing's use reduced the differences between image and material practice as much as possible. Brunelleschi's experiment may have demonstrated the efficacy of perspective to mirror vision, but its potential for envisioning in three-dimensions was unfilled. Even in the early seventeenth century, mathematical and architectural theorist Juan Caramuel would claim that "the art of perspective described by Serlio and other Renaissance architects could not be the third Vitruvian architectural *idea* [as it is generally argued] since it has no application in architecture."[183] While perspective was a great tool for picturing architecture, Caramuel argues that the authority it gained from this ability held little weight when in came to the

[183] Perez-Gomez and Pelletier, *Architectural Representation and the Perspective Hinge*, 120.

need to prefigure a building. The path between the spatiality, the picture plane and the eye (embodied or otherwise) seemed to occur in only one direction.

The Drawing as Truth

In other words, although projective techniques were established and understood, drawing was hardly the transparent tool it would become to architects of later centuries and to us. To a large extent, the epistemological obstacles presented by drawing had to do with its instrumentality. Although the various representational forms could clarify and reproduce certain aspects of reality, when used to design something new rather than to capture an aspect of something pre-existing, the limits of its instrumentality were felt. Although a space could be abstracted to a representation on the picture plane, when space was interpolated from an image, it tended to remain stubbornly image-like. This imperfect correlation between image and reality seemed to be a source of some anxiety. One mitigating strategy was to combine of multiple systems (and therefore multiple truths) within a single image, as Raphael did in Uffizi 164 A. r. Another was to make the reality over which the image could govern more drawing-like, as was the case of for the sgraffito projects. However, both of these options speak to drawing's accuracy on a pragmatic level, nuancing technique and construction to better fit representational and architectural understandings. The increase in the credibility of images may also have come from a new symbolic conceptualization and a different means of uniting the symbolic and instrumental character(s) of drawing.

While representation can generally be seen as means to gain knowledge about a specific place or object, it can also have a higher purpose. Speaking of a later period, Svetlana Alpers picks up on a similar relationship within Dutch genre painting, "If we take the 'reality effect' of Dutch painting as an attempt to structure perceptions about the world—in other words, to offer knowledge about the world—then painting becomes an experiment in observation and meaning-making."[184] Although Alpers' argument revolves around Dutch painters of the seventeenth century, her identification of perceptual structuring through imaging as a meaning-making enterprise is certainly applicable during the Renaissance.

When Brunelleschi was demonstrating the "truth" of his system of representation, he was less interested in learning about the baptistery and more involved with the contemplation of perception, perspective and the structures and logic they share. These efforts were not merely an attempt to learn better how to picture places but also an attempt to peel back the primordial veil of reality and see the geometrical essence, or the Godly patterns, which regulated it. "Thus it can be argued that it was the geometrisation of the world that allowed access to a new transcendental truth. … Perspective marked the moment of an epiphany, the revelation of meaning and the God-given geometric order of the world."[185] During the Renaissance, knowledge of this geometric structure was akin to knowledge of God. Père Mersenne (1588-1648) claimed in his *Questions in Genesis,* that "geometry [was] useful for expressing more fully God's qualities and works."[186] Samuel Edgerton wrote in his study of the interplay between the cartography and perspective that,

[184] Svetlana Alpers, "Picturing Dutch Culture," in *Looking at Seventeenth Century Dutch Art: Realism Reconsidered.*, ed. Wayne Franits (Cambridge, England: Cambridge University Press, 1997), 59.
[185] Perez-Gomez, "The Revelation of Order," 15.
[186] Perez-Gomez and Pelletier, *Architectural Representation and the Perspective Hinge*, 133.

"Mathematics seemed to be the chief instrument of the Divine Will, and the geometric grid was its earthly metaphor."[187] Lucia Nuti similarly contended that, "Ptolemaic maps lack any viewer at all, because they are not representations of the world seen, but of the mathematical essence of the world."[188] In sum, although all the projective systems instrumentalize the experience of an object or place, the "truth" they express became authoritative because such images were governed by a Divine geometry. Pictorial projection provided a "matrix symbolic of a world in which everything has its ordained place and man himself is in harmony with God's master plan of the universe."[189] It allowed a human being to see God's underlying design. The unification of the various systems of projection through the discovery and/or creation of relationships like *construzione legittima* demonstrated that, rather than expressing different essences or truths about an object, these projective systems revealed the same Divine geometry.

In other words, during the Renaissance the instrumentality of images was symbolic. The incomplete, abstract, and un-mimetic aspects of drawing were potentially acceptable because they signaled the geometric vision of the Creator. The difficulties exuded by drawing's instrumentalization could be justified because they were the same difficulties humans always had understanding God's plans. They were the material distortions of Divine truth. So, although drawing put an emphasis on formal aspects of design, and formal considerations replaced much of the symbolic aesthetic that governed the Mediaeval world view, this switch was mediated by the transfer of symbolic power to

[187] Edgerton, "Florentine Interest in Ptolemaic Cartograpy as Backbround for Renaissance Painting, Architecture and the Discovery of America," 287.
[188] Lucia Nuti, "The Perspective Plan in the Sixteenth Century: The Invention of a Representational Language," *The Art Bulletin* 76, no. 1 (1994): Note 71.
[189] Edgerton, "Florentine Interest in Ptolemaic Cartograpy as Backbround for Renaissance Painting, Architecture and the Discovery of America," 287.

the act of designing. Rather than simply relying on the symbolism of the object imitated, the act of design itself became imitative. It was an emulation of God's actions. While the ritualized aspects of the Mediaeval process were also symbolic, the masons were passive participants. They enacted the mystic rituals passed down to them. During the Renaissance, however, when artists prefigured architecture through drawing they were using Divine tools to engage in a God-like process. They had taken on an active role. They still imitated God, but this time they imitated God's actions rather than believing they transcribed His results.

The Drawing as Divine

By the mid-sixteenth century, this was the new definition of design. When Vasari wrote of *disegno*, the architectural drawing that had taken on a position of prominence governing the imagination and fabrication of the architectural idea.[190] About this methodological shift Perez-Gomez writes that both theology and science played a part. Quoting the sixteenth-century Jesuit architect Juan Bautista Villalpando, he writes that "the human architect must share the Divine Architect's capacity for visualizing a future building, [Villalpando] insists that plans and elevations are similar to perspectives, as they are merely 'pictures' of a building-to-come."[191] This new earthy purview for prefiguration is reflected in other aspects of theology, as well. In natural theology, which Stuart Peterfreund contends originates from the medieval Beastiary tradition, God's

[190] Millon, "Models in Renaissance Architecture," 24.
[191] Perez-Gomez, "The Revelation of Order," 13.

existence is understood by his manifestation within those things he creates.[192] Initially, the objects which evidenced God's design were animate, which is to say that God's design was evident in the anatomy and physiology living things. As Francis Bacon described it, "Natural Theology is also rightly called Divine Philosophy. It is defined as that knowledge, or rudiment of knowledge, concerning GOD, which may be obtained by the light of nature and the contemplation of his creatures".[193] But as the Renaissance artists took on more and more responsibility for design and as their own designs became increasingly complex, so the proof of God's existence and the understanding of His work came to rely on the manifestation of human-like creations within His universe. By the beginning of the eighteenth century, Boyle describes the familiar concept of the universe as a clockwork:

> it is like a rarer clock, such as may be that at Strasburgh [sic], where all things are so skillfully contrived, that the engine being once set in motion, all things proceed, according to the artificer's first design, and the motions of the little statues, that at such hours perform these or those things, do not require, like those of puppets, the peculiar interposing of the artificer, or any intelligent agent employed by him, but perform their functions upon particular occasions, by virtue of the general and primitive contrivance of the whole engine.[194]

Seeing the universe as a mechanical device, akin to something created by humans, affirms the theological justification for our own design activities. As the mathematics of projection allowed us to see the Divine geometry which lay beneath our perceptions, so finding a clockwork in the universe affirmed that through our own design acts we were revealing God. There are even direct suggestions to the world of architecture in Boyle's

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[192] *The Works of Francis Bacon*, 4:341 quoted by Stuart Peterfreund, "The Clockwork in the Creature: Bacon's Sylva Sylarum (1627) and Boyle's Transformation of the Argument from Design," in *Group for Early Modern Cultural Studies* (Chicago, Illinois2007), 1.
[193] _____, "From the Forbidden to the Familiar: The Way of Natural Theology Leading up to and Beyond the Long Eighteenth Century," *Studies in Eighteenth-Century Culture* 37 (2008): 4.
[194] Bolye *Works*, 5:251-2 quoted by Peterfreund Ibid.: 13.

characterizations. Peterfreund illuminates Boyle's God as "the master-builder of this world who, according to Boyle's *Usefulness of Natural Philosophy* (1663), was "pleased to construct this vast fabrick." A "fabrick" that Peterfreund goes on to argue figures the world as architecture.[195]

In other words, over the course of the seventeenth century, theology moved from God's work being a model of knowledge for humans to discover to God's work being made manifest by human design. Where previously our creations were little more than attempts to transcribe the Divine, now our creative process allowed us to better understand God and His processes. While the shift to a mechanical model in theological arguments occurs after design falls into a fully human purview, the fact that human authorship and creativity gets processed through theology demonstrates how fundamentally symbolic it was for humans to take on the role of design and the accompanying act of prefiguration. While mediaeval aesthetics were extensions of theological thought, Renaissance aesthetics molded the theological thought of the following centuries.

Representing Form

These arguments offer a means to see how deeply the conceptualization of design runs, and how very symbolic it was for humans to take on the role of designer. Such conceptual leaps were possible, to no small extent, because of the unique status granted to the idealized or abstract knowledge provided by drawing and in particular to the very abstracted image offered by orthographic projection. The Neo-platonic underpinnings for

[195] Ibid.: note 17.

late Mediaeval and the early Renaissance periods were essential to elevating the status of architectural drawings.

> Such a picture is intended to be a *schema kat'analogon*, an abstract shape linked with the real world through measurement analogy. The geographical image skips sensorial input to use only the mathematical data collected by geographers and thus to display a superior level of knowledge. The resulting map is a *mimesis* of a reality not seen.[196]

This idea of the un-seeable reality is essentially the Neo-platonic idea of "form" or "essence".[197] It is this quality, this idea of form, that Raphael strove to picture with Uffizi 164 A.r. His angle of view, his flattening of the geometry, his attempts to render equally those equivalent parts all speak to a desire to capture his ideas of the Pantheon, are all part of his attempt to capture the idea of the Pantheon—the image it creates in the mind—rather than the experience or specific view of it. Further, I believe that it was this goal to reach beyond the miming of visual experience to an abstract idea that Raphael was thinking of in his letter to Pope Leo X. When he wrote that certain shapes could only be understood through the use of multiple drawings, he was conceiving of drawing's role in the documentation of Rome, but he was also anticipating a process where the architectural idea is prefigured and communicated with the help of certain drawings. Lotz believed Raphael was further motivated to make this radical change in the process of architectural design by his work at Saint Peter's.

> The spatial complexities of the main and secondary cupolas, the arrangement of large and small orders, the process of harmonizing the old and the new building that he took over from Bramante, could not be represented, let alone planned, by the mere use of a round plan and model.[198]

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[196] Nuti, "The Perspective Plan in the Sixteenth Century: The Invention of a Representational Language," 126.
[197] Although it is more accurate to say these concepts are Aristotelian, the two were largely conflated during this period.
[198] Lotz, *Studies in Italian Renaissance Architecture*, 22.

Lotz here gestures towards a complexity that cannot be understood by plan and model alone but instead requires orthography's formal fidelity. And yet, although drawings are at the heart of this new understanding of architecture, simultaneously, within this system the image is merely an interlocutor. The idea of the building, its "reality not seen", is not what the drawings capture. The physical expression provided them is another *schema kat'analogon,* another "abstract shape linked with the real world through measurement analogy."[199] Rather than relying on mimesis and the total, coherent vision of space mimetic drawing engenders, efforts towards which can also be seen in Raphael's Pantheon drawing, the use of triadic form abstracts the view of the object, breaking it into pieces. It shifts the burden of the architectural whole from the drawing to the mind of the viewer. The expectation for each plan, section or elevation is not that the building or its space be fully articulated, but that each drawing capture its own idiosyncratic slice. These individually incomplete representations of the building's whole are then parsed together in the mind of the viewer based on the geometric (Godly) syntax that triadic form provides. This process builds an understanding of form and space: an idea which constitutes the knowledge of the design. Triadic form goes beyond creating an image of the building that is stable on the paper, and instead generates an internal understanding of the architecture in the mind of the viewer, which can be queried and tested. The idea regulates the drawing while the drawing helps the artist to better understand the idea. Hugh of St. Victor (1096-1141) described a similar relationship when he wrote: "Our mind cannot ascend to the truth of invisible things, unless instructed by the consideration of visible things, that is, so that it will recognize visible forms as notions of invisible

[199] Nuti, "The Perspective Plan in the Sixteenth Century: The Invention of a Representational Language," 126.

beauty."[200] Similarly, Perez-Gomez wrote that the philosophers and inventers of our traditions "perceived projection as the original site of ontological continuity between universal ideas and specific things."[201]

And yet, while this system was reinforced by philosophical understandings of the abstract, a fundamental conceit exists within it. The abstract presented by orthography occurs in the mind, but the idea created is not of an ideal but a particular manifestation. It is not an image of the ideal church but of a particular church. The reader will recall that these techniques emerged from the needs of construction during the Gothic period and that their power is rooted in their ability to preserve shape. It is this power that results in their conventionalization within architecture, and it is this link to the physical that makes orthography not just a reflection of the world, but a tool that can direct the creation of objects in that world. As Wolfgang Lotz pointed out in his interpretation of Raphael's letter to Pope Leo X, only orthogonal projection made it possible "to understand all of the measurements and to know how to find all of the parts of a building without error."[202] Therefore, the idea created by orthography both is and is not abstract. The understanding offered by drawing may exist in the realm of ideas, but the image it generates is concerned with the physical embodiment of the object. Orthography's authority is rooted in its dominion over this world, not just the abstract one. In sum, it is an idea powerfully reinforced by references to the universal and ideal of the Neoplatonic God, but one ultimately concerned with the particular and material.

In this equivocation between the ideal and the physical it is possible to discern the intellectual power of 'the abstract' during the Renaissance. So powerful was it that a

[200] Perez-Gomez and Pelletier, *Architectural Representation and the Perspective Hinge*, 89.
[201] Perez-Gomez, "The Revelation of Order," 5.
[202] Lotz, *Studies in Italian Renaissance Architecture*, 32.

drawing that gestured towards the abstract adhered some of the universal and Godly authority of abstraction to the image. In turn the maker of the image and subject matter also likewise were associated and connected to the ideal. Thus even the most instrumental of images was highly symbolic. What might be lacking in iconography was replaced with a mode of 'seeing' that symbolized God. An artist who had learned to make such images was expert in a geometry through which God revealed himself, and the subject of such a depiction had been made to reveal the Godly design which lay within it. So it is that the Renaissance belief in Neoplatonic abstraction sanctified not only the emergence of orthography (alongside the other forms of projection), but the elevated status of those who practiced it and the elevated status of those objects which were best depicted through it.

Here we can begin to unravel why an artist would be motivated to make images that gestured towards accuracy without adhering to our definition of that term. The answer seems to be that during the Renaissance, such claims of authoritative vision were expected. Nuti comes to a similar conclusion regarding the acceptance of cartographic images when she asks, "And why was this kind of image immediately accepted and acknowledged as true, although only a few isolated elements could be verified by the eye, if not because it fulfilled the expectations of sixteenth-century culture?"[203] Even more importantly, if the image was generally acknowledged as a unique vision, persuasive in its accuracy, its creation distinguished the artist. Here, the repeated copying of Raphael's U 164 A r becomes especially significant, particularly if it was created as early in Raphael's career as seems likely.

[203] Nuti, "The Perspective Plan in the Sixteenth Century: The Invention of a Representational Language," 128.

Form, Symbol and Icon

No less important, however, is what can be said about the subject matter of the images and the authority the image grants to it. It is worth recalling that the Medieval aesthetic system minimized formal considerations. As Krautheimer argued, it was the symbolic not the formal that governed imitative acts. The switch to a formal system was necessitated by drawing, since orthographic projection conveyed form above other qualities, but it is not surprising that mediatory projects exist that unite formal and symbolic aesthetic concerns. The Cancelleria in Rome is one such example. According to Cammy Brothers, although newly built in early sixteenth century, the Cancelleria achieved the stature of an ancient monument.[204] As early as 1506, Maffei argued for the importance of the Cancelleria façade saying that it followed the principles of Vitruvius in its use of a flat and smooth rustication.[205] The new deployment of a Vitruvian aesthetic certainly demonstrates one path through which an *all'antica* architecture might be symbolically embodied, but the Cancelleria also takes a more direct route. Like many other early Renaissance buildings, the Cancelleria was a sort of ancient reliquary as it preserved in its *cortile* many pink and grey granite columns taken from the Baths of Diocletian.[206] [Figure 33]. Such a literal appropriation allows the Cancelleria to take on many of the symbolic meanings Krautheimer attributes to Mediaeval aesthetics. These columns taken from an ancient monument symbolize Rome's reincarnation. However, more is at work here than Krautheimer's medieval metonymy. The corner columns of the

[204] Cammy Brothers, "Architecture, Texts and Imitation in Late Fifteenth and Early Sixteenth-Century Rome," in *Architecture and Language: Constructing Identity in European Architecture, C. 1000-C. 1650*, ed. Georgia Clarke and Paul Crossley (Cambridge, U.K.: Cambridge University Press, 2000), 88.
[205] Maffei, *Comentariorium rerum urbanorum* quoted in Ibid.
[206] Ibid., 90.

cortile have been refashioned into a new form. On one level, such an alteration was symbolic of the new Renaissance commercial powers because shaping granite was only possible as a result of the recent importation of tempered chisels.[207] Until the late fifteenth century, granite columns could only be reused, not reformed.[208] While the use of reshaped granite certainly signified a technological power equaling to the ancients, I would argue that the desire to re-form was significant as part of the new set of Renaissance claims. This move united in a single column both the symbolic and formal systems of meaning. The new "L" shaped corner columns were believed to be a second antique columnar form.[209] Therefore based on the historic scholarship of the time, the builders of the Cancelleria attempted to reconstruct a Roman model by using materials known to be Roman, but also by applying what were believed to be antique forms. They were imitating both the materials and the forms they believed typified an *all'antica* architecture. In hybrid instances like these, the principle of formalism and the growing priority of form within design can be seen to have taken root.

Such examples demonstrating the mediation between aesthetic systems are useful, but in the end it was the overwhelming power of abstraction that drove the shift to drawing as architecture's medium. There is one aspect of Brunelleschi's experiments which I have not discussed which can be used to illustrate this point. In both experiments Brunelleschi was careful to limit what he represented. Only certain objects, namely those that were themselves geometric or could conform to perspective's "reason" were depicted

[207] Michael J. Waters, "Reviving Antiquity with Granite: Spoliated Granite Columns and the Development of the Roman Renaissance," in *The Sixtieth Annual Meeting of the Society of Architectural Historians* (Pittsburgh, Pennsylvania2007).
[208] Ibid.
[209] Ibid.

through perspective.[210] In the first experiment Brunelleschi left the clouds and the sky above the baptistery to be reflected in the silver he burnished above the building in his painting. In the second experiment, he dispensed with this technique and instead cut the panel away above the rooflines of the piazza buildings. Rather than attempting to render "bodies without surfaces", as Leonardo described objects like clouds, Brunelleschi left them to be reflected rather than represented in his experiments.[211] This point is important because it has implications for a Neo-platonic understanding of drawing. In particular, as Damisch points out, because the elements reflected in the mirror are in their natural state rather than in their abstracted representational forms, they were not "the entirely ideal[s] one of light, but rather the atmosphere as the location of sublunar phenomena."[212] In other words, those objects that could be revealed by perspective were closer to the ideal than those that could not. If an object could not be contained by perspective's "reason" it meant that God's geometric hand could not be found within it. Such objects did not reinforce the Renaissance belief in Geometry as a Divine structure. Instead objects that were best contemplated were those with "surfaces that are more or less smooth, angles that are more or less pure, and lines of intersection that are more or less clean; that instruct the mind and conduct it, in a sequence of incremental steps, toward the horizon of the pure 'limit-shapes' that are the object of geometry."[213] Objects that conformed to such a description were useful for discovering the Divine within the concrete, the invisible beauty that lay within the visible. By translating such physical objects into

[210] "*Casamenti, piani e montagne e paesi d'ogni ragione*" Manetti quoted by Damisch, *The Origin of Perspective*, 93.
[211]Ibid.
[212]Ibid., 94.
[213]Paraphrasing Husserl, *L'Origine de la géometrie*, 210-211Ibid., 95.

pictures that were based on projective geometries, artists presented a means of de/re-constructing that object, of revealing the divine idea behind the embodiment.

But which architectural objects fit such descriptions? Even though the orthographic techniques that were being used had originated within the Northern tradition, Gothic architecture with its skeletal linearity was a hard fit with the abstract ideals that had developed for orthography. The projective links between perspective and orthography made the same smooth surfaces and clean angles preferential for both forms of representation. In Italy, it was the antique model that fit these formal requirements, and there were readily available subjects for artists to contemplate as is evidenced by early sketchbooks like the *Taccuinno Senese*, the *Codex Barberini*, the *Codex Escurialensis*, and the *Codex Coner*. The authors of these manuscripts processed the classical examples they illustrated through their new graphic tools revealing the Divine patterns that lay beneath these forms and their own familiarity with Divine patterns. In building after building, the Divine pattern in the architecture was revealed through drawing's abstraction of the Classical subject. A demonstration repeated so often that God's existence within these particular forms became canonical. Robin Evans described a similar process through which formal principles were legitimized when he wrote that:

> [By the mid-sixteenth century] an alliance had already been struck between the abstractions of orthographic projection and the fundamental organization of classical architecture. With a subtlety bordering on subterfuge the drawing technique conferred properties on its subject: rectangularity, planarity, axiality, symmetry, frontality.[214]

In short, Evans argues that the properties of projection became the properties of Classical architecture. Classical buildings were essentialized through drawing, and as patterns were identified, with the help of Vitruvius, a set of systemic principles gradually developed for

[214] Evans, "Architectural Projection," 25.

a new *all'antica* architecture. Within this process the mode of representation and the desired architectural expression were symbiotically synchronized. Here, the valuation of Classical architecture, the goal of an architecture *all'antica*, the systematized contemplation of architecture as form and the use of a syntactic abstract drawing technique, were mutually affirmed.

This question of suitability reveals the importance of the unique and particularly appropriate environment provided by Italy. For not only was Italy home to abundant antique examples of such purely planar and platonic architectural forms, but its own aesthetics had tended to perpetuate these Roman preferences rather than the more skeletal forms of the Gothic period.[215] This aesthetic tendency facilitated a formal turn towards antiquity, a turn that was further legitimized by the intellectual reliance on Classical thinking which had already stimulated so much of the new Humanist thinking. Not only was the intellectual environment ripe for a new conceptualization of architecture, but the physical environment was rich with examples that provided an appropriate formal basis for this new architecture.[216]

Further, through its expanding economy Italy provided yet another incentive for reconceptualizing architecture through drawing. As Italian merchants and bankers increasingly accumulated wealth, so too did their demand for palazzos and other publicly ostentatious buildings multiply. To best distinguish themselves, they desired buildings which exemplified the newly understood ideal forms. Such creations had the power to associate the patron with a Divine authority. As artists had succeeded in elevating their

[215] Frommel, "Reflections on the Early Architectural Drawings," 101-02.
[216] Brothers writes eloquently of the need to abstract not just forms as did the medieval practioners through the creation of pattern books, but the need to glean principles from these forms: a syntax with which these forms could be deployed in new circumstances. See Brothers, "Architecture, Texts and Imitation in Late Fifteenth and Early Sixteenth-Century Rome."

own status by the demonstration of their literacy in Divine geometry, so patrons sought to elevate themselves with their own Divine alliance. Simultaneously, as this patron class grew with the expanding market and economy of the Renaissance, the demand on the new and rarified group of architect-designers also grew. This increased demand made it impossible for the architect to oversee every aspect of a building from its genesis to its completion. A code had to be established that would allow the designer to instruct from afar, and even instruct those ignorant of the new forms.[217] Triadic form became this new code and its indispensability as the architect's interlocutor was soon apparent. Such drawings allowed architects to multiply their presence directing multiple projects simultaneously. This new mode of working furthered the architect's fame and aesthetic authority as a result of an increased body of built work and perhaps even more importantly, through the wider circulation of drawings and architectural ideas in print.[218] Thus, as the expanding markets of the Renaissance demanded expanding access to new architectural ideas, the formal abstraction provided by drawing allowed the personal abstraction of the architect. Just as Divine patterns could be found everywhere within the physical world, through drawing an architect's personal vision could also permeate the newly emerging culture of *all'antica* architecture.

Whether it was an assumed suitability within Classical forms towards perspectival and orthographic representation, a particular desire to contemplate the antique, easy access to such models, the desire to self-aggrandize, or market forces that demanded

[217] As early as 1902, Goodhart-Rendal identified this need to instruct the ignorant builder as the key drive for the adoption of drawing during the Renaissance. H. S. Goodhart-Rendel, "Architectural Draughtsmanship of the Past," *Journal of the Royal Institute of British Architects* 58 (1951): 17.
[218] Again, I would direct a reader to Mario Carpo's writing for more on the importance of the printing process to the development of the architect during the Renaissance. Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography and Printed Images in the History of Architectural Theory*.

greater efficiency and greater accessibility to design—Italy brought together a uniquely catalytic set of circumstances. The result of such fecundity was hubristic appropriation of design as a human act. Geometrically-sound projection granted authority to this Humanist annexation, and drawing became the medium for design prefiguration. Initially, such designers applied their skill to a wide range of subjects, but eventually the unique demands of building created a specialty. Out of this environment, the professional architect was born. Here was a designer whose training and social class was higher than that of the mere a craftsman or builder. This new designer was a scholar, a practitioner of the fine arts. By the mid-sixteenth century, triadic form was conventionalized as drawing's architectural syntax. And while when contemplating the history of our built environment we often refer to the 'architect' for projects that pre-date the Renaissance or that emerge from cultures whose traditions are not based on Renaissance practices, this is the true moment of origin for our profession. As Christoph Frommel has argued, "In spite of all the changes in style and technique, this continuity in the methods of design links the architecture of our time to that of the Renaissance;" and that "there had never been such continuity between antiquity and the Renaissance."[219] In sum, it is in this moment and this place where drawing's reign over architecture is established that we finally find within history's mirror an image that truly reflects ourselves.

[219] Frommel, "Reflections on the Early Architectural Drawings," 101.

CHAPTER FOUR

THE RISE OF PROCESS

Drawing's Transparency

In the transition from the previous two chapters to this one I have stepped forward in time several hundred years, moving away from the period of drawing's rise and well into the period of its reign over architecture. As I turn my focus to these later stages of drawing's dominance, it is important to take the measure of drawing's relationship to architecture. Through the previous two chapters I've sketched the core tenets of this relationship, and while the specifics have been continually nuanced since the initial adoption of the combined use of plan, section and elevation, the relationship's fundamentals have remained relatively unquestioned. These core beliefs rest on a system of transparency that drawing established between itself and building, between the acts of design and construction. For it is the assumptions made about drawing, assumptions that Robin Evans has named "architecture's enabling fiction," which allow the architect to design, separating the prefiguring moment from the building's realization.[220] It is the belief that the image created by drawing is a transparent and stable representation of the building, that drawing can capture the building's essence, which enables someone who

[220] Evans suggests that, "while such an enabling fiction may be made explicit, this has not been done in architecture, and that because of this inexplicitness a curious situation has come to pass in which, while on the one hand the drawing might be vastly overvalued, on the other the properties of drawing—its peculiar powers in relation to it putative subject, the building—are hardly recognized at all." Evans, *Translations from Drawing to Building and Other Essays.*, 154.

does not build to visualize and thus control the building's form. Likewise, the acceptance of drawing's transparency allows a finished building to be documented through drawing, to be captured and presented again in a mobile and transmissible format. This later process allows the dissemination of the architect's style and fame. Together, the doubled movement from drawing to building and back again forms an axis of projective transparency that makes the graphic description of architecture possible. [221] In short, the adoption of drawing as the architect's medium is what establishes and defines the discipline of architecture. The belief in this medium, in its honesty, in its ability to create "a uniform space through which meaning may glide without modulation," is what brings the profession of architecture into being.[222]

And yet, if pressed, everyone will admit that it is not actually the drawings that are transparent. Drawing's technical nature, its difficulty, makes it impossible to see a plan as the same as a building. And yet, by using plan, section and elevation together as a system of representation, an image of the building is formed, an imagined building, an ideal to match and be transparent to the material reality of the building. The doubled axis set up between drawing and building is thus hinged, or perhaps better, the ideal percept works as a linkage transmitting the motion of one system into the motion of the other.[223] Architectural transparency, then, is a relationship connecting three distinct and dissimilar objects: a set of drawings that are only and quintessentially two-dimensional, an abstract,

[221] Evans has actually described this relationship as a tetrahedron, connecting not only orthographic drawing to a building and an ideal but also to visually-based representations like perspective. I don't disagree with Evans' image, but as my purposes are slightly different from his, his conceptual model of architectural representation is not fully applicable here. Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge, Mass.: MIT Press, 1995).
[222] Evans, *Translations from Drawing to Building and Other Essays.*, 154.
[223] The linkage is a device of mechanical engineering and kinematics used to translate one type of motion into another, e.g. rotational motion into linear motion. The piston/rod/crank of an automotive engine is a classic four bar linkage.

idealized building whose dominant quality is form, and the three-dimensional material presence of architecture. Holding these aspects together is a transparency pact, a treaty that was first drafted by those early architects of the Italian Renaissance who decided that the way to understanding architecture was to understand its forms, that ideas could be encoded into shapes, and that this encoding was to be the task of architects. These are the implicit assumptions that enable the adoption of the combined use of plan, section and elevation in architecture, a form of drawing whose power lies in its essentialization of the building as shape.

Drawing's Opacity

And yet, the representational power of combined orthographic projection also forms its boundaries. In order to speak as accurately as they do about shape, size, proportion and spatial relationships, plans, sections and elevations ignore many architectural qualities. The majority of these limitations belong to drawing *tout court* and are not specific to orthographic projection. For example, it is often thought that other forms of drawing, perspective for example, can fill in for many of orthographic projection's failures of expression. Perspectival drawings can capture effects that speak to other architectural aspirations (quality of light, materials or atmospheric effects), but such effects can only be imported into drawing. Drawing can mime their presence, but it cannot teach these qualities. The exploration of light's play across a surface, the tendency of a material to absorb this light or seem luminous, the play of primary and secondary reflections are all processes which require physical models and the most careful and attentive of observational powers. To the extent that perspective-based picturing works to

trigger certain visual "reality effects," the process of generating such a naturalizing representation can slow the eye and intensify the gaze, but what this process teaches is seeing. It is not capable of teaching about light or material effects from within its own logics. Its rules speak about observation, and to the extent that the qualities of materials or light can be learned through observation, drawing can assist this process, but drawing can not generate knowledge about these effects on its own. Orthographic projection can, however, resolve questions of form. Without the need for a referent, it can telegraph decisions made in one plane onto the other two. It can expose collisions and suggest solutions for the three-dimensional crises formed when the inner eye fails. The combined use of plan, section and elevation functions as a set of prescription lenses for our ability to imagine in three dimensions. No matter how reliant a design is on eidetic forms, drawing brings into focus the implications of those ideas which cannot help but remain unresolved in the space of imagination. Drawing can generate formal knowledge, but it cannot behave this way with other qualities.

In the end, it is this power, drawing's ability to create knowledge about form, and the implicit agreement that architecture is about form above all else that defines the designs of the last 500 years. This is not to say that building before the Renaissance lacked form, or formal considerations, but to substitute formal considerations for all others is the marker of the architectural discipline. So long as drawing is the major tool of architectural design, so long as it serves as architecture's conceptual medium, there can be no other option. It is not surprising then given the extent of what drawing ignores in exchange for its ability to prefigure shape, that its dominance has come under question, that it has become the locus of inquiry and challenge within architecture, and not just in

recent years since the rise of computation as a new medium of design. In fact, drawing might be understood to force its own challenge because the transparency pact that it establishes only works so long as the object remains the focus of architecture. When objects lose their primacy, when other considerations outside of the "thingness" of architecture begin to occupy intellectual concentration, then drawing starts to lose its relevancy in architecture.

Kahn's Challenge

For example, the architecture of Louis Kahn creates, perhaps, the most clear projection of non-formal thinking into design. Part of Kahn's aesthetic was derived from the construction-process, manifested in the exposed joint lines of the concrete-forms or in his signature unfilled form ties, for example. [See Figure 34]. These features each index or receive the imprint of certain specific aspects of the building's construction, but together they recount a larger story. Taken as a whole they transform Kahn's architecture into an icon of the process of building, a process whose re-telling had, in Kahn's hands, become one of architecture's aesthetic goals. [Figure 35]. As poetic as Kahn's work was, however, there was a tension to be found between his own methods of creation and the methods he so beautifully expressed. Although Kahn's appreciation of building as a craft and an art was profound, this focus lay outside his own inherent process of creation. The needs and procedures of building are not automatically encoded in by drawing. Instead, Kahn brought his tacit understanding of construction to drawing and translated its processes into formal terms through his own use of drawing as a design tool. In so doing, he appropriated the processes of another discipline as architecture's focus.

Kahn's own focus on process was also not surprising. Drawing's adoption during the Renaissance was a reflection of the dominant episteme of the time: the belief in visual observation as a source of knowledge. The practice of design through drawing is continuing affirmation of vision's place within contemporary technological and epistemic principles. However, throughout the nineteenth century a series of shifts occurred in science and industry which placed emphasis on principles, on the *Urphänomene* rather than its instantiation, on the process over the product.[224] In short, during the nineteenth century the focus on things had begun to shift. Such ideas percolated through nearly every kind of nineteenth-century history and science, often shaping and suggesting methods for the new disciplines. In each of these emerging fields, discoveries of formal pattern and organization were cited as evidence of process.[225] The focus on "things"

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[224] My reference here is to Goethe's definition of morphology and *Urphänomene* as a formal principle which allows categorization and ordering. Joan Steigerwald, "Goethe's Morphology: *Urphänomene* and Aesthetic Appraisal," *Journal of the History of Biology* 35, no. 2 (2002). To use Goethe's words, these systemic patterns were thought to reveal the "pure phenomena" behind their forms. Another name for these "pure phenomena" is process.

By the dawn of the twentieth century, morphology, or the study of form, would be acknowledged as "the foundation of all biology." Significantly, the questions taken on by morphologists could be applied in cross-disciplinary ways. "Did organization capture the essence of an animal's life? What was the relationship between the animal as a unified whole and its parts? Betweens the body's structures and its mode of life?" Such questions led to a primary dichotomy within morphological study readily apparent by the twentieth century. This division existed between those who saw "the body's structures as the primary, independent factor controlling animal life and those who [viewed] such structures as resulting from the functional needs of the organism." Lynn K Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900* (Chicago: University of Chicago Press, 1995), 1-7. and Hans Driesch, *Science and Philosophy of the Organism*, 1908, p. 17 quoted in Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900*, 1.

Collins attributes this confusion to the fact that morphological study took on both living and non-living forms (animals and plants), thus resulting in the debate over whether morphology was concerned with interrelated structures of things that live or the structures of things that grow. Such questions might be equally applied to architecture, and many other pursuits throughout the nineteenth century. At the heart of this discrepancy is the question of whether form follows function (the body's structures "as resulting from the functional needs of the organism)" or function follows form ("the body's structures as the primary, independent factor controlling animal life"), a debate which would have ramifications when applied to architecture well into the twentieth century. Peter Collins, *Changing Ideals of Modern Architecture 1750-1950*, 2nd ed. (Montreal: McGill-Queen's University Press, 1998), 151.

[225] In each of these emerging fields, discoveries of formal pattern and organization were cited as evidence of process. For example, Buffon's *Histoire Naturelle* (1749) posited the idea through the examination of living forms one could visualize the "improvement" or "degeneration" of species. Darwin's discovery of

which used to be predominant object of inquiry, things which could be observed visually, had shifted to a focus on the principles which shaped the things.

Architecture also responded to this reorientation. [Figure 36]. For example, here, Viollet-le-duc tells architects to take a principled approach to the design of an object:

> Naval architects and mechanical engineers do not, when they make a ship or a locomotive, seek to recall the forms of a sailing ship of Louis XIV's time or those of a stage coach…they obey blindly the new principles given to them, and produce works which possess their own character and their own style.[226]

To change the character of architecture, Viollet-le-Duc argues, to make it more honestly transparent, only required that the architect change how design was approached. The transparency pact was still in operation, but Viollet-le-Duc's analysis modified its terms. He expanded the terms of transparency away from architectural form and towards the internalized phenomenon that gave logic to those forms. If the building was to function like a machine, then the architect should behave as the mechanical engineer; if the building was to speak, then the architect should act as the poet; if the building was to grow, then the architect should manipulate the laws of its development. Auguste Choisy also suggested that it was process that governed style. In *Histoire de l'Architecture* he writes, "Style does not change according to the caprice of more or less arbitrary fashion, its variations are nothing but those of processes."[227] Reyner Banham summarized Choisy's beliefs by saying that he viewed "form as the logical consequence of

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evolution was similarly a process inferred through formal study, but it was not only the natural sciences where such an emphasis on pattern could be found. The discipline of comparative philology, traceable to the late eighteenth-century (re)discovery of Sanskrit, similarly led to a quest or the universal, pan-linguistic structures that could describe a progressive lineage of language. In all of these studies, form was not seen as an end in itself, it was not just the shapes of plants or animals or languages that were interesting, but the patterns and trends these shapes formed in relation to one another.

[226] Viollet-le-Duc, *Entretiens sur l'Architecture*, 1863 quoted in Collins, *Changing Ideals of Modern Architecture 1750-1950*, 162.

[227] Auguste Choisy, *Histoire de l'Architecture* quoted in Reyner Banham, *Theory and Design in the First Machine Age* (London: The Architectural Press, 1960), 24.

Technique."[228] What each of these arguments assumes is that by focusing on process, architecture could achieve a new, more complete transparency. Not just the Renaissance transparency between the building and its image, but a deeper consistency that penetrated through the forms of architecture to a set of logical principles and systems for which such forms became iconic. This intellectual tendency could be similarly found in other fields where the discovery of governing principles and processes like evolution offered a greater understanding of the natural world. An architecture that did not cover over its own inherent principles and process, one that was procedurally transparent, could not help but be a pure cultural expression of its own time. Perhaps one of the most eloquent sources of this drive for honesty is John Ruskin who thunderously condemns deception in his *The Seven Lamps of Architecture*. After establishing that dishonesty in architecture is more heinous than it is in the other arts, Ruskin ends by writing:

> We may not be able to command good, or beautiful, or inventive architecture; but we can command an honest architecture. The meagerness of poverty may be pardoned, the sternness of utility respected; but what is there but scorn for the meanness of deception?[229]

According to Ruskin, an honest architecture did not dissemble, it expressed precisely what it was. Such a transparent approach would lead a modest building to appear modest, and a humble building to appear meager. While such expressions may still have been seen as aesthetically flawed, in the face of transparency all such flaws were pardonable; dishonesty, on the other hand, was not.[230] This belief in transparency as a transcendent, redemptive aesthetic defined much of the architecture of the late nineteenth and first-half

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[228] Ibid., 23.
[229] Collins, *Changing Ideals of Modern Architecture 1750-1950*, 107.
[230] This formulation may be seen to counter formulations like those in Ralph Waldo Emerson's essay, *Art* (1841) which criticize American architecture for the selfish and even cruel aspect of its great mechanical works. Peter Kohane and Michael Hill, "The Eclispe of a Commonplace Idea: Decorum in Architectural Theory," *Architectural Research Quarterly* 5, no. 1 (2001): 72.

of the twentieth centuries. No matter the flavor of architectural expression, so long as it was honest, so long as the building could be understood as a transparent medium, the design was ethically, if not quite aesthetically, redeemed. Although all these theorists suggest that a transparent engagement with process was the key to reorienting architecture, following their suggestions was an impossible task, made so precisely because of the kinds of transparency drawing allows and the kinds it does not.

The problem is that drawing does not easily allow one to focus on process. The architectural drawing is unapologetically focused on the object, and although drawing is the process that enables design, it tends to diminish or disguise its role as a process in favor of a strong sense of truth correspondence between it and the object it represents. Patrick Maynard summarizes this phenomenon when he writes of Plato's description in *Meno* on the method for doubling the area of a square. In the resulting figure, Maynard notes, "the drawn shapes we see may have been understood in terms of operations…[but these processes are] not visible in the product."[231] Maynard's point is that although the process of drawing encodes one form of knowledge (the procedural), this knowledge is only present during the active stage of process. Once complete, the drawing becomes an object that is, paradoxically, both an absolute document of its process of formation and nearly opaque in what it communicates about that process. Today, and for that matter throughout the last 500 years, the prevalent understanding of architectural drawing is as a

[231] Patrick Maynard, *Drawing Distinctions: The Varieties of Graphic Expression* (Ithaca, New York: Cornell University Press, 2005), 12.

noun rather than a verb, as an image rather than an act, thus making architecture's focus object-centric rather than process-centric.[232]

So, while it is possible to hear the call for an architectural reorientation fairly early on in the quest for an honest architecture, such calls tend to stay on the abstract rather than the concrete level. As a result, even as architects may have begun to question their own processes, when they turned to incorporate these concerns into drawing, they were inevitably re-directed onto the objects of architecture rather than their own processes of design. When Kahn sought to clarify the architect's relationship to the process of building, he had no choice but to import a process external to his own, no choice to translate processes foreign to his own into drawing's terms.

Modernists and Drawings

Of course, Kahn was not the first to confront the growing gap of expression between drawing and building. Le Corbusier was keenly aware of the conflict between drawing and design. In *Vers une Architecture* he writes at length about the tendency for the page and its rules to delude designers. He makes this point in his writing about the plan:

> To make a plan is to clarify, to fix ideas.
> It is to have had ideas.
> It is ordering these ideas such that they become intelligible, feasible, and transmissible….
>
> [At the *École des Beaux-Arts* the plan] has become a sheet of paper on which black marks that are walls and lines that are axes play at being mosaics and decorative panels, make diagrams with dazzling stars, create optical illusions. The most beautiful star becomes the *Prix de Rome*. But

[232] Mario Carpo argues brilliantly that evidence of this changed understanding of drawing is to be found in the changed use of image within architectural treatises of the fifteenth and sixteenth centuries. See Carpo, "Drawing with Numbers: Geometry and Numeracy in Early Modern Architectural Design."

> the plan is the generator, "the plan determines everything; it is an austere abstraction, an algebrization dry to the eye." It is a plan of battle. The battle ensues, and that is the great moment. The battle consists of the clash of volumes in space and the morale of the troops is the bundle of preexisting ideas and the driving intention. Without a good plan nothing exists, everything is fragile and does not last, everything is poor even under a clutter of opulence.[233]

The slippage that Le Corbusier makes use of between the general and architectural meanings of plan is not insignificant. It expresses an equivalence in his mind between concept and that one-third of triadic form most invisible to the embodied eye. In what is alternately referred to as "Plan" and "The Illusion of the Plan" in *Vers une Architecture,* Le Corbusier is clear about his belief that figuralism, the rendered, decorative aesthetic of the drawing on the page pursued by the *École des Beaux-Arts*, was a distraction from the plan's essential function as the idea of a building. To be clear, Le Corbusier's idea of a building is not the imagined platonic ideal that the Renaissance transparency pact formed. His idea is a manifestation of the newly expanded transparency, of the regulating logic that dictates formal expression.

When conceived of as the idea, the essence of a rationalized system, the plan became particularly apt to extensibility beyond the building. For example, when the plan became equivalent to an idea about circulation and the ways in which types of circulation could be systematized, it could be applied to many different scales of design. Such an understanding of design can be found in Werkbund's approach, which conceived of an equivalence between the design problem posed by a chair and that of a building. And yet this scalar transformation of design occurred in both directions. Design-qua-systematization allowed designers to apply their craft to ever-larger exercises. The plan could govern more than just the intent for a building. It could regularize and encode the

[233] Corbusier, *Toward an Architecture*, 215.

intent of entire cities. Such visions aren't precisely new. During the Renaissance, grand city planning images were created for both ideal cities like Sfordinza as well as real ones like Rome as in the case of Pope Nicholas the V's from Alberti's time. However, this earlier application of architectural principles to the urban fabric did not take the same abstract and systematized approached. Unlike the earlier designs on a large scale, this new city planning was not based merely on the line, not on axes or the "beautiful stars" Le Corbusier found so condemnable, it was not an *ex post facto* web of prospects connecting monuments. It was, instead, the systematized rationalization of design applied to whole cities. Like a complex machine, the city could be understood as a series of prefigured systems interlocked into the urban totality. Le Corbusier's City for Three-Million as well as Frank Llyod Wright's Broad Acre City are both examples of this drawn systematization as a means to solve the problem of design presented by the city.

Interestingly, although Le Corbusier advocates the abstract qualities of drawing, he recognizes a conflict between architecture and design, between the experienced design and the one schematized in the abstract space of drawing. Partially, this conflict is expressed in his rejection of the figural within architectural drawing, in his rejection of the experience of the eye. The drawing that appeals to vision, that delights the eye through beautifully composed "stars" or through illusionistic perceptual play, is to be avoided, he writes.[234] The plan is a desiccated thing, "dry" to the eye. He advocated for the idea, the conceptualization of architecture possible through drawing, while denying the representation, the figural trace on the page. Le Corbusier's conflict splits drawing away from itself, valuing the abstraction it engenders while rejecting its material and phenomenological aspects.

[234] Ibid.

In a sense, Le Corbusier's response is perfectly reflective of the way in which drawing is both an expansive and instrumentalizing tool of design. To the extent that things have shape, to the extent that they are formal, drawing is a profound tool for helping us not only to communicate these forms but to better understand them. It is, in fact, the slow process of careful looking, formulating and then testing understanding, through the comparison between the multiple views of architectural drawing, that makes it such a compelling tool for bringing artist and viewer together.[235] And yet, for all its power to communicate and augment knowledge of shape, and for all the seeming validity of the belief that shape-knowledge should be essential since architecture is essentially about things, from the nineteenth century onward, drawing's form-centric focus created more and more problems. Eventually, as architecture placed and ever-greater emphasis on process, the shortcomings of drawing could no longer be ignored.

Drawing allowed Kahn to analyze and control the formal expression of the processes he wanted to express, but it offered him no means to augment his understanding of construction. The act of drawing is not representative of the act of contruction, and instead only allowed him to intervene in the formal expression of these acts. It allowed Kahn to design indexes of these acts but not to work with them directly. Kahn's knowledge of and intervention in the constructive process was made remote and abstract by drawing. Through drawing, he could influence process, force it to leave behind certain marks, but not actually engage and interact with it.

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[235] The similarities between this process of comprehension and the process of creation involved in the making of a drawing should not be ignored. The making, matching and remaking process that Gombrich described for drawing is replicated as a viewer makes, matches and remakes her understanding of a drawing's subject matter: "for all the skill of hand and eye that marks the master, a constant readiness to learn [is the signature of the Post-medieval artist], to make and match and remake til portrayal ceases to be a second hand formula and reflects the unique and unrepeatable experience the artist wishes to seize and hold." Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation.*, 173.

Index as a Path to Transparency

To understand what it means for Kahn to have integrated process through his control of its indexes requires an exploration of the index itself. In the mid-nineteenth century, C. S. Peirce offered up the concept of the index as part of what he called the trichotomy of signs: likenesses, indices and symbols. Indexes are representations based on, to use Roland Barthes' term, *quasi-identity* rather symbolic representation.[236] A footprint in sand is often used as the classic example. The indentation not only resembles the foot that made it, but provides evidence of that foot's actual presence. The imprint is reversed, but identical to and stands in for that foot, creating a quasi-identity for it. The index, Peirce argued, sat in the middle of this trichotomy because it marked a junction point of connection and experience.

> The likeness has no dynamical connection with the object it represents; it simply happens that its qualities resemble those of that object, and excite analogous sensations in the mind for which it is a likeness. But it really stands unconnected with them. The index is physically connected with its object; they make an organic pair. But the interpreting mind has nothing to do with this connection, except remarking it, after it is established. The symbol is connected with its object by virtue of the idea of the symbol-using mind, without which no such connection would exist.[237]

In other words, the index holds a unique position within representation. The index is both more than a shared characteristic and more than metaphysical joining of two dissimilar objects. It is a structure that is both inherent to the material presence of an object and transcendent of that material presence, requiring the insight of experience in order to be understood. Where likenesses rely on resemblance to create their relationship with the thing to which they refer, and symbols rely on convention in order to establish their

[236] Barthes quoted in Rosalind Krauss, "Notes on the Index: Seventies Art in America," *October* 3 (1977).
[237] Charles S. Peirce, Nathan Houser, and Christian J. W. Kloesel, *The Essential Peirce : Selected Philosophical Writings* (Bloomington: Indiana University Press, 1992), MS 404, section 7.

relationship, through their physical connection to it, indexes *reveal* something about their referent.

For example, understanding a medium like photography, Peirce argued, requires that we see it as more than just a likeness.

> Photographs, especially instantaneous photographs, are very instructive, because we know that they are in certain respects exactly like the objects they represent. But this resemblance is due to the photographs having been produced under such circumstances that they were physically forced to correspond point by point to nature. In that aspect, then, they belong to the second class of signs, those by physical connection.[238]

Rosalind Krauss nuances Peirce's definition arguing that while a photograph offers an "exact" likeness of certain aspects of its referent, a great deal of its significance stems from the process that created the likeness, and the way that process writes a different kind of meaning into the photograph. In other words, categorizing a representation as icon versus likeness versus symbol, can be seen as reliant on both the kinds of knowledge it embedded in the representation and on the kinds of knowledge sought from it. For example, if a photograph is used as a memento of someone's features, it is understood as a likeness. However, if it that same photograph is used to document that someone was at a certain place, a presence documented in the photograph, then it functions as an index. Alternatively, when an artist draws a design for the purposes of ascertaining "whether what he proposes will be beautiful and satisfactory," he uses the image as a likeness.[239] If however, the design is examined to trace the process of excogitation on the part of the artist, the image is then understood to be an index.

Krauss makes another essential point about the index through Barthes: that the

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[238] C.S. Peirce, "Logic as Semiotic: The Theory of Signs," *Philosophic Writings of Peirce*, New York, Dover Publications 1955, p. 106 quoted by Rosalind Krauss, "Notes on the Index: Seventies Art in America. Part 2," *October* 4 (1977): 63.
[239] Peirce, Houser, and Kloesel, *The Essential Peirce : Selected Philosophical Writings*, MS 404, section 7.

index operates as a "*message sans code,*" which is to say that it operates outside the usual institutional, symbolic or aesthetic systems.[240] Krauss writes that the "connective tissue binding the objects contained by the [index] is that of the world itself, rather than that of a cultural system."[241] She uses this idea to explain why text and captioning are so important to an artist like Duchamp, as they begin to position and explain the piece. Such a positioning is necessary since the historical understanding representation is circumvented by the index, leaving no code through which one can understand what a piece communicates. The truth correspondence of the index is so absolute that the usual avenues to nuance the meaning of representation are closed. All that remains is the presence of the object. Krauss argues that text is used as one manner of filling in for this absent code, and her explanation is helpful when reflecting on architecture.

> the new architectural conformation does not however aim to signify socializing or symbolic contents in accordance with a centuries-old custom that immediately made them understandable to common sense. The 'subject'—or 'argument'—of the work are rather the processes and the system of rules which an increasingly skilled craft—and art—impose upon the architectural object[242]

In other words, as architects increasingly engaged the processes which give their designs form, rather than the forms of the objects themselves, ideas of style and decorum become more and more irrelevant as a source of meaning. The symbolic meanings inhered by such historical/cultural systems lose their footing. And yet, drawing does not allow the architect to turn away from form altogether. While a designer may reject the traditional formally based aesthetic systems, the process of design through drawing inevitably

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[240] Roland Barthes, *Camera Lucida : Reflections on Photography* (New York: Hill and Wang, 1981). quoted in Krauss, "Notes on the Index: Seventies Art in America. Part 2," 60.
[241] Krauss, "Notes on the Index: Seventies Art in America. Part 2," 60.
[242] Bruno Reichlin, "Reflections Interrelations between Concept, Representation and Built Architecture," *Daidalos* 1 (1981): 69.

redirects focus back onto the object and its forms. As it did for Kahn, rather than allowing one to concentrate directly on process and causation, drawing puts attention on its expression, on its indexes. Architecture's new rhetoric becomes that of these indexical systems. Different processes engender different codes, but these differences are only taxonomic. Their bases, the core of their structure, are the same. The source of their meaning is their unified assent to the importance of process, and their ineluctable translation of procedural logic into the formal logics of drawing.

Eisenman's Challenge

With hindsight it seems inevitable that Kahn's attempts to incorporate processes external to architecture could only be answered with an attempt to interrogate architecture's own processes, which is to say the architect's process of design. This is precisely the response that Stan Allen was seeing when he argued that since the seventies a design-centric "attention to process has been the explicit sign of a conceptually ambitious, theoretically driven work." [243] Allen attributes this turn to process to Peter Eisenman, whose architecture, Allen argues, stands in evidence of his design process, offering a means for the visitor to reconstruct and reanimate the "motions" involved in Eisenman's process.

> Beyond specific references to his formal vocabulary (which are really quite rare), any time we see work that justifies itself by reference to the history of its design process…we are in the territory first mapped out by Eisenman in the seventies [244]

[243] Stan Allen, "Trace Elements," in *Tracing Eisenman: Peter Eisenman Complete Works*, ed. Cynthia Davidson (New York: Rizzoli, 2006), 63.
[244] Ibid.

Eisenman ceases to use process solely a means to something else, and instead makes process the artistic focus of his design. As a means of following Allen's argument further and giving precision to Eisenman's contributions, I would like to narrow the focal range of Allen's argument to a specific architectural work. Where Allen speaks of Eisenman's *oeuvre*, I would like to offer a specific reading of a single project, to substantiate Allen's argument. The building is Eisenman's House VI.

House VI was one of Eisenman's first built designs. [Figure 37]. Commissioned by Suzanne and Dick Frank, and, therefore, more traditionally named the Frank House, Eisenman designed and initially constructed House VI from 1972-1975.[245] Proponents of the design, including Kenneth Frampton, see the building as the apotheosis of Eisenman's work, citing its intricate geometry and "dense orchestration of compacted form, comprised simultaneously and to the same degree of planes, transparencies, volumes, and masses."[246] The criticisms of House VI have focused on the lack of rigor in the building's detailing and construction, and on what might be summarized as Eisenman's emphasis on the intellect to the detriment of other human needs or sensibilities. Interestingly, both sides of the debate make accurate points in their description of the project's successes and failures. This collision begins to frame the building's significance, illustrating one avenue to understanding the building as an expressive and timely piece of architecture.

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[245] A small building enclosing just 1500 square feet in Cornwall, Connecticut, and sited on an irregular site of six acres, House VI stands about 40 by 25 by 20 feet high. The building was Eisenman's second design to be constructed, and perhaps as a result of his relative inexperience with detail, or perhaps due to his disregard for it, the Frank house suffered severe construction failures as originally built. In 1987 it became necessary to strip down to its structural system and rebuild it. Suzanne Frank, "The Client's Response," in *Peter Eisenman's House Vi: The Client's Response*, ed. Suzanne Frank (New York: Whitney LIbrary of Design, 1994), 49-50.

[246] Kenneth Frampton, "Preface," in *Peter Eisenman's House Vi the Client's Response*, ed. Suzanne Frank (New York: Whitney Library of Design, 1994), 13.

To read House VI as an index means to understand the geometric complexity Frampton praised as a trace of Eisenman's own design process. Like a detective, a visitor must unravel the evidence left behind to reconstruct events they have not directly experienced.[247] The "events" that define Eisenman's buildings are the serial transformations of the geometries structuring his designs. As Allen suggests, Eisenman's work "presumes the viewer's ability to 'read' the building by decoding the traces and reconstructing the narrative of design procedures."[248]

The actual procedures Eisenman used are most clearly visible in his own process drawings, rather than in or on the building, itself. These reveal a relatively simple point of genesis for the design: a grid subdivided into a four-square and nine-square. [Figure 38]. He imbeds these one into the other, and then pushes on the fractal-like recursion of the four-square geometry inherent in the nine-square by cropping the original whole back down to one of its corner four-squares. As Eisenman writes on this sheet, this move creates "two centers" out of the original one. [Figure 39]. Having settled on this geometric structure as the one from which he will derive the rest of the design, this first phase of Eisenman's process, the geometric one, had ended.

The next step in Eisenman's process is to determine which geometric gestures will receive material instantiation in the house and how. Following the doubled grid he constructed in phase one, Eisenman traces its patterns through a series of materialized clues which make up a perceptual game of presence and absence within the house. [See Figure 40, Figure 41, Figure 42 and Figure 43]. As this series of images demonstrates, this second phase of his process has no resolution, no moment of harmonious stability

[247] Carlo Ginzburg. "Clues: Roots of an Evidential Paradigm," in *Clues, Myths and the Historical Method* (Baltimore; Johns Hopkins University Press, 1989) paraphrased in Allen, "Trace Elements," 52.
[248] Ibid., 60.

that terminates the design. Instead, this interminable process turns House VI into a moment of frozen process. Eisenman has written that, "the building is not an object in the traditional sense, not the end result of a process, but more accurately a record of a process, so that the process itself becomes the object."[249]

However, while this second part of Eisenman's process may be never-ending, his geometric process has a resolution. It was a composition of wholes; ideal forms that served to organize the design, which were then cropped. This process is separate from the experimental instantiations of the grid which will become the incomplete, partial trace that is House VI. Eisenman acknowledges this rupture writing that, "[o]nce the conceptual structure [of House VI] is understood, it detaches itself from the initial physical experience."[250] It is this opposition between the two forms of perception and between his two processes of design that allows Eisenman to say that a dichotomy lays at the core of the building.[251] Eisenman's purpose is to divorce the physical presence of a building from one's conception of it. He seeks to divide the more usually integrated flow

[249]Peter Eisenman, William Gass, and Robert Gutman, "House Vi," in *Peter Eisnman's House Vi the Client's Response*, ed. Suzanne Frank (New York: Whitney Library of Design, 1994), 23.
[250]Ibid.
[251] Eisenman has taken pains to stress the importance of disharmony and incompletion in architecture. Informed by Foucault, he sees the transgression of wholeness as a displacement of an anthropomorphic center and reflection of the alienated self: "If you say A/B A/B, that is an alternation of wholes outside of the classical canon, which tries to take A and B and bring them into symmetry -- as in B/A/B/A/B.…When you have A/B/A/B/ you have alternating pairs with no center, closure or hierarchy. A/B/A/B/A is complete. A/B/A/B is not." Christopher Alexander and Peter Eisenman, "The 1982 Debate: Contrasting Concepts of Harmony in Architecture," in *Studio Works 7 (Harvard University Graduate School of Design)* (Princeton: Princeton University Press, 2000).

It is interesting, then, that House VI as an asymmetrical, disharmonious and dynamic composition is resolved as a series of symmetric, stable wholes, as these are the geometries that began the design for Eisenman and the eidetic forms that serve as the mind's geometric vocabulary. These platonic and ideal geometries are incomplete, but irrepressible in the design. Denied, obfuscated nearly to the point of permanent invisibility, it is their order that rules over the interrelationships of the parts, and it is their order that a visitor discovers lying beneath the forms of the house. Eisenman might claim to love instability but he can't define himself or his designs without the harmony he claims to find so uninteresting. It is the original, classically symmetrical order that gives meaning to the interrelationships of his incomplete ones. Without the original harmony to regulate it, Eisenman's incomplete order is no order at all, and the dichotomy that is so important to activating the visitor cannot be created.

between percept and concept. This is not just an ex post facto reading applied to his work, it is written in the bifurcated processes he employs. The reason for this doubled process and the tension it creates between percept and concept is to create in the visitor an activating dissatisfaction with the design. Eisenman writes that within House VI, the "particular juxtaposition of solids and voids produces a situation that is only resolved by the mind's finding the need to change the position of the elements."[252] In other words, Eisenman's goal is to create a kind of sliding puzzle out of House VI. He wants to reanimate his process of design, thawing that process the building froze in its instantiation. For Eisenman, the building is not a stable thing, but an active and mobile actor in the environment, a conception at odds with our perception of the building as a stable, solid artifact.

To play the game as Eisenman intends, however, one must first discover the rules by which he was playing. It is through this new process—the visitor's process of experiencing and attempting to deduce what is documented in his design drawings through the physical trace of the building, that House VI truly becomes indexical. In acknowledging that there is a dichotomy at the core of the design, Eisenman acknowledges that the game he lays out is, in fact, doubled. The house might be perceived as an architectural sliding puzzle, a complex and unstable reality, but its conceptual key is neo-platonic and references classicizing aesthetic traditions within the architecture. Both parts of the game rely on the idea of the index but each refers to a different kind of causation, a different formative process.

The perceptual index references the second stage of Eisenman's process when he experimented with the various instantiations of the geometric grid he designed. Here he is

[252]Eisenman, Gass, and Gutman, "House Vi," 23.

indexing his process of selection and expression. He emphasizes some grid lines over others and chooses how they will be expressed (here as wall, there as slot, et cetera). Through his selections Eisenman undermines the traditional aesthetic and usual sources of architectural meaning. In other words, he un-codes his messages, establishing the fact that what he wants to communicate lies outside established aesthetic customs. The typical functions of a house and the cultural meanings of its spaces and elements are demonstrated as irrelevant. Bedrooms lack; doors become columns; columns hover above the ground supporting nothing. What is left is the establishment of the particular identity of House VI as this physical manifestation among an exponentially large variety of what could have been produced by the grid. House VI stands for itself above all, for this set of decisions above the others. In this sense, House VI is an index for Eisenman's presence, a signature of his design sensibilities and the refined decision-making process only he as designer could have engaged. Eisenman is the causal object. However, the minute a visitor engages in the sliding puzzle game that Eisenman lays out (indeed, he would argue that such an engagement is unavoidable due to his "particular juxtaposition of solids and voids"[253]) the stability of the building and Eisenman's role as author begin to waiver. The building stands for itself above other possibilities, but when a visitor mentally experiments with these other possibilites, they too are presenced. Within the sliding puzzle game House VI also serves as the quasi-identity for all of the other instantiations which the grid could have structured. Eisenman is presenced as author of this house, but unlike Krauss' argument where the index presences the causal author

[253] Ibid.

absolutely, House VI manages to remain ambiguous. Eisenman and his House VI compete alongside the visitors and all of their versions for authorship and presence.[254]

It is in this moment of ambiguity when the presence of the causal object becomes tenuous and insufficient that Eisenman re-highlights process. Underneath these games of the *perceptual* index, as both the building and Eisenman's drawings demonstrate, lies an entirely different process. Arguably, Eisenman's sliding puzzle game, and the competition he sets up between his House VI and all those possibilities residing in the visitor's mind, all serve as a mask for the real author of all the House VIs. That author is the grid.

The grid stands as the idea, the ideal form materialized by the building. To the visitor, the grid that Eisenman designed is a mathematical system, a set of rules that govern decision-making. In this way, the grid itself can be seen as an origin, a causal object, or at least a boundary across which visitors are denied access. In this manner, Eisenman relies on a classic (Classical) architectural aesthetic which seeks to highlight the Neo-Platonic gap between design and built form, between the "ideal" and the "real". Eisenman's efforts and decisions to instantiate the grid, along side the similar efforts he engages within the visitor, become acts of translation between these ideal and material forms. Such an understanding underlies much of architectural practice where the senior architect does the creative design and the junior designers do the less prestigious work of translating the creation into reality. In one sense, then, House VI could be read as an attempt to reify the highest form of architectural design. Eisenman engages visitors in the

[254] These expressions of multiple authorship may lie outside the typical architectural dialog, but it is an aesthetic move in conversation with ideas about authorship from literary and artistic circles at the time. Perhaps it is better understood as a *message code transposé*, a move which is relevant within larger cultural circles being applied and adapted to the architectural aesthetic, the rules from other disciplines serving as a caption for their application here.

design process, but only of the translative type. His own generative process through which the grid was designed is hidden. The building presences the grid, but does not explain it.

And yet, although the grid behaves as a screen, implying that it is the origination point for the design, it is still not a compositional ur-form. Instead, as Eisenman's own design drawings show, its own point of origination are the traditional, neo-classical, patterns of architectural composition. The nine-square and four-square patterns he intersects are the same ones Wittkower found in his analysis of Renaissance proportions, and are the same patterns that Wittkower's student Colin Rowe (who was in turn Eisenman's teacher) used to compare Palladio and Le Corbusier.[255] Historically, of course, it makes sense to derive compositional inspiration from the villa type, since as a weekend house, House VI shares with the villa certain class and functional requirements, but Eisenman does not want to reference these historical meanings. Instead, his designs negate the value of these patterns. By overlaying and cropping the two grids, he undermines the properties inherent in them: symmetry, stability, harmony, et cetera. He both contorts and destroys these patterns, but he cannot simply ignore them. He does not start with a clean slate, inventing principles appropriate to a contemporary weekend house, but instead responds to the cultural system within which he was trained. In so doing, he acknowledges the continued relevance of these grids within House VI's architectural environment, within its cultural ecology, all the while Eisenman opposes their propriety for the post-modern house.[256] They are present within his architecture, but in the face of their presence Eisenman can only emphatically disagree. He cannot engage

[255] Rudolf Wittkower, *Architectural Principles in the Age of Humanism*, The Norton Library (New York: W. W. Norton, 1971).
[256] Susan Buck-Morss, "Apocalyspe at the Getty," (Los Angeles: The Getty Research Institute, 2008).

these principles or alter them to be something that he views as more appropriate, and significantly neither does he generate alternate principles which do. His is a claim of "NOT THIS" without the offer an alternative point of origination. His intention is simply destructive.

Through this negation, however, history is indexically marked in Eisenman's work. He presences the compositional history of architecture without allowing its design traditions to be engaged. In effect, he silences the codes that usually allow architecture to speak, his own voice and explanation of the design filling in. In other words, Eisenman differentiates his work as a *message sans code* against the foil of a traditionally encoded, historic architectural aesthetic.

> …architects have traditionally been very slow to understand that culture has been turned upside-down, all by itself. When we have science fiction movies, the people from Mars come down, and they speak in mathematical terms. They speak in mathematical terms because it's a universal language. This house, in a sense, speaks in mathematical terms that Martians could understand. What that is saying is that you don't have to be from the elite of society, you don't have to know architectural history, cultural history, social history, you just have to come and experience the house. This is a house that any man could understand and be sensitive to because it speaks in universal terms….That's what I am talking about. It doesn't speak in the classical conventions that only the learned and the elite understand. It is a house for everyman. That's exactly what I am saying. And it speaks to the America of today not the patrician America of two centuries ago.[257]

Eisenman's work suggests that history is both here and that its principles are worthless. While he claims that his design speaks to the America of today, in truth the design only argues for the need to speak a different language, it stops short of offering a new code and is, instead, trapped by a voice which can only comment against the old one. Perhaps

[257] Quoting Eisenman in Robert A.M. Stern, "Dream Houses," in *Peter Eisenman's House Vi the Client's Response*, ed. Suzanne Frank (New York: Whitney Library of Design, 1994), 43-44. Transcription is my own from the video of Dream Houses.

more so than the architectures that have followed Eisenman's message in House VI is "not this code." In this sense perhaps House VI succeeds at being a *message sans code* better than others; for it is only in this liminal moment, only at the point of negation before a new system is in place, that symbolic meanings can be so completely suppressed.

Eisenman's Transparency

To my mind, then, Allen's use of the index as an interpretive key to Eisenman's work is, indeed, tremendously fruitful. Towards the end of his critique, however, Allen argues that by turning the focus of design back onto its own, Eisenman creates a self-referential spiral, a spiral within which design becomes closed off, speaking only to itself and doomed to irrelevance.[258] However, I believe that my analysis of House VI as a specific example of Eisenman's use of index, reveals a complex engagement which is not easily dismissed as simple self-reference. Yes, his design activates his own process as a source of meaning, but this focus on process is a starting point for the contemplation of architectural interaction, not the "solution" to some question already formed. The project is an early attempt to form an essential question, and as such, the loop that Eisenman forms is not closed. Eisenman's questioning continues to be relevant today, and can only be seen as insulating architecture when one assents to a definition which situates form as design's central quality.[259] Only when one sees the grid before the drawing, the object

[258] "These operations work effectively to interrogate the means of representation which are foregrounded in process, but they are powerless to engage any material not already implicated in the hermetic procedures of design. The result is a self-referential architecture, locked in the examination of its own history. The effect is to slow architecture down, rendering it incapable of responding to the rapidly changing demands of the city and its technologies." Allen, "Trace Elements," 63.
[259] Ibid.

that rules over design before the medium which calls forth and extracts such objects, only when one thinks about the design process through those things about which drawing enables a designer to think, rather than thinking through the act of drawing as process, does this spiral become closed.

Overtly, House VI is a commentary on the processes and principles of formal composition, but it is also an early attempt to form the essential question that a process-centric architecture demands: can architecture engage process when the medium of architectural design is drawing? With House VI, Eisenman highlights what he views as the myriad failures of historic architectural composition, but in so doing, he also opens the gap between the realities of drawing as an instrument of design and the fictions of transparency that architecture maintains about drawing's role.[260] House VI might itself not contemplate this gap, but as a whole the project demands that the gap be contemplated. In effect, I am arguing that although Eisenman calls out the multiplicity of processes involved within design, his engagement remains predominantly with formal composition and his critique of cultural historical codes. However, the continued relevance of his projects is rooted in the tendency of such commentaries to be held together by a third, implicit questioning of, not just architectural representation generally, but drawing specifically as architecture's conceptual medium.

Eisenman's questions play within these various transparencies, and while Kahn's work implicitly opened one kind of fissure within architecture's transparency pact (through his focus on the construction process and its inevidable incompatibility the

[260] Allen writes: "I would like to suggest also that, while such an enabling fiction may be made explicit, this has not been done in architecture, and that because of this inexplicitness a curious situation has come to pass in which, while on the one hand the drawing might be vastly overvalued, on the other the properties of drawing—its peculiar powers in relation to it putative subject, the building—are hardly recognized at all." Evans, *Translations from Drawing to Building and Other Essays.*, 154.

processes of drawing), Eisenman's self-consciously engages these fissures. In effect House VI is a project contemplating many different failures within the design process. He opens these up so that the gaping hole between the realities of drawing as an instrument and the fictions which architecture maintains about drawing's role are made into objects of contemplation. Making these dissonances visible becomes the purpose of Eisenman's work. In effect, Eisenman's entire work is an index. It points to the representational shifts and instabilities that exist as architecture begins to shift its priorities and its conceptual medium.

Transparency and the Index

The very concept of the index as a form of representation is based on assumptions about the transparency and the honesty of the inscribing process of the medium in which the index is substantiated. It is this promise of honesty which differentiates traditional photography as an index and digital photography as non-indexical. In the case of traditional photography, the photochemical process does not lend itself to manipulation, and even if such manipulation is attempted, alterations to the film are detectable, revealing indications of such efforts. Digital photography, however, encourages manipulation, and alterations can putatively be made without detection, making digital photography a less than honest and transparent medium, or at least a less indexical one. However, the reality is that neither of these processes is inherently more honest than the other. Whether light is recorded through photochemical or digital sensors is not the issue. The honest or deceptive qualities of a photograph are not inherent to the medium so much

as they are inherent to the shared set of assumptions between the artist and the viewer about the process that took place and about what the image presents.

For example, Julius Shulman's 1954 photographs of Los Angeles are not neutral, documentary artifacts of the city. Most viewers accept that his images are carefully edited views of the city, but Shulman's compositional efforts went beyond selecting a different viewpoint or lens. The fact that Shulman used a photochemical process did not prevent his images from being the highly constructed, deceptive and even fictional views of his imagination. In one instance, a rare image of Shulman at work shows potted rosebushes placed directly in front of the camera and tree branches hung from tripods in order to make a newly constructed house appear to be nested into a mature and verdant landscape.[261] [Figure 44]. If a viewer assumes that Shulman's intervention was limited to the selection of the view, the constructed nature of his images break this honesty assumption. Does Shulman document or does he create? If one assumes he was in full possession of his artistic license when composing his views of Los Angeles, then the photographs take on a different role. With an assumption of artistry in place, the photos can be more accurately understood in context. By granting Shulman's status as an artist we gain an understanding of the processes through which the photographs were created, and it ceases to matter whether a photochemical process required that Shulman stage the photos, or whether, had a digital process been available, he could have inserted his roses and tree branches as part of post-processing. Instead, what matters is how the photos indicate Los Angeles' efforts to appear sophisticated, or at least the latent sophistication Shulman believed the city capable of, and the efforts that both took to present Los Angeles in its most aesthetically pleasing light. In short, Shulman's photos demonstrate

[261] "Julius Shulman's Los Angeles," The Los Angeles Central Library October 6, 2007-January 27, 2008.

that the indexical nature of a representation isn't inherent in the medium, but instead depends on the approach an artist takes to the work joined with the interpretive approach taken by the viewer. When these two approaches correspond, a transparency results that allows the representation to operate as an index. When this transparency is compromised, the indexical qualities weaken.

Architectural Transparency as an Icon of Index

House IV works itself into this gap between artist and viewer, and the inherent assumptions of their interdependency as a means to transparency. But, it is not just transparency that is at stake. Through drawing it is a belief in transparency that becomes the foundation for the architectural discipline, and I would argue, it is this fiction that supports all the other forms of transparency in architecture. For as the architect can project an idea on to the drawing board and from there to the builders and into the building, so too can architecture transmit the ideas it encodes back to the world. It is, for example, this belief in architecture as a medium of expression, a medium capable of transparency that enabled the nineteenth century to look for an architecture that could encode its own moment, which could, without deception, present that moment as a definable aesthetic, as a style. The nineteenth-century quest for architectural honesty was really a quest for self-expression, one made possible by the belief in the transparency that drawing supported.[262] Beginning with Hegel, art was increasingly appreciated as the expression of the aspirations of an age, and while Hegel may have limited such powers to societal expression, as "the nineteenth century rode on, art took an expressionist turn; as

[262] Daniel Herwitz, *Aesthetics: Key Concepts in Philosophy* (London: Continuum International Publishing Group, 2008), 78.

individual liberty and desire became thematic in societies, the concept of expression became more personal and individual."[263] The corollary of this idea of individualized expression on the part of the artist was a belief in the individual aesthetic experience on behalf of the viewer. Daniel Herwitz argues that this twinning of souls between the artist and the audience puts an emphasis on process over product.[264]

However, from the mid-1960's onward, theorists like Robert Venturi, Peter Eisenman and Jacques Derrida (among others) increasingly undermined architecture's basis in a transparent and honest expression. Venturi argued that rationalist tendencies which simplified expression were out of step with the "complexity and contradiction" of contemporary culture.[265] While there may have been a longing for simplicity, such theorists posited, any simplified expression could not continue to be seen as a transparent or honest rendering of our culture or our buildings. In their La Villette project documented in *Chora L Works,* Derrida and Eisenman extended this failure of truth, bringing it to a crisis. This project brought together both designer and interpreter for the creation of a collaborative work. Of their efforts Derrida wrote that the project "always causes something else to be said—allegorically—than that which is said….[In sum, it] causes one to lie. The truth of this work lies in its lying strength."[266] By exposing the difficulty, the inevitable falsehoods and impossibility of transparency involved in the La Villette project, Derrida and Eisenman helped to undermine the transparency that had under girded architectural expression throughout the previous hundred years.

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[263] Ibid., 92.
[264] Ibid., 93.
[265] My reference here is to his pivotal book: Robert Venturi, *Complexity and Contradiction in Architecture*, second ed. (New York: Museum of Modern Art, 1977).
[266] Quoted in Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (New York: Thames & Hudson, 2000), 292.

However, what is interesting about Derrida's interpretation is that embedded within the project's message of the impossibility of truth is an assumption that architecture is actually capable of carrying this message. In other words, underneath the "lies" the La Villette project expressed was an acknowledgement of architecture's power to effectively hold such contradictory meanings. So even when the inevitably of lying was the object, the purpose and success of the work depended on architecture's ability to transparently and honestly express such societal or disciplinary paradoxes. In short, it was not architecture's transparency that failed as Derrida asserted. In fact, the project proved that architecture was capable of all the contradictions of present/presence and past/absence the post-modern period wanted. In a sense, Eisenman's work argued that Venturi's complexity and contradiction could be found in architecture without recourse to historicism or pastiche. Less an undermining of architecture's transparency, what the project really worked against was the idea of a stable interpretation, of a single explanatory truth to the exclusion of others. What it highlighted was the opacity that lay between design and interpretation, between preconception and reception. In short, Eisenman and Derrida's project was a critique of the transparency of representational systems, of an architecture that sought to control and instrumentalize meaning, of a narrowly defined relationship between signifier and signified. The project was also, however, a celebration of the object's ability, and in this case the architectural object's ability, to encode more than can ever be made sense of at once—to be, as Reinhold Martin has called it, part of a discursive network made up of "the entire world of words and things that is captured by the deceptively simple designation 'architecture'."[267]

[267] Reinhold Martin, "Empty Form (Six Observations)," *LOG* 11 (2008): 16.

A Battle Over What Defines Architecture

The self-reflexive turn of this inquiry might seem an inevitable development, but it created heated debate within Eisenman's own period. The dialog between those who esteemed Eisenman's viewpoint and those who despised it played out throughout the late sixties and early seventies in what have come to be known as the battle of the "Grays" versus the "Whites".[268] Looking back on this period of discourse, Goldberger wrote that excepting their shared youthful exuberance and love of dogma, more than any other common quality, what held both groups together was their opposition to the other.[269] More than a lighthearted disagreement, the rhetoric between the two sides was often heated. In *Five Architects*, Colin Rowe anticipated that what he called an allegedly pluralist, but, intrinsically, determinist, technocratic and historicist establishment who would manhandle the Whites.[270] Sympathetic to the Gray's theories, in a famous 1982 debate at Harvard Graduate School of Design, Christopher Alexander claimed that Eisenman and architects of his ilk were destroying the world.[271] Exchanges such as this

[268] Eisenman was part of the Whites, thus named for their predilection for white buildings, particularly in the hands of Eisenman and Richard Meier. Other members of the Whites included Charles Gwathemy, John Hejduk and Michael Graves. Loosely organized around "neo-cubist" or "neo-corbusian" principles, in 1975, the 'Whites' wrote and published a book based on their work called *Five Architects.* Peter Eisenman et al., *Five Architects: Eisenman, Graves, Gwathmey, Hejduk, Meier* (New York: Oxford University Press, 1975). The development of this publication inspired an alternate group, the so-called "Grays", lead by Robert A.M. Stearn to write a series of response articles held together under the title, "Five on Five." The other 'Grays' included Romaldo Giurgola, Allan Greenberg, Charles Moore, and Jaquelin Robertson. Echoing the theories of Venturi, the 'Grays' embraced the alternate, more humane rationality of historic and vernacular design methods. Where the 'Whites' sought the purity of Platonic abstraction, the 'Grays' rejected the abstract as a false perfection, preferring instead "the gray shades of reality." Robert A.M. Stearn, "Five on Five," *Architectural Forum* 138, no. 4 (1973).
[269] Paul Goldberger, "Architecture View: A Remembrance of Visions Pure and Elegant," *The New York Times*, January 3, 1993.
[270] Eisenman et al., *Five Architects: Eisenman, Graves, Gwathmey, Hejduk, Meier*, 8.
[271] Alexander and Eisenman, "The 1982 Debate: Contrasting Concepts of Harmony in Architecture."

certainly kept emotions running high, but even in light of their differences, the work of these oppositional groups shared substantial common ground.

Both groups sought to reconsider not just the inspiration for design, not just its address to either the intellect or the emotions, but the very processes through which design was carried out. When Venturi rejected Modernism it was not only its forms but its technique that he attacked.[272] He impugned architecture's top-down approach as he elevated buildings that were contradictory precisely because they were evolved rather than designed.[273] Eisenman's self-conscious representation of design methodologies was a more obvious reconsideration of process. Both sides, then, were invested in dismantling certain aspects of the canonical processes of design. Therefore, that despite their oppositional stances, the Whites, the Grays and their followers can be properly seen as engaged in a singular and coherent rather than divergent project. This project, I believe, was the reformation of architecture's design processes.

Instead of seeing the dialog on design that played out between the Grays and the Whites as something that arose solely from their postmodern climate, this discourse might be better understood as the culmination of a conflict originating in the nineteenth century, a conflict stemming from drawing and its uneasy relationship with process. A mirror of these issues within architecture can be seen in other fields which were similarly rooted in the territory between form and process. As was the case in architecture, so too did morphology find itself divided between those who understood its project as interpretive and aesthetic (like Goethe), and those who sought the causal, generative

[272] Venturi, *Complexity and Contradiction in Architecture*.
[273] Henri Lefebvre, *The Production of Space*, trans. Donald Nicholson-Smith (Malden, MA: Blackwell Publishing, 1991), 358.

processes that lay beneath transformation.[274] However, unlike morphology which is content to study form, the difficulty with architectural design is that it is, by nature, about creation. For design to be process-focused necessitates that generative principles be found, even when the only path to these is through interpretation. As a result, in the nineteenth century, as part of the quest for a honestly derived architecture, interpretation gets recycled as generation.[275] Morphological analysis reveals patterns in the corpus of architectural history. From these patterns architectural behaviors are deduced. These behaviors are then taken as a generative formal aesthetic, and the new designs are "honest" because they replicate the patterns morphological analysis originally found. In this way the techniques of morphological interpretation are translated into architecture, but the conflict of morphology, the question of its focus on transformative versus generative processes, is glossed over. For this reason, architectural rationalisms are eventually understood as circular. Arguably, it was this, perhaps flawed, but aesthetically driven project that the Grays and the Whites were trying to dismantle, a disassembly that Eisenman brought to a crisis in House VI.

The contribution Eisenman made with his design for House VI was to reiterate the generative circularity inherent in the indexical, honest, architectural rationalisms, by deliberately circling design onto itself. In House VI, it was not just an interpretive principle from building being recycled in design, but the tools and processes of design being fed back on themselves.[276] As part of this recursion, Eisenman created an

[274] Goethe stressed that the goal of discovering *Urphänomene* was interpretative and aesthetic, not generative and causal. Steigerwald, "Goethe's Morphology: *Urphänomene* and Aesthetic Appraisal."
[275] Allen suggests that same recycling is what undermines Eisenman's turn to process. Allen, "Trace Elements," 63.
[276] Allen writes that Eisenman's focus on process causes a closed circle, one in which "the means of *interpreting* things are recycled as a model for *making* things." Ibid.

architecture where drawing, the process which is his tool of generation, is the central player. He instrumentalized architecture undermining ideas about function, symbolism and comfort, stripping away the last of those architectural qualities that lay outside drawing's purview. However, he also demonstrated that even when design is about nothing but drawing, simple generative motions are nearly too much for it to hold. The design for House VI stemmed from elementary sequences that created clearly ordered organizations of shape, straightforward in concept but nearly beyond the scope of drawing's power to represent.

The resulting formal arrangements push the boundaries of legible image-making. In his official presentation drawings of House VI's geometry, Eisenman celebrates this illegibility. (Figure 9). These images demonstrate that while the geometric transformations Eisenman was using are easy to describe, drawing is barely capable of holding these interrelationships stable. His process drawings reveal a similar instability as Eisenman attempted to use color as a legend, coding the divisions belonging to separate geometric systems with different colors. Even with this code, however, the coherence is barely sustained as is evidenced by Eisenman's coloring and re-coloring of the specific divisions. [Figure 45].

Therefore, when Alexander accused Eisenman of destroying architecture, he may have been correct, but it was the process of design that Eisenman was dismantling. And while Alexander may have opposed Eisenman's aesthetics, he participated in the dismantling efforts. In his seminal book *A Pattern Language*, published in 1977, Alexander attempts to empower anyone to make meaningful design by ordering a new genealogy of pattern within architecture. Through this study of form he attempted to

derive architecture's underlying generative principles. Like similar attempts from the nineteenth century, however, Alexander's project did not directly yield generative tenets. He writes that, "[a]lthough we intended that the pattern language would be generative, that is, would allow people to generate buildings and building designs, for themselves -- truthfully, this does not happen…."[277] Instead, Alexander moved away from pattern and toward "sequence", the rules that order formation. He now describes his *Pattern Language* project as an attempt to provide the "genetic material" of a generative architecture.[278] In other words, Alexander's focus moved away from forms and even from the patterns of interrelationship derived from formal analysis, toward sequences and processes, in other words, he moved to algorithms. Arguably, this is the same route that lies at the base of Eisenman's works. Although the precise forms of House VI are instantiated through a series of drawings, the generative principles that order these materializations are geometric algorithms, better understood as sequences or written rules than drawings.[279] In short, what the Grays and the Whites were both invested in, and what in the end they both succeeded at dismantling, was the power of drawing and its rule over design.

It can only be seen as uncanny that by the late 1980s when, arguably, the Gray-White debate had run its course, a new medium was being adopted as an alternate route to design, a medium whose purpose was the execution of algorithms. On the one hand, this coincidence might be understood as a natural progression, the end of the line for one

[277] Christopher Alexander, "Pattern Language Website." http://www.patternlanguage.com/leveltwo/recipesframe.htm?/leveltwo/../sequencetheory/sequenceopener.htm

[278] Ibid. http://www.patternlanguage.com/leveltwo/aimsframe.htm?/leveltwo/../history/generative2.htm

[279] Eisenman's process would translate into an algorithm something like—take a square, sub-divide it into a four-square; take an identical square, sub-divide it into a nine-square; overlap these two patterns; et cetera.

paradigm pressuring the development of the next. On the other, the work of the Grays and the Whites can be seen as part of a much longer historic dialog and a much larger historic shift. Their efforts may have been the translation of a cultural sea change into architecture: a change of focus from form and a definition of knowledge that stems from formal interpretations, to a focus on process and a definition of knowledge that seeks the explicit articulation of those processes that generate form. This shift is not new in the 1970s, but has instead been gaining acceptance and influence for more than two centuries. It is a new episteme ordered not on formal logics, but on the logic of processes. To use today's terms, it is an order based on algorithm and program.

In this sense then, the rejection of drawing might be seen as a natural part of the progression towards today's computationally driven design. It is no longer form that is of primary interest, and therefore, it is no longer drawing that can be architecture's sole or main conceptual medium. Instead, the focus is on the processes that shape form. The medium must capture these processes. This ineluctable retreat from drawing is evident in the recent rhetoric of today's educators. For example, George LeGendre recently wrote that "[a]ll of this younger generation approach the problem from a purely computation angle—they think of forms as procedure and mechanisms and codes."[280] In other words, they don't think of forms at all, but the principles with which to generate them.

In this way, Eisenman and his focus on process occupies a role in the family tree of computational architecture, though *pace* Allen, perhaps not precisely the originating one with which he is credited.[281] Despite the claims of some of today's designers that their work is a final, revolutionary break with the past, the shoulders on which

[280]Hans Ulrich Obrist, "George L. Legendre in Conversation with Hans Ulrich Obrist," *AA Files* 56 (2007): 56.
[281] See Note 2.

computational designers stand on go back much further than Eisenman.[282] Some members of the computational avant-garde do offer credit to earlier architects, as Hani Rashid did when he wrote that he was, "deeply respectful of the preceding generation in terms of the sheer amount of dismantling that was necessary."[283] However, the dismantling efforts undertaken by the Grays, the Whites, and their respective followers occurred on an edifice whose foundations were already undermined. Their work moved the architectural discipline away from its focus on form through drawing and towards a fully process-based order. And yet, this new order was rooted in the nineteenth century, not in their period. It was a track that had already been laid, but one which architecture had not fully taken. Eisenman's accomplishment, and that of his comrades, was to help architecture make its way from the interpretive models of process, which had been architecture's means of compromise between process and form, and towards a fully process-oriented generative model. Arguably, then, today's crop is a result of the intellectual seeds planted as early as two centuries ago. It is my hope that today's designers will find it helpful to understand that their own design questions and problems have this lineage, that their work has this theoretical historiography. As George Kubler wrote in *The Shape of Time*, "[d]espite the inventor's solitary appearance he needs company; he requires the stimulus of other minds engaged upon the same questions."[284] Rather than laboring under the impression that they break completely new ground,

[282] Or as Rashid writes a few sentences earlier: "Our generation is finally becoming active and getting out from under the shadow of the older generations. The embrace of digital technology, for example, has been experience firsthand by our generation and that cannot be acquired or theorized by an older generation." Hani Rashid in Bernard Tschumi and Matthew Berman, *Index Architecture: A Columbia Book of Architecture* (Cambridge, MA: MIT Press, 2003), 3.
[283] Hani Rashid in Ibid.
[284] George Kubler, *The Shape of Time: Remarks on the History of Things* (New Haven: Yale University Press, 1962), 115.

perhaps today's designers can be inspired by the efforts of previous minds, minds which also attempted worked through this problem.

CHAPTER FIVE

THE ADOPTION OF COMPUTATION

In order for architecture to emerge as its own profession as part of the early Renaissance, a couple of key developments were necessary. First, the act of design had to be isolated from the activities of the builder or craftsman, and its practitioners had to be legitimized with their own body of essential knowledge and skills. Second, and perhaps more radically, design had to be redefined as an activity predominantly concerned with the prefigurement, stabilization and control of a projected building's final forms.

To a great extent these definitions still hold true today. Our current understanding of the method and purpose of design has become so naturalized that narrating its development as a historical event is somewhat contentious. By focusing on the shifting role of drawing within architecture, however, the historic nature of the core tenants of design becomes clear. When one focuses on the history of drawing it becomes apparent that its rise and adoption as the medium of design is completely intertwined with both the new professional definition of the architect's role and the new aesthetic definitions for design. The medium is the discipline.

Similarly the rise of process and adoption of a procedural medium of design can be seen to effect architecture on both a professional and aesthetic level. In Chapter Four, I attempted to weave together some of this new tapestry, sketching part of the early cultural bases for the shift to process-based knowledge, and detailing some of

architecture's early attempts to adjust aesthetically to a focus on process. This current chapter attempts to move further into the shift, taking a more recent snapshot focusing on vanguard practices within architecture in 2009. This emphasis is appropriate since the use of computation in architecture is a recent occurrence constrained for the most part to the last two decades, with the most mature deployment of computational logic as evidenced in the following case studies being an even more recent phenomenon. And yet, there is a longer relationship between architects and the computer that must be acknowledged, and this historic interaction interestingly forms a reflection of both sides of the chasm currently being bridged. On one side of this precipice were the architects and critics of twentieth century modernism, and on the other were the inventors and innovators of the modern computer. Throughout the twentieth century both were attempting to tackle a monumental design task: how to make the universal machine universally usable. Theirs was a challenge forged in the furnace of the industrial revolution, then as now, the confrontation they faced was the collision of human and mechanical sensibilities. Both sought a solution through interface design, and while neither side entirely excluded the considerations of the other, for each the core of the problem, and therefore the root from which the to resolve had to spring, came from decidedly different places. For the architects the solution was formal, and for the computer scientists it was procedural.

Since architecture traditionally concerned itself with machine design as well as the design of buildings, and since the computer is nothing more than a very complex machine, it is not overly surprising that both fields would confront this problem and even share some of the same major figures. In many ways the universal machine carries the mark of its predecessors. The computer's tasks may have grown very complex, but

during the nineteenth-century devices meant to accomplish even relatively simple tasks were marked by their labyrinthine complexity. One need not venture far into their descriptions of, for example, the mill's cacophony of noises, of its rapid and violent motions that made the air thick with cotton particles, which in turn sickened the workers with bissinosis (also known as mill fever or brown lung disease) to grasp the issue. Such descriptions make it easy to understand the hostility of such machines and the need to resolve this collision of basic needs and sensibilities, particularly during the late nineteenth-century. But if the problems interface design stem from this moment, and if the computer shares its complexity of design with such machines, it makes sense that some of the themes and issues contemplated by today's solutions might be traced back as well.

From architecture the solutions proposed during the early twentieth-century presented an adaptation of rationalist aesthetics to the machine. Although such theories could result in very different architectural expressions, the theories themselves shared a similar philosophical grounding. They each sought to naturalize their aesthetic, their preference for the expression of a particular architectural quality like function or structure, by relying on the scientific tenets of morphology. Namely, such theories sought to emulate morphology's over-arching belief that an object's organization and the relations between its parts and whole captured the essence of its "life". The goal of Rationalist expression was the transparent rendering of some aspect of the object's internal "essence" on its externals.[285] If such an essence was believed to be the building's structure, then the building's organization and relationships could consistently express its

[285] In its reliance on beliefs about transparency, Rationalist thinking is also tied to the structures of drawing and the transparency pact that drawing established for architecture. See Chapter....pgs….

structural pattern. In this way the buildings themselves became reflections of the natural environment (or at least of that period's understanding of the natural environment) and the aesthetic was thus legitimized or made "true" by its emulation of the natural world.

At IBM a large group of architects were hired not just to design the computer but the entirety of the corporation that IBM would become.[286] Their solutions to computer design, at least, speak to the challenge of design in the face of enormous complexity. In alignment with Rationalist principles, early attempts sought to display the computer's logical workings, and sought to align human actions to this logic. The open display of cables, patch cords, vacuum tubes and eventually tape reels all functioned as icons of the mechanical logic of the computer. But, this morphological expression failed to acknowledge the actions required by humans to make the machine worked. This formal interface did nothing to make itself more simple or easier to use, instead the design was concerned with the expression of the machine. Theirs was an aesthetically elegant solution in architectural terms. It spoke of the glory of human invention, our mastery over the logic of logic. Such early computers were marked with the signature of this feat of machine logic. They were iconic, but not functional even when the iconographic system used the computer's own functioning as its basis.

As elegant as these solutions may have been aesthetically, however, they simply did not solve the usability problem computer presented. Even when that most basic tenet of architectural aesthetics, transparency was relied on the machine became no more usable. The architect's aesthetic, rooted as it was in drawing and the formal parameters drawing emphasized, failed to solve the usability problem presented by machines.

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[286] John Jeffrey Harwood, "The Redesign of Design: Multinational Corporations, Computers and Design Logic, 1945-1976" (Dissertation, Columbia University, 2006).

Lewis Mumford whose work bridged the scholarly circles of technology, science and architecture, believed the solution was to be found in simplification. He wrote:

> we need to guard ourselves against the fatigue of dealing with too many objects or being stimulated unnecessarily by their presence, as we perform the numerous offices they impose. Hence a simplification of the externals of the mechanical world is almost a prerequisite for dealing with its internal complications. To reduce the constant succession of stimuli, the environment itself must be made as neutral as possible.[287]

Mumford's demand for a neutral and simplified external environment opposed the predominant architectural theories of the time. His call reinserted human sensibilities into such understandings. He prioritized not the deeply transparent legibility of technology, not its emulation of theories of natural world, and but instead the veiling of its logics in order to address its usability. Providing both a update and legitimization of Mumford's argument in his analysis of the post-war development of IBM, John Harwood writes that:

> Simply put, a human being cannot *use* a computer's logic circuit alone for *anything*, save as a paperweight….In order for the computer to be useful, there must be at least one *interface*—a *medium*, a "channel," a "line of communication"—between the "user" and the machine, that allows human gestures to become voltages, and voltages to become human gestures.[288]

In essence, as both Harwood and Mumford would articulate it, the problem is that to be usable, whatever interface is designed, it cannot express the same logic as the universal machine it mediates or it would fail to serve its purpose. A translation is absolutely necessary thus undermining the goals of transparency articulated by the various rationalisms that emerged in late nineteenth- and early twentieth-century design theory. Further, as Harwood writes, no mechanical object, which is to say no formal composition could by itself create the solution.

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[287] Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Company, 1934), 357.
[288] Harwood, "The Redesign of Design: Multinational Corporations, Computers and Design Logic, 1945-1976", 21.

> Since, we are warned, reasoning through the pure form of Boolean logic or its "machine language" equivalents of "on and off" electrical states will "quickly drive [us] insane" due to the sheer mass of numbers required to formulate even the simplest statement in a higher-order language, no matter which kind or kinds of mechanical objects are used, computers and their users also require another "system"[289]

If my argument that drawing puts emphasis on and constricts architecture's focus to issues of form, then following on Harwood's assertion, it can only be concluded that as a discipline architecture is ill-equipped to contemplate, much less solve the problems and issues that arise form machine-based society.

Coming to the problem from another viewpoint, and therefore, with another kind of solution, were the computer scientists who sought to make the computer more functional. These actors all thought the way out lay in a different kind of interface. Rather than the formal solutions envisioned by the architectural and industrial designers, these players sought to re-engineer the process through which humans interacted with the computer. For example, as his Ph.D. dissertation Ivan Sutherland, who is considered by many to be the father of computer graphics, translated an architectural mode of thought into a form of computational input with his program *Sketchpad*. Many believe that today's graphic programs have yet to actualize the potential that Sutherland's *Sketchpad* embodied in 1963.[290] Similarly Alan Kay, having been inspired by cognitive and educational psychology, believed that users should be able to fashion their own media tools from within the new media. Encouraged by the writings of Piaget and others, Kay believed that just as languages were formative to cognition, computer languages like

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[289] This warning is to be found in any number of manuals on higher-order computer languages. A pair of such texts are quoted in: Friedrich Kittler, "Protected Mode" in: Kittler, *Literature, media, information systems: essays*, ed. and intro. John Johnston (Amsterdam et al: G+B Arts, 1997): 156-168. Ibid., 21 and Note 5.

[290] Lev Manovich, *The Language of New Media*, 1st MIT Press pbk. ed., Leonardo (Cambridge, Mass.: MIT Press, 2002).

SmallTalk were also formative and should, therefore, be simple enough for children to use. He proudly rehearsed examples of comparatively sophisticated programs written by junior high students.[291] Nearly all subsequent developments, whether they occurred at Kay's Learning Research Group at Xerox PARC or at other venues, always addressed the computer as a procedural medium rather than addressing its formal qualities.[292]

Lev Manovich captures the history of this progression, and so I quote from him at length.

> The conceptual and technical gap which separates [the] first room size computers used by military to calculate the shooting tables for anti-aircraft guns and crack German communication codes and contemporary small desktops and laptops used by ordinary people to hold, edit and share media is vast. The contemporary identity of a computer as a media processor took about forty years to emerge – if we count from 1949 when MIT's Lincoln Laboratory started to work on first interactive computers to 1989 when first commercial version of Photoshop was released. It took generations of brilliant and very creative thinkers to invent the multitude of concepts and techniques that today make possible for computers to "remediate" other media so well.[293]

As a media processor the computer is doubly focused on process. Its attention can be aimed at either its own processes or its emulation of another media's processes. It is for this reason that Manovich finds the term 'remediation machine' such a powerful descriptor of the computer. No matter who the innovator, the solutions which emerged to address the problem of the computer's usability from the field of computer science were all focused on the machine as a processor, on the computation as a media emulator, and on themselves as procedural innovators.

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[291] Alan Kay, "Doing with Images Makes Symbols: Communicating with Computers," in *The Distinguished Lecture Series: Industry Leaders in Computer Science* (USA: Unversity Video Communications, 1987).

[292] Sutherland's invention of input devices like the light-pen stand in exception to this rule, but the light-pen was a means of achieving the new forms of interaction that Sutherland designed, rather than the main focus of the design itself.

[293] Lev Manovich, "Alan Kay's Universal Media Machine," in *Software Studies (Forthcoming)* (2006), 4.

It was into the moment of the rapid computer innovation during the 1970's at places like Xerox Parc, and of intense interest on behalf of those computer scientists in other artistic media, that Peter Eisenman's House VI was designed. Eisenman's own interest in process is reflective of the kinds of design issues seen in such other fields, and his attempts to freeze, represent and reactivate process in his visitors has affinity with the concerns that were circulating at places like Xerox Parc. In the thirty-year gap that exists between the kinds of thinking Peter Eisenman exemplified with House VI and the practices seen in this chapter's case studies, architectural computation has matured enough to become an alternate media in which the activity of design can take place. Through such experiments, architecture is attempting to adapt as a discipline to the demands of a machine-based culture.

Both of the cases presented in this chapter make use of computation as a new medium, are highly original, and also typify two trends being felt throughout architecture. The first case continues some of the architectural-rooted, which is to say formally-rooted, aesthetic thinking explored by Eisenman. Evan Douglis's use of algorithmic/autogenic design consistently attempts to marry the aesthetic systems of form with those of process. He has moved beyond the regime of drawing, but he has not completely stepped outside it. The second case examines the diverse roles and redefinitions of "design" taken on by Gehry Technologies. The continued flexibility demonstrated by that firm in adapting to the problems that emerge as projects become ever more complex can be seen as one response to the fracturing and diversification of the architect's role in contemporary practice. Together these cases present a set of movements within the discipline of architecture that mirror the shifts that originally defined the profession: one, a means

through which design is being redefined and the other, a means through which the architect's role is. If these basic definitions are shifting, what result might one expect for architecture as a cohesive discipline?

Evan Douglis and the Extension of an Aesthetics of Process

Evan Douglis is a Brooklyn based architect and the chair of undergraduate architecture at the Pratt Institute. He has also held teaching positions at Columbia and Cooper Union. His practice, Evan Douglis Studio, has received many accolades and awards, and in 2005, was selected as part of Architectural Record's Design Vanguard Competition. Douglis is invested in taking an interdisciplinary stance to design, and like many other computationally-based designers, he views his work as research into both the fields of computer aided digital design and into new materials and fabrication technology.[294] The signature of this philosophical stance can be found in long-lived nature of his design process. Each of the projects he has undertaken has tended to produce both a specific solution to the design problem presented by the site and program, and a more generalizable solution to the problem of form generation. This second solution can have multiple iterations at a variety of scales. In the sections that follow, I will touch of two different projects that Douglis has undertaken since 2006, specifically looking to understand the nature of his questions, his iterative approach to design and what the overarching goals of his research might be.

The first of these projects is fLORA_flex system. Originally an entry for the European Ceramic Workcenter (EKWC) competition entitled *Brick: The Exhibition,* participants were selected from a worldwide field in two rounds of competition for

[294] Evan website bio

display at Rotterdam 2007 Biennale. The design of a new brick may initially seem a strange project for Douglis to attempt. Known for his ornate, geometrically complex surfaces and his use of algorithmically or parametrically generated forms, bricks are usually understood as anything but intricate and complex. However, the call for entries postulated that,

> Now that the facade no longer has a structural supporting function, but is simply the skin of the building, brick can shake off its rectangular nature. And that is where the challenge lies... Could the new brick be round, hexagonal, perforated or transparent?[295]

Such an invitation to rethink the form of brick taps into Douglis' interest in material and fabrication research as well as providing an opportunity for him to continue his exploration of algorithmic design.

To generate his brick form Douglis utilized a two-stage design method. First, he generated a governing geometry in the form of a master path, and then he set the rules by which a second geometry would use this master path to scribe out the brick's form.[296] In both stages of his design, Douglis is focused on process as opposed to the direct refinement of form. He may alter his processes in order to produce forms that he finds more pleasing or appropriate, but the never directly manipulates the forms themselves. The object of his design is both the material form but also, and often more importantly, the processes by which such forms are determined. In this way Douglis' work bridges between the drawing-based and process-based aesthetic systems.

For example, the initial master paths or lines that Douglis attempted to use to create the fLORA_flex bricks were calligraphic. They weren't simple easily

[295] Ceramic Workcentre European, "Brick: The Exhibition," http://www.ekwc.nl/index.cfm?art_id=188.
[296] This bifurcated design process is strikingly similar to Peter Eisenman's design process for House VI. The two-stage design scheme is not their only commonality, as I will discuss a little further on in this chapter.

comprehended forms but were instead formally elegant in their own right. However, because the movement of the secondary geometry would be both translational and rotational, it quickly became apparent that the forms generated by the complex master paths were too intricate. The shapes created from these calligraphic lines were overly dynamic both in terms of their own aesthetics and in light of their function as a modular unit that could be stacked to define space. [Figure 46, 01.1 and 01.2]. To simplify these initial forms, a less complex master path was necessary, and Douglis finally settled on the use of double circle or "ghost cylinder" as the most basic geometric key for the design. Because the cylinder has similar geometric and packing properties as a standard brick, this choice in master geometry ensures that his brick would potentially function the same way. In this case the end result is a refined form, but the motivations informing the choices and refinements were not strictly formal. Instead, the forms were understood as a means of instructing process and were refined based on how they would inform the generative process rather than their own aesthetic value.

To generate the new brick form from the ghost cylinder, Douglis propelled and rotated a flange along the path of the circle. As the flange intersected itself, Douglis set up rules to govern how the flange would be cropped at the intersection. The path the flange traced out became the shape of the new brick. [Figure 46, subfigure 01.3 is the final geometry]. Interestingly, this process shares some intellectual similarities to the one that Peter Eisenman used in buildings like House VI, as well as others.[297] House VI was generated from the intersection or collision of two geometric grids. Eisenman's process drawings then demonstrate an experimental stage where this geometric key underwent a series of alternative materializations, some parts instantiated as masses or planes in space

[297] For discussion of the House VI design See Chapter 4, pages …. To …. And Figure 37 to Figure 45.

and others as voids. While there are no set rules that Eisenman was using to determine which geometries will receive which gestures, his process was similar. The difference is only that Eisenman's own rules remained implicit, based on his aesthetic judgment rather that explicitly stated ones that Douglis used. This shift is another illustration of how Douglis' work moves closer to a process-based aesthetic than Eisenman's drawing-based formal compositions could.

In other projects, House El even Odd in particular, Eisenman extends the process he demonstrated in House VI, however, by articulating an entire script of movements which have resulted in the building design. Again, the connections between the building's final forms and this script are less explicit than Douglis' algorithms, but the intellectual process of design reamins similar. Robin Evans critiqued Eisenman's process for relying on an illogical fiction in which the geometric substance of architecture had to be abstracted to something akin to a clay or plasticized body.[298] Eisenman's ideas about architecture serving as an index for the design process necessitated this kind of malleable substance, something that was mutable and would be inscribed with the movements Eisenman imagined as the genesis for his design. Evans argued, however, that such a process was little more than a trope, a metaphor having little to do with the reality of architecture and its formation.[299] Had Eisenman's process not been so sympathetic to algorithmic design, had his own interest in a process-based architecture not foreshadowed computational design so accurately, the dismissal would have been well founded. But in fact, Eisenman had tapped into the direction of things to come. By engaging process, even when his only real means to engage it was through a mental exercise, he began to

[298] Evans, *Translations from Drawing to Building and Other Essays.* INSERT PAGE NUMBER
[299] Ibid.

develop a new basis for architectural aesthetics.

Douglis picks up the themes and problems of this new aesthetic. Instead of a mental geometric routine, Douglis uses the actual geometric equations. His rules are explicit and if the forms those rules generate are unsatisfactory, he does not make capricious alterations to them. To change the form means the rules themselves must change: parameters and algorithms must be altered, not just their formal instantiations. At least initially, like Eisenman Douglis is still making forms out of the abstract, indistinct, perhaps one might even say the un-architectural "stuff" of digital models, but unlike his predecessor Douglis' forms are rigorous and unequivocal expressions of his procedural logic. While Eisenman may have called House VI a moment of frozen process, the process he froze wasn't fully made manifest. Douglis' design method, on the other hand, articulates and privileges process. If its importance hasn't completely subsumed the product, as Douglis adjusts his procedural rules based on their formal results, a complete and explicit mapping between process and product is the inevitable outcome of "autogenic" or self-generating design.[300] Eisenman's design begins to suggest the possibility of such a mapping but his work falls short of it.

While Douglis' work can be understood to extend some of Eisenman's aesthetic experiments, the two diverge in the area of craft. Douglis is deeply invested in the process of translating a design into built form. On the other hand, Eisenman infamously disregarded building details, insisting in House VI, for example, that the roof be of the same width as the wall in order for the building's geometry to conform to the grid layout. Unfortunately, it is not possible to fit the necessary construction details into the shallow

[300] Douglis' most recent book is an edited volume entitled *Autogenic Structures*. It explores the recent trends in generative surfaces and forms and the theories behind them. Evan Douglis, ed. *Autogenic Structures* (Florence, KY: Taylor & Francis,2008).

profile Eisenman specified. This kind of oversight, coupled with a generally poor relationship with his contractor, meant that House VI was so poorly constructed it had to be entirely rebuilt just over 10 year after its initial construction.[301] Douglis' stance on craft, however, could not be more different from Eisenman's.

To some extent this shift in priorities is attributable to the control afforded by computation. Much of Douglis' work is built using CNC routers or prototyped using 3-d printing. The Prouvé Exhibit/Auto-braids [Figure 47 and Figure 48] and HAKU Restaurant/REptile projects [Figure 49 and Figure 50] illustrate Douglis' use of these techniques. In a sense, these production tools allow Douglis to meld some of the processes of design and construction together. Since Douglis uses very similar languages to design as these machines use to govern the creation of the work, there is a deep logical sympathy between the design and craft. The same logic did not exist between the fabrication of House VI and the geometry that Eisenman used to govern the design.

The fLORA_flex project, however, introduced its own constructive logic. While the EKWC encouraged a re-thinking of brick's form, the use of ceramic as the new brick's material was taken as a given. For Douglis this meant further considerations of craft, as after his brick was designed, he had to engineer a way for it to be mass-produced. Unlike the case when using CNC routers to produce his designs, as he did with Auto-braids, the geometries of his new brick did not share a deep logic with the techniques of slip casting. However, by breaking the final brick into quadrants, casting these parts and reassembling them into the final form, it was possible to piece together the final brick. [Figure 51 and Figure 52]. While this solution is a common one in the slip-casting of ceramics, it is still not an ideal solution for mass production. However,

[301] Pull reference from chapter 3 – a client's response.

Douglis' investment in working through a craft-based solution is a hallmark of his process. He is always deeply involved in both the design and realization of his projects, and this level of investment carries with it the potential for feedback and refinement. In this sense he differs from both Eisenman, and, as I will discuss further in the next section, from Frank Gehry, who both turn the realization of their designs over to other designers. By keeping both aspects of a project in his sights, Douglis' work always carries the signature of hybridism. His designs are always marked by the feeling of two or more systems existing simultaneously.

In the case of the fLORA_flex brick design, it is possible to sense the collision of systems in the construction photos, but the same sense exists in the design itself. Douglis' insight in selecting the circle/ghost cylinder as his master geometry created a great degree of sympathy between his final forms and those of a typical brick. Because the ghost cylinder exhibits the same bi-lateral symmetry, as does a traditional brick, the two forms share some general similarities. The preference for 90-degree axes encoded by this symmetry allows him to assemble his bricks using many of the same geometric rules that govern the typical brick. Due to the dynamic nature of the brick forms, it was necessary for Douglis to create a substitute for the typical mortar joints. Rather than using a malleable material that might fill in much of the dynamic geometry, the mortar joints were designed themselves as fixed pieces. In the end two of these were necessary, one for brick-to-brick bearing conditions and another for brick-to-floor (or other flat surface) bearing. [Figure 53]. This more rigid mortar design means that the fLORA_flex system has inherently less potential for manipulation during assembly than a more traditional brick. While Douglis' brick might appear to break free of the rectangle, rather than

choosing a new 'dynamic' geometric system like the hexagonal system the brief suggests, the rules that allow the traditional brick to become a larger-space defining unit generally still hold.[302] The brick itself may reflect the parametric geometries enabled by computation, but the system is imbued with the orthogonality of more typical design and construction. [Figure 54].

After the submissions to Rotterdam Biennale and to *Brick: The Exhibition*, Douglis created two further evolutions of his design. The first of these worked to re-introduce some of the formal flexibility that the original submission omitted, not by allowing different arrangements of the bricks, but by iterating different designs for each brick. As was the original design, these were ordered algorithmically with variations based on the speed of rotation for the form-generating flange. By scripting the entire wall generation rather than just the generation of a single brick, Douglis creates a wave of motion across the wall as the aperture of each brick opens and contracts. [Figure 55]. This new design is less amenable to mass production through slip-casting, although a large enough demand for the bricks could justify the creations of all the moulds necessary. That said, mass-customization trends could make such a modular wall system easy to construct so long as ceramic was no longer the material of choice. Notice, as well, that Douglis has introduced a third mortar joint in this design as means of terminating the

[302] A variety of different 'bond' designs also allow bricks to fill three-dimensional space. Running and stacking bonds inherently fill only one brick thickness or wythe, while Flemmish or English bonds make interlocking packings that take up several thinknesses. While standard bricks can be made to curve or form arches, such flexibility occurs in the spaces between the individual bricks. The voussoirs of an arch are created out of the mortar, not shaping the bricks into wedges as is the case with stone masonry. Other masonry systems do exist that encourage non-rectilinear layouts. For example, the Catalan vault uses ceramic tiles arranged in a herringbone pattern to create shallow, self-centering vaults, and curved retaining walls are often now made with interlocking tetrahedral masonry units. Each of these other systems allows for a greater range of three-dimensional curvature, but again such systems rely on the interstitial spaces between the units to provide the range of curvature. The unique shapes of the masonry units in these systems are designed to increase the degree to which these interstitial spaces might be manipulated.

wall edge. In the more simple wall design the edge bricks were cantilevered from the last mortar joint. Such a move further illustrates the feedback loop that exists for Douglis because of his investment with craft as well as design.

By looking between both of the wall designs that Douglis produced, it is possible to see an amplification of the hybridity, which I believe mark of all his projects. The original assembled the fLORA_flex system generates an ornate but regular perforated screen. The doubled geometry is clearly visible; the wall consisting of both a standard rectilinear geometry of assembly and a dynamic parametric pattern based on calculus. The design fuses both systems and both systems can be easily perceived working together to create the total effect of the wall. In the second proposed assembly, a third system of ordered variation is introduced into these original two. The wall demonstrates the hybridism of not two, but three systems of logic. In this way Douglis is colliding the orthographic geometries of traditional, drawing-based architectural design with the generally calculus-based geometries of parametric calculations and the emergent patterns that stem from the use of algorithm. His work is a reflection of this particular moment as the collision of each of these logics, each of these processes of design, the orthogonal, parametric and algorithmic, is occurring in today's practice of architecture.

I would like to leave my analysis of the fLORA_flex system, to discuss one more recent of Douglis' projects, because I believe this project provides an interesting inflection to the theme of hybridity so evident in work. This project is the interior design for Choice, a restaurant in Brooklyn, New York. It is rather surprising that the owner of Choice selected Douglis as his architect. Douglis' aesthetic is formally dynamic. His is an ordered complexity born of emergent patterns engendered by computational design. He

has used the term "dazzle topologies" to describe the surfaces he creates, and he gravitates to the baroque period as an historic moment whose aesthetic was sympathetic to his own. And yet, when it comes to his finish aesthetic Douglis prefers a more high-tech look. Highly-polished surfaces and high-shine automotive paint, finishes that deny the passage of time are his preference. For Choice, however, the client wanted a more historic look. He wanted less the highly polished surfaces of a machine aesthetic and more the warmth of hand-craft and time worn materials.

In some cases, Douglis was able to appease the client with simple material choices. The floor will be edged in a stone from China which resembles petrified wood and signage walls will be of Cor-ten Steel. These materials both produce the feel of age for the client. In other cases Douglis' usual geometric exuberance is allowed to reign. The ceiling pattern, for example, is a reiteration of a design originally developed for a project in Los Vegas. This fiberglass, hex-based tile system has an undulating surface with "cones" and "meandering surface scrolls that set up pin-wheel effects."[303] [Figure 56]. Each of these features represents an attachment point at the back of the tile. These attachment nodes can, on the finish surface, be closed off with caps or occupied with program like sprinkler heads or chandelier attachments. While originally the surface was intended to carry and automotive finish, for Choice the same ceiling will be faux finished in burnt umber with platinum highlights, To create the ornate pattern, Douglis attached variously-sized miniature rubber donuts over the surface. These masked the burnt umber

[303] Evan Douglis, Interview, April 16 2009.

and provided a secondary surface pattern that interfered with the immediate impressions of the tile forms.[304] [Figure 57].

In this instance Douglis is deploying his virtuosic understanding of craft to produce a "certain iconography as a way to control the associative projection of the client."[305] This iconography is not based on form, but instead on a certain approach to process and material. Through his deep understanding of craft, he is able to evoke a different period of making than the one he himself inhabits. In this sense he is operating simultaneously between the "nineteenth and the twenty-first centuries" and does so with sufficient complexity that the audience can find its own mythos." [306]

Perhaps the best illustration of this collision of time and craft can be found in Douglis' use of glass at Choice. For two separate aspects of his design, the exterior windows and the chandeliers, Douglis parameterizes the logic and laws of molten glass as a means of colliding material and computational making. In the case of the glass wall, Douglis has designed a slumped glass tile whose effect is similar to the subtly three-dimensional scales of a reptilian skin. The design of this wall required that hundreds of tiles of varying form be produced, but the question was, what were the limits of this range? To discover the answer to this question meant that Douglis had to embrace the laws of glass craft.

To produce any of this range of glass tiles that Douglis envisioned would require a slumping jig, and to be effective this jig had to obey the laws of molten glass. In other words, to properly design the jig, the applicable rules about glass slumping had to be

[304] Since the writing of this text the client has decided to return to the original finish for the ceiling tiles. Therefore the final tile design will consist of the cones and spirals and the bronze finish only, and the overall patterning system will be simplified by one order of complexity.
[305] Douglis.
[306] Ibid.

parameterized. Too much of an angle and the glass would stick to the jig. Too little an angle and the tear-drop effect would be lost. Once these physical laws were understood they were incorporated into a model so that a range of possible variations in both the jig design and the resultant tile could be understood. From this modeling, a series of jigs were constructed allowing for the production of a test-run of the slump glass tiles. These were then used to create a physical mock-up for the client.

While the glass tile design and production is interesting, except in its choice material, there is little within its creation process that stands outside Douglis' usual hybrid methods of computation and craft. His design of the chandeliers, however, introduces a different means of interpreting parameters. As part of the ceiling system, Douglis has designed chandeliers that are intended to hang from the largest cones of each hexagonal tiles. The production of the chandeliers embodies a translation of the formal control usually provided by a digital-based algorithmic design into an analog process. Douglis has not designed the form of these poly-lobed chandeliers, but instead has designed the "line-work" which controls how their forms are produced. As part of his normal process this line-work would take the form of a parametric equation, but here it takes on a physical manifestation. [Figure 58]. Made up of a series of wire loops attached and held in place by small tube-like washers, the chandelier is created when glass is blown into this armature. The shape of the glass is dependant on how the wires adjust and redistribute pressure as the glass bubble grows, fills and is divided by the "lines". [Figure 59].

In addition to the physical laws which govern the behavior of molten glass, this line-work is Douglis' only means of control over the final form of the chandelier. "I am

interested in the aesthetics of it but I'm also interested in regulating the aesthetics….The glass is living, and it's bouncing and pushing and twisting and breaking and oozing off of this line-work."[307] While the contact between the wires and glass is direct material to material, and while it would be possible to mathematically model the same procedure, the "intelligence" of the materials carries with it is own physical algorithms. As is the case with parametric design the forms are still remotely rather than directly controlled, even if this remote control occurs through physical contact. If this paradoxical situation were not enough, Douglis pushes on the boundary of one more. By refusing to digitally predetermine the chandelier's form, Douglis collides outputs of computation and craft. Actual physical rather than simulated process are used, thus conflating the object of design and its representation. In Douglis' chandeliers, the simulation has become the object.

As a whole one way to understand Douglis' work is as an extension of the aesthetic of process and the experiments and questions that Eisenman began with his. Where much of his predecessor's significance stems from his questioning of the gap between drawing as a process and a process-focused design, Douglis' work offers a new definition of design that uses process as a medium. In his case the artist and the artistic eye are still present, and in this sense he is still operating in the realm of the architect as defined by the Renaissance shift to drawing, but his medium is no longer drawing. He still evaluates the formal implications of design, but his engagement is not directly with form. Rather than the continuous refinement and perfection of a singular object, Douglis oversees the creation of whole families or potential families of objects. Rather than a perfected form being the harbinger of successful design, Douglis values the formal

[307] Ibid

latency within a process. His work becomes particularly interesting when Douglis transposes the lessons he learned from computation as his procedural medium back onto the world of materiality, seeking to tease out its inherent algorithms. This final step is one that Eisenman could not ever have contemplated because, as a student of drawing, he valued platonic abstraction above materiality.

Gehry Technologies and the Process of Design

Gehry Technologies (or more commonly Gehry Tech) is a spin-off company from Gehry Partners, LLP, the design firm headed by well-known designer, Frank Gehry. In the late 1980's, as Gehry's own work reflected his ever-greater investment in sculpturally complex form, the challenge of realizing these designs necessitated the creation of a special technology team. Originally charged with the task of making Gehry's geometries buildable at an architectural scale, the team eventually grew into a distinct firm comprised of a group of specialists who "initiated new ways of thinking about architecture and building, using advanced 3D aerospace technologies to design, document and go directly from design to construction without intermediate paper documentation."[308] In other words, through his insistence on dynamic forms nearly impossible to represent within an orthographic system, Gehry had designed a new architectural process, one that circumvented the use of drawing as design's medium. Gehry Tech was spun off as one means to propagate the use and benefits of this new process.

In 2002, Gehry Partners spun off Gehry Tech as a separate venture tasked with

[308] "Gehry Technologies Company Page," Gehry Technologies, http://www.gehrytechnologies.com/index.php?option=com_content&task=blogcategory&id=12&Itemid=8.

disseminating the unique and innovative means of practicing architecture developed within the design firm. As one of its core activities, Gehry Tech advocates the use of a proprietary software system called Digital Project, a CATIA- based Building Information Management (BIM) platform.[309] Using this software allows Gehry Tech to work directly with the client "to increase creativity and control; reduce project risks, costs, and completion times; and improve processes and decisions through collaboration, project visibility, and information access."[310] According to their website, Digital Project creates "a single digital model which can be accessed and modified by all teams participating in the same building projects."[311] Most succinctly, Gehry Tech is an architectural consultancy firm specializing in parametric or BIM modeling.[312]

This initial definition, then, is not far outside how an architecture firm might understand its relationship with other types of subcontractors. Just as mechanical or structural engineers can consult on a building design, putting their expertise at the service of the architect, so Gehry Tech can put its BIM expertise and specifically its fluency with Digital Project at an architect's service. However, unlike those other forms of consultancy Gehry Tech's role is much more mutable. By it's nature a BIM model is parametric; it models the consistent relationships or parameters that exist between the various parts and elements of a building. To access the full functionality and power of a parametric model it should reflect the processes and concerns of the design on a deep level. There is, therefore, an alignment between the crafting of the BIM or parametric and

[309] Although Gehry Tech's proprietary software is called Digital Project, practitioners like Thelen use its name interchangeably with CATIA the parent program. I am taking a cue from Thelen and will use the more general term CATIA throughout this chapter rather than distinguishing when Digital Project was specifically used.
[310] "Gehry Technologies Company Page."
[311] Ibid.
[312] Neil Thelen, Interview, April 19, 2009.

the crafting of the architectural design. Gehry Tech's role differs in this way from more traditional consultancy relationships. While structural or mechanical systems must always be accommodated in design, it is not necessary that the logic of the architectural design align with the logic of these other systems. There are aesthetic reasons why such an alignment might be sought, but Gehry's own signature designs stand in evidence of an architecture that makes the structural and mechanical systems subservient to formal concerns. However, unlike the role of mechanical and structural systems, it is not so easy to dismiss the interaction between the parametric model and its logics, and the logic of the building design. Pragmatically speaking, this stronger relationship means that it is difficult to define a stable and comprehensive scope of services for Gehry Tech's involvement in a project. Their role is often mutable and grows in scope as the benefits, solutions and efficiencies they offer a project are discovered.

Understanding the power of the services that Gehry Tech offers is best achieved by exploring how its roles evolved in one of its recent projects. The Yas Island Hotel is a good choice for this demonstration because the project is extreme in both size and schedule. The hotel is associated with the new Formula One Grand Prix circuit, and the schedule to debut the UAE franchise of that race in late October of 2009 is driving the hotel's construction and schedule.[313] That deadline forces the project into a fast-track construction timeline of a mere eighteen months.

Consisting of two oval towers linked by a bridge that flies over the racetrack, the hotel is unified by a glass and steel grid shell 'façade'. [Figure 60]. The towers will house

[313] The UAE has been awarded the Formula One Grand Prix franchise beginning in November of 2009 and extending through a 7-year renewable contract. On June 25, 2008, the Federation Internationale de l'Automobile announced that the Abu-Dhabi marina circuit would host the final round the 2009 schedule.

499 rooms, reception facilities and a Michelin starred restaurant.[314] Finishing both the design and construction of such a project in only eighteen months would have been an unattainable feat were it not or the unique team of firms assembled for the project, all of whom have experience using BIM to manage the pressures and schedules of a monumental fast-track project. To learn the nuances of Gehry Tech's involvement, I was fortunate to interview Neil Thelen, a specialist who was part of the Gehry Tech team from the project's inception. He provided both back-story to the project and detail for the various roles and challenges that Gehry Tech undertook. The following pages rely heavily on Thelen's narrative of the project's evolution.

The both the track and hotel projects are the brainchild of General Sheikh Mohammad Bin Zayed Al Nahyan, Abu Dhabi Crown Prince.[315] [Figure 61]. The Sheikh envisioned the building as Yas Island's flagship hotel. Keenly aware of how the hotel might appear during televised events of the race, its blimp view—if you will, he wanted the hotel to seem to be the jewel of the racetrack.[316] [Figure 62]. As a result the design is very concerned with the building's impression as an independent and prestigious object. The initially approved design consisted of a single oval tower. The construction on this tower commenced in 2007, but as the work progressed the Sheikh decided that this original building did not embody the sign of innovation and leadership that he sought for the track. He gave the architectural firm one-week to come up with an improved design, and when they failed to do so, the firm was fired.[317]

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[314] "Confluence Projects Website," http://www.pcmconsulting.co.uk/projects.aspx?id=1256.
[315] Yas Island is a 6000-acre (25 km^2) artificial island that will be a racing and tourism destination. It will host at least eighteen hotels, three golf courses, a Ferrari theme park, a Warner-Brothers theme park, six marinas and an equestrian center.
[316] Thelen.
[317] Ibid.

In order to improve the hotel design, the Sheikh decided to set up a private competition between five international architecture firms.[318] The competition was invitation-only, and the firms were, more or less, asked to charette the design as the turn-around for the competition was once again one week. The new hotel was to have no set budget for construction, which allowed the firms a certain creative carte blanche, but even with the lack of fiscal constraints, the fast-track time line for the project still presented a massive creative challenge. Given that construction for the original hotel, including its foundations, had already begun, one firm, Asymptote, made a particularly clever use of the original hotel. By leaving that building in place they could take advantage of the time already spent in its construction. Their design doubled the initial footprint with a second tower rotated 90-degree and placed on the other side of the track. These two towers were unified by the open grid-shell that covered both buildings and connected by a bridge that flies over the track. [See Figure 60and Figure 61 for a view of this bridge]. Their design created that impression of a singular prestige object that the Sheikh was looking for, and he approved Asymptote's design in December of 2007.

However, having won the competition Asymptote now faced the daunting task of its realization. Because they are a relatively small firm, they lacked the in-house depth to realize their design within the eighteen-month construction schedule.[319] In response they broke the design into what is, for all intents and purposes, two simultaneous but separate projects: the hotel and the grid shell. They then assembled teams to tackle each. Gehry Tech joined the grid shell team along with ARUP, ARUP lighting, Front Inc., Waagner

[318] At the time of this writing, the names of these firms were not available for public disclosure. Ibid.
[319] Ibid.

Biro Group, Schlaich Bergermann & Partners, and Al Faittem Corillian.[320] A separate team was assembled for the hotel. As part of the grid shell team, Gehry Tech fulfilled two distinct roles: one related to the visualization, rationalization and optimization of its design, and the other related to its construction.[321]

During the design stages of the grid-shell, Gehry Tech was closely allied with Schlaich Bergermann & Partners, who as structural engineers, were tasked with the translation of the general form of Asymptote's grid shell into a safe and realizable structure. Gehry Tech helped Schlaich Bergermann to solve three problems. First, the properly engineered grid shell that Schlaich Bergermann had produced exhibited "stuttering" along its axes. The lines it created were not smooth, but instead wavered back and forth rather than creating a consistent axis. [Figure 63]. The misalignment was subtle, but if one was walking along the grid shell and sighted upward along one of the axes, this "stutter" would have been noticeable and was aesthetically unacceptable.[322] Therefore, the first problem Gehry Tech was faced was the smoothing out of these axes.

While such a formal problem seems like it should be easy to solve, because the grid shell design represents the resolution of a set of functional parameters, each of its nodes were independent. The position of the nodes was not determined by a pre-rationalized and formally determinate curve but instead by the functional needs of the grid shell. Gehry Tech's task was to re-rationalize these nodes so that they could be governed by a smooth and unifying curve. This re-rationalizing problem was difficult because it basically required that the "logic" of the design be reprogrammed. Once the

[320] Other contractors are involved with the project, but this group made up an original team, members of which were all flown to Dubai in December of 2007 to help plan the realization of the grid shell.
[321] Thelen.
[322] Ibid.

new logic was found, Gehry Tech could import Schlaich Bergermann's geometry, but how that geometry was understood, which is to say how it was rationalized and reprogrammed, determined how the problem of the stuttered axes might be solved.

One means of understanding the geometry and solving the stuttering problem existed in the work of Helmut Pottmann at Vienna University of Technology. Pottmann is the head of Geometric Modeling and Industrial Geometry Group at the Institute of Discrete Mathematics and Geometry. His work with meshes has allowed him to pioneer a means of relaxing a perturbed mesh.[323] Potentially this same technique could be used on the grid shell design to "relax" the axes and allow them to find alignment. [Figure 64]. However the grid shell was not mathematically a mesh, it was parametric and made up of NURBS which are geometrically and mathematically different than meshes.[324] To make it possible to use Pottmann's theories, the geometry of the grid shell had to be made to compliant or communicable as a mesh.

This need for one kind of system to speak to another is a common problem with both BIM or parametric software. The general term for this ability is interoperability. Defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged", interoperability can exist on both syntactic (exchange of data alone) and semantic levels (exchange of data and interpretive systems). Much of the problem-solving endeavors that Gehry Tech accepts have their roots in problems of interoperability. Even in their most basic work with Schlaich Bergermann, interoperability was an issue. In fact, none of the various BIM softwares

[323] H. Pottmann, P. Grohs, and B. Blaschitz, "Edge Offset Meshes in Laguerre Geometry," *Adv.Comp.Math* (2009).
[324] NURBS or Non-Uniform Rational Basis Splines are a mathematically precise means for representating both rational and free-form surfaces, often used in computer graphics because of their precision and relatively small computational size. Thelen.

(Autocad, Revit, CATIA, et cetera) interoperate. As a result, nearly any model generated has to undergo a translation process. In the case of Yas Island, design communication between Gehry Tech and Schlaich Bergermann involved coding all the three-dimensional point coordinates from the Gehry Tech model so that it could be deconstructed into an excel spreadsheet and then reconstructed at Schlaich Bergermann.[325] [Figure 65]. Other methods exist to translate between different BIM softwares, but currently only the geometry can transfer, not the intelligence. In other words, only syntactic interoperability is presently possible. However, the International Alliance for Interoperability (IAI) is advocating the use of an industry-wide coding standard called IFC (Industry Foundation Classes) to transfer the intelligence-rich definitions of building components within a model.[326] Similar to a DXF, or Drawing Exchange Format, IFC provides a common language for maintaining information between different BIM applications. The goal of IFC is to reduce the need for remodeling the same building in each different application. In other words, it is a step toward semantic interoperability.

Unfortunately, there is not yet an industry standard IFC, but instead several different versions, and so Gehry Tech's work on Yas Island necessitated that they come up with their own interoperability solutions.[327] Excel worked for their communications

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[325] Ibid.

[326] "The development, maintenance, implementation and dissemination of *Industry Foundation Classes*, IFC and IFC enabled products is part of the buildingSMART initiative of the *International Alliance for Interoperability*, IAI, and its affiliated organizations and companies. The purpose of IFC as part of the buildingSMART initiative is '*enabling interoperability between AEC/FM software applications*". It is embedded in a broader scope of achieving beneficial change in industry, using Building Information Modeling (BIM) and IFCs as the trigger to smarter ways of working. The mission of the IAI calls for: *"... defining, promoting and publishing a specification for sharing data throughout the project life-cycle, globally, across disciplines and across technical applications using object technology in order to fulfil the vision of process improvement and information sharing in the construction and facilities management industries.'* Prof. Dr. Svein E. Haagenrud, "Stand-Inn Ifc Development," (Europe Innovea: Innovations and Standards), 5.

[327] Mohamed Nour and Karl Beucke, "An Open Platform for Processing Ifc Model Versions," *TSINGHUA SCIENCE AND TECHNOLOGY* 13, no. S1 (2008): 126.

with Schlaich Bergermann, but something more complex was needed to solve the mesh problem and allow them to make use of Pottman's software. In the end, finding this solution involved bringing Pottmann together with experts from Gehry Tech and a programming specialist from MIT.[328] Everyone was assembled and over a four-day intensive period, the team worked together to figure out how to export the parametric model into the mesh software, relax it and then export the new coordinates from the mesh and back into the parametric model. Again, the interoperation was achieved on a geometric basis alone, but since the problem itself was aesthetic and based on form, this level of interchange was sufficient.

The second design problem emerged after the location of each panel node was set and attention turned to the panels themselves. The doubly curving freeform shape of the grid shell means that each of the more than 4500 panels is unique. Even in light of the unlimited budget for the hotel, minimizing the cost of manufacturing each of these panels was very attractive. Because the grid-shell is an open frame with space between each of the panels to allow for ventilation in the Arabian Desert, a significant tolerance actually exists for the shape of each individual panel. [Figure 66]. Therefore, the initial optimization plan proposed by Gehry Tech was to use this tolerance to group the panels into families.[329] Software was written to stack each of the subtly different panels in a progression of geometric similarity. By arbitrarily breaking this stack up into families and assigning each of these families a single profile that represented the average shape of that family, the number of unique panels could be greatly reduced. [Figure 67]. Unfortunately this method was not necessarily sympathetic with how the panels were arranged on the

[328] Thelen.
[329] Ibid.

grid shell. Although the difference between the profile of each family as minimal, in the progression presenting a fairly subtle shift from one family to the next, on the grid shell panels from very different families might appear side by side. The result was not aesthetically satisfactory since it changed the perception of the shell from a continuous surface to that of an assemblage or piece-meal effect, as the exact shape of panels and the size of the air-space surrounding took on a random or haphazard feel.[330] [Figure 68]. While making these differences visually imperceptible was possible, it required that so many families be created, the cost-benefit of the standardization was lost.

The failure of this first attempt at optimization meant that a new means of achieving efficiency had to be found. Rather than focusing on the panels as a whole, this time Gehry Tech looked at the construction of the panels themselves. Each panel is made up of linear, extruded metal struts connected by angled joints into which the glass is set. In the non-optimized design each of these components is variable. Of these three parts, it is the joint which is most costly to manufacture as an individual piece. Because the struts are straight and of a consistent profile, producing these at differing lengths only means making differently placed cuts. And while traditional methods of manufacturing glass favor the standardization of shape, computer controlled laser-cutting makes possible to specify that each piece be cut differently for nearly the same cost. Therefore, by simply minimizing the cost of the joints, one achieves the same ends as trying to minimize the entire panel.[331] This analysis lead Gehry Tech to the successful solution they called the "integer optimized panels". By examining the angles of each of the joints from the model, and rounding these numbers to integers (so 42-degrees rather than 41.6749…-degrees),

[330] Ibid.
[331] Ibid.

the number of unique joints could be greatly minimized and the cost of the panels reduced, while maintaining the visual integrity of the design.[332] [Figure 69].

The last design problem that that emerged for Gehry Tech to solve was the result of an elimination of one of the original design ideas. The glass of the grid-shell was intended to be polychromatic, and the panels were to be connected to servomotors allowing the panels to gently move and appear to shift color in response to light. When the servomotor idea was eliminated from the design, a means of creating a similarly dynamic color shift was sought for the project. The question was which subtle rotations could be set into the panel mounting to achieve the desired effect. Analyzing the light angles in relation to the reflective properties of the glass and presenting the effects of such an analysis visually was a daunting enough challenge, but Gehry Tech took things one step further. Their purpose was not just to model the end result of a single configuration, but instead to produce a means of modifying these effects so that desired visual changes could be intelligently communicated back to the model in terms of the panel's mounting conditions.[333] Gehry Tech used Processing, a visually-based open source programming language innovated by Casey Reas and Ben Fry, to develop a what they called a means of "painting the grid-shell with rotation".[334] The program would allow the desired colors to be input through a gui-interface and processed in the model as the result of panel rotations computed in terms of the mounting configurations. [Figure 70]. In theory theirs was an elegant solution to a complex problem, but unfortunately that

[332] Ibid.
[333] Ibid.
[334] "Build (sic) on top of Java programming language, Processing features a simplified programming style and an extensive library of graphical and media functions. It can be used to develop complex media programs and also to quickly test ideas. Appropriately, the official name for Processing projects is sketches. In the words of Processing initiators and main developers Ben Fry and Casey Reas, the language's focus 'on the 'process' of creation rather than end results.'" Manovich, "Alan Kay's Universal Media Machine," 20.

rapid fast tracking of the project caused this final effort to be abandoned before it could be incorporated into the design.[335]

Once the design phase was complete, Gehry Tech was awarded a second contract for the grid-shell construction. Working with Waagner Biro as lead contractor along side Al Futtaim Carillion in Dubia, Gehry Tech was hired on to model and run simulations of the construction process for optimization.[336] This second phase of Gehry Tech's work involved solving several construction challenges. For the purposes of illustrating the nature of Gehry Tech's efforts, this chapter will only focus on a couple of these. Other problems like optimizing the installation of the bathroom pods and providing dynamic up-to-date project program visualization, while still interesting, present issues that are commonly solved through BIM and embody a very traditional use of CATIA in the construction fields.[337] The problems I will detail here use CATIA-based simulations to optimize solutions, but each issue also represents a hurdle that only exists due to the fast-track nature of the Yaz Hotel project and to the complex form of the grid-shell. Although the deadline for the hotel was tied to the Formula One Grand Prix race in November 2009, much of the major work on the grid shell had to be complete for the flooding of the marina scheduled to take place in the spring of 2009.[338] The three issues I will explain below (the scaffold, the ladder bounding boxes and the welding plan) all relate to this flooding deadline.

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[335] Thelen.
[336] Ibid.
[337] Hotels, even the most exclusive one like the Yas Island Marina Hotel, are designed with modular, as opposed to individually customized, bathrooms. The majority of their construction occurs off site and the bathroom 'pods' are then installed as units during the building's construction. Since the pods require extensive mechanical hook-ups (plumbing, electrical, et cetera), sequencing their installation so that it doesn't interfere with the rest of construction can present a complex problem in any large project, much less a fast-track one.
[338] This flooding was originally schedule to take place on March 9, 2009, but at the time of this writing, that date has been pushed to early May. Thelen.

Once the massive pylon foundations were constructed to support the grid shell but before its actual construction could begin, scaffold had to be erected so that workers could access all levels of the project allowing construction to proceed. The problem was that ground conditions of the soon-to-be-flooded site and the free-form shapes of the grid shell made it difficult to determine what form that the scaffold should take.[339] Contractor, RMD Kwikform, uses a rectilinear kit of parts, which can be configured into nearly any necessary arrangement, but the problem presented by the curving organic shape of the Yas Island grid shell was which arrangement was best for its construction. [Figure 72]. Gehry Tech used CATIA to parameterize the RMD Kwikform's kit of parts and generate solutions that would generate a workable scaffold. The model allowed several different scaffold designs to be produced and optimized for things like number of parts, transportation costs and ease of assembly. [Figure 71]. The responsive nature of their simulation meant that different rationales or theories for the construction could be tested and from these the degrees of efficiency could be identified, leading to an optimum design. [Figure 73].

The benefit of CATIA is that it need not begin with a set of formal inputs like RMD Kwikform's kit of parts. For example, the grid shell is made up of two interlocked systems: the glass panels whose design was previously discussed as well as an underlying dia-grid frame of steel. The frame is a welded structure to which the panels are connected making use of attachment nodes at the intersection of each of the grid struts. To make assembly easier and safer, part of the dia-grid's construction was designed to take place on the ground. A total of 172 "ladder bounding boxes" were constructed at an assembly site then transported three-quarters of a mile to the building where they were lifted into

[339] Ibid.

place.[340] These ladder bounding boxes were then "stitched" together using a total of 1696 cross pieces.[341] [Figure 74]. One benefit of this construction system was that it limited the on-site welding, which is more difficult and more dangerous, to 3392 individual welds.[342]

To optimize how the grid shell would come together using the ladder bounding box process necessitated a simulation model that could cope with the open-ended nature of the box arrangements. Their size was limited by the need to transport them and the curvature of the road along which they would travel, and the order of their construction had to be coordinated with the assembly on site.[343] Making the design comply with all the information encoded by such limits was the job of the simulation model. This model ensured that each proposed box corresponded to the size and shape limitations of what could be transported, but it also was able to simulate the timing of each box's fabrication. In determining the order of fabrication, certain rules about proximity between the boxes had to be incorporated so that the linking stitches between the boxes would have something to connect. Gehry Tech's model was able to optimize both of these features so that each box was of the proper size and shape for transport and lifting, was delivered at the proper time, and could be lifted into place.[344] The delicacy and precision of this orchestration eliminated problems before they could occur and cause construction delays, while still minimizing the number of boxes (and therefore the number on on-site lifts) as well as the number of stitches.

Once the number of welds was minimized, construction design also had to account for the process of the welds themselves. With so many welders on site and such

[340] Ibid.
[341] Ibid.
[342] Ibid.
[343] Ibid.
[344] Ibid.

pressure to finish the welds as quickly as possible, certain safety precautions had to be in effect.[345] Both optimizing the welding process and maintaining safety was such a complex task that Gehry Tech built an additional simulation model just to analyze it. [Figure 75]. Both pragmatic and safety concerns could be dealt with within the welding model. The average speed of welders and the time it took to complete each weld were used to work out ideal timing and sequences. In addition certain safety rules were parameterized to ensure that welders on the lower levels could only work if there were no other welds occurring overhead, and if certain diagonal distances between welders could be maintained.[346] If the simulation model for the ladder bounding boxes orchestrated construction , the welding design model was used to choreograph a ballet, the entry and exit of each welder precisely timed to align with the arrival of ladder bounding boxes. Always driving the need for these optimization efforts was the flooding of the marina. Because this event would require that the scaffold come down (and therefore the grid shell be complete), a means had to be found to control that which is usually least amenable to control: the time and work output of a group of a very large group of craftsmen all working within the same size-restricted site. Gehry Tech successfully used its expertise with parametric simulations to not only achieve the time management goals imposed by the flooding deadline, but they also minimized costs and redundancies while maintaining on-site safety.

This series of vignettes detailing the scope of Gehry Tech's consultation on the Yas Island Marina Hotel begins to form a picture of how BIM or Parametric Consulting differs from the more usual form of architectural consultancy. Interestingly each issue

[345] Ibid.
[346] Ibid.

they worked on was essentially a design problem, even though only some occurred in relation to the traditional design process while others occurred during construction. The flexibility they offer in solving any of these design challenges without respect to the boundaries traditionally circumscribing architecture reflects the expanding roles of the designer within architecture. And yet even as architects acknowledge this expansion, it is possible to simultaneously hold fast to the traditional definitions of the architect's role. It is possible to see just this contradiction in the Yas Island project. The traditional break between what the architect does and what the contractor does is well marked by the division between Gehry Tech's two contracts for the project (one with Asymptote and the other with Waagoner Biro). A marked schism existed in the deliverables for each.

While the work that Gehry Tech did on both halves of the project was consistently executed in CATIA (with some interoperation occurring to other platforms like Processing), at the end of the design phase the intelligence embodied that model was abandoned. What was delivered was a wireframe that encoded none of the BIM object identification or design parameters. What Asymptote got, and what they transferred to Waagner Biro, was the geometry, and interestingly, it is here that the real force of architecture's traditional definitions makes itself felt. Because what was encoded in the model were the design's forms, and even though this formal knowledge was embedded in a digital model and not into physical drawings, the information provided adheres to the rules that drawing sets up. It is impossible to imagine that all the work and rationalization that was encoded in the BIM model would be sacrificed, and yet this is what happens when the model is reduced to a wireframe. Just like drawing, a wireframe tells you about shape and formal relationship, but little else, but it isn't merely nostalgia for architectural

tradition driving the design's essentialization to form. It is the discipline itself and the legal definitions that it has wrought to protect itself, which make the wireframe the only responsible deliverable. Because the architect is liable for the accuracy and soundness of the design, if that design includes fabrication information, for example, the architect becomes liable for those calculations as well. Asymptote's model took things like fabrication systems into account, and used those systems to generate the design, but by omitting this information, the architect's liability was limited. Instead, the Waagner Biro translated the wireframe model using AutoCAD and scripted it from the ground up for fabrication.[347] This level of redundancy makes little sense, and if Asymptote was the developer or if the developer owned the model rather than the work being done as a part of the architectural contract, such inefficiencies could be eliminated.[348] However, in its current state, the legal definitions of architecture have been crafted to maintain its professional boundaries. Whether such definitions and boundaries will be adapted remains to be seen.

Until then Gehry Tech is seeking to remake relationships on its terms. Besides the issue of contractual liability, it is often just too expensive for the architect to pay for their services. As a result, Gehry Tech is attempting to redefine the financial relationship they have to the project. Their new model has then contracting directly with the client rather than with the architect or general contractor. To justify the addition of their fee to the project budget, they argue that their services will save the client money. Instead than operating on an hourly basis, the company has begun to share the risk of their services with the client. Overall project budgets include a usual tolerance to cover budget over-

[347] Ibid.
[348] Ibid.

runs. On a typical project this number ranges between 7-10%, while on a complex or fast-track project the number is often as high as 15%. So if a proposed project has a total budget of fifty-million dollars, between 3.5 and 7.5 million is projected to cover cost overruns. Gehry Tech proposes that their involvement can save all or part of this overrun line. Their fee is then defined as the split those savings with the client, or in the event that they produce no savings, Gehry Tech receives no payment for their services.

Sharing in the financial risk of the project benefits Gehry Tech in a number of ways. It locates their firm on equal footing with the other primary contractors involved in a project. This position provides them with the necessary authority to stream line and facilitate the realization of the project throughout both the design and construction phases. In short, Gehry Tech's contributions are situated as equivalent to the services of architects and general contractors. Additionally, by extracting their fee from savings they share with the client, both they and the client become invested in re-engineering the design and construction process. Directly allied with the client, this position allows them to dictate certain processes that architects, contractors and subcontractors may have been otherwise reticent to attempt. As overruns are often seen as an easy way to increase the size of the contract and the amount of profits, previously there has been very little incentive to resist accessing this portion of the budget. In a sense, although Gehry Tech claims that their purpose is project specific, that their goal is to "reduce project risks, costs, and completion times," in fact the result of their efforts cannot help but occur on a disciplinary level.[349] By inserting themselves into a project proforma and carving out efficiencies adequate to their fee in addition to a savings for the client, one must ask why any project would not seek their assistance. In other words, the new structure that Gehry

[349] "Gehry Technologies Company Page."

Tech proposes makes their involvement and the increased productivity they offer indispensible. In short, their new processes of design and construction are positioned to replace less efficient ones in existence today, and in so doing replace the processes and priorities of design and construction that drawing structured 500 years ago. Their firm and its activities are radically and irrevocable redefining the role of the architect and the terms of the architectural contract.

Familiar Shapes

Throughout this chapter and its examination of Gehry Tech and Evan Douglis, the question has which began this dissertation has been brought to a head. If I return to the source of many of these questions and meditations, Gehry's New Guggenheim at Bilbao, I see that my question has changed. It is no longer possible for me to simply ask what this new aesthetic is. My questions have evolved just as architecture's use of computation has. Now I ask, if the transparency pact of drawing-based architecture creates a deep resonance between the forms that a visitor can "read" off of a building and those that exist in the designer's mind, what happens when architecture ceases to use eidetic form as its compositional principles? What does it mean for Gehry to break this transparency pact by using forms that are simultaneously dynamic and beautiful and lacking in legibility, or perhaps better, lacking in formal sensibility? If Eisenman's work reified the connection between the visitor and architect, while severing the building's connections to the cultural codes that usually supported this expressive channel, Gehry breaks what is left of this essentialized transparency.

If there is one thing that most people can agree on about Gehry's buildings, it is that they photograph beautifully. It is, for example, difficult to take to take a bad picture of the Disney Music Hall. In each photo the building seems to make a new formal statement, and it is very rewarding to continually create one beautiful image after another. But, it is the frame of the viewfinder that is making Gehry's works sensible. When abstracted as light-data and edited by the lens, both image-maker and image-viewer can agree on what it is that the picture holds. There is no way, however, for one visitor to agree with another on the specifics of how they've internalized one of Gehry's buildings. By extension, there is also no way that Gehry's understanding and motives for his compositions can be transmitted to the visitors by his forms. Gehry's buildings express because they are cultural creations that carry the signature of their moment of creation, but they are not a deliberately composed message the way, for example, Karl Schinkel's Altes Museum was. The forms of the Disney Concert Hall are no more a specifically choreographed series of messages about the building-type and its place in society, about the clients and their grandeur or their beneficence or their power than they are a refinement of the forms and messages of Bilbao. There can be no statement because without sensibility there is no transparency, no cultural coding, no formal expression. In other words, there is nothing left of the foundations that drawing built for the discipline of architecture. It makes sense then that Gehry Tech seems to re-define the discipline with every step and every project it undertakes. By broadcasting Gehry's design processes, they circulate an architecture that exists outside of formal consideration, and therefore, outside the traditional boundaries of architecture.

Douglis, on the other hand, approaches form with none of Eisenman's or Gehry's irony. He re-embraces form by refusing to deal directly with it. He sees forms instead in terms of algorithm and in so doing offers a solution not imagined by the putative masters of formal composition. The paradox here is that, seemingly, through algorithm Douglis pushes architecture towards an even greater abstraction than that of drawing, but his embrace of craft and materiality collapses not just this greater distancing but drawing's as well. His internalization of craft taps into the tacit knowledge that architecture has maintained along side drawing since its adoption of that medium. This tacit knowledge is the of the same ilk that Kahn struggled to translate into form with his carefully designed indices of construction. Like Kahn, Douglis draws on the unarticulated algorithms that architecture has always processed, those built into the physical constraints of construction and materials. He processes these not as limitations but as un-verbalized and implicit codes brought into the very basis and logic of design. His work thus demonstrates how the architecture might be seen as a microcosm, a reflection of the world which in turn can itself be understood as one great computer. Douglis finds, for example, the algorithm in glass and wire. Through the dance of their interaction he creates a chandelier whose process of formation reiterates and teases out the natural laws and processes encoded within the materials. In so doing Douglis shows the similarities that exist between everyday materials and the computer. He demonstrates why the process of simulation on the computer might be understood as a mystical representation in the same what that the Renaissance understood perspective and orthographic projection to be mystical in their ability to connect the physical world to the divine realm of the ideal.

In light of the cynical viewpoints of post-modernist theory and aesthetics, such connections hardly seem appropriate today. And yet, historically speaking it has been common for building, which is to say human creativity writ large, to emulate its moment's best understanding of how the world was structured. The architectural logics which structure the core of its aesthetic system, are habitually aligned to the logics of science. In the Renaissance, the best of this science was the geometry of projection, which was thought to link the physical, material forms of this world to the platonic ideals which were believed to structure divine thought, and therefore, the universe. During the Renaissance the mathematics of projection were equivalent to Divine logic. During the nineteenth-century, science diverted its focus off of form and on to formative processes. Evolution replaced geometry. Early reflections of this shift had architecture internalizing the principles of morphology and seeking to pattern its formal relations on its own internal logics they was natural forms were believed to be ordered. Today, after the sequencing and our partial understanding of DNA, the architectural aesthetic has become procedural and generative because these are the processes believed to govern the natural world. It may not be openly recognized or acknowledged, but architecture has re-aligned both its creative motives and methods with those believed to shape the universe's creation. Architecture, then, stands at a remarkably similar precipice now to the one it stood at in the beginning of the sixteenth-century. Shifts within the scientific model of the universe have created a new episteme which is being processed on a cultural, technological, and aesthetic level. To remain relevant, these shifts demand that architecture reconsider its definitions on a disciplinary level, that questions be asked about its purposes, processes and meanings. We have only recently arrived at the point

where answers have begun to be offered, and therefore we are just now at a moment when critical writing can begin.

FIGURES

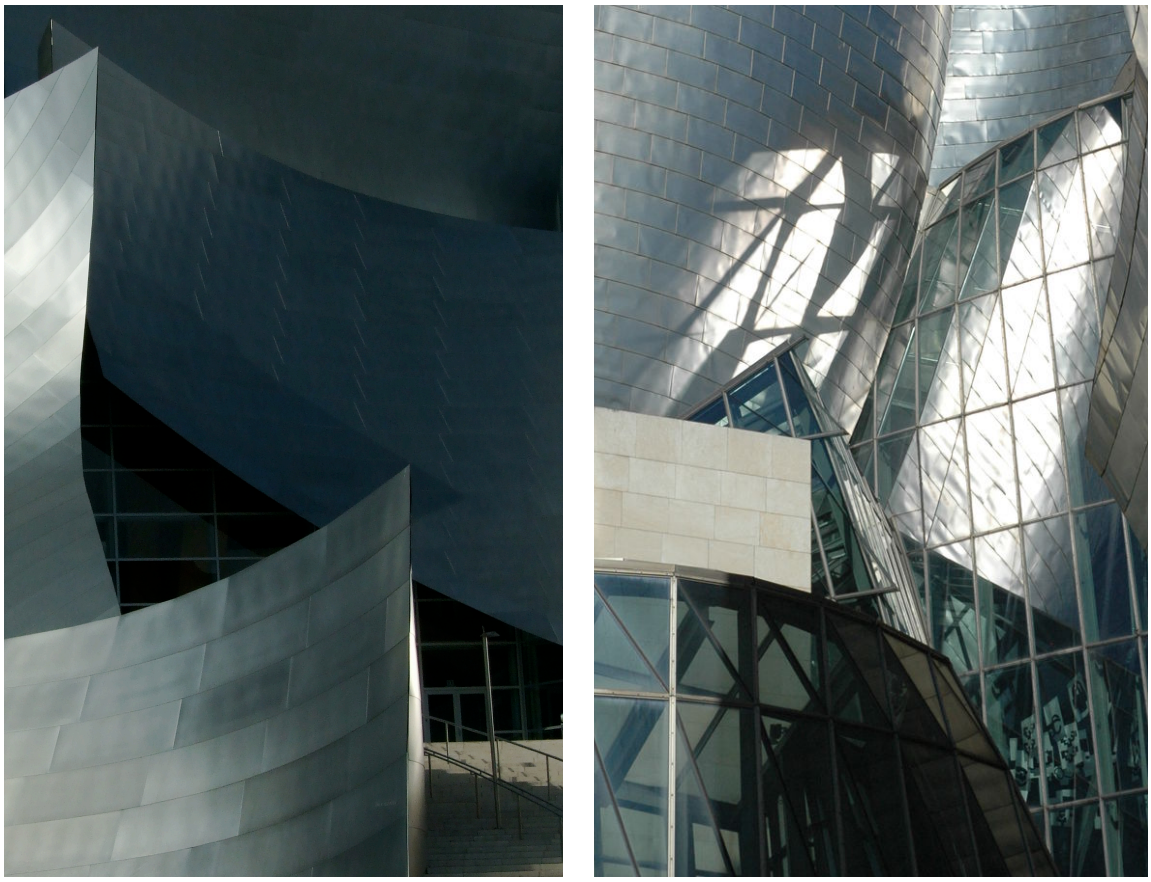

Figure 1: Image of Disney Concert Hall in Los Angeles on left and the New Guggenheim Museum in Bilbao on Right.

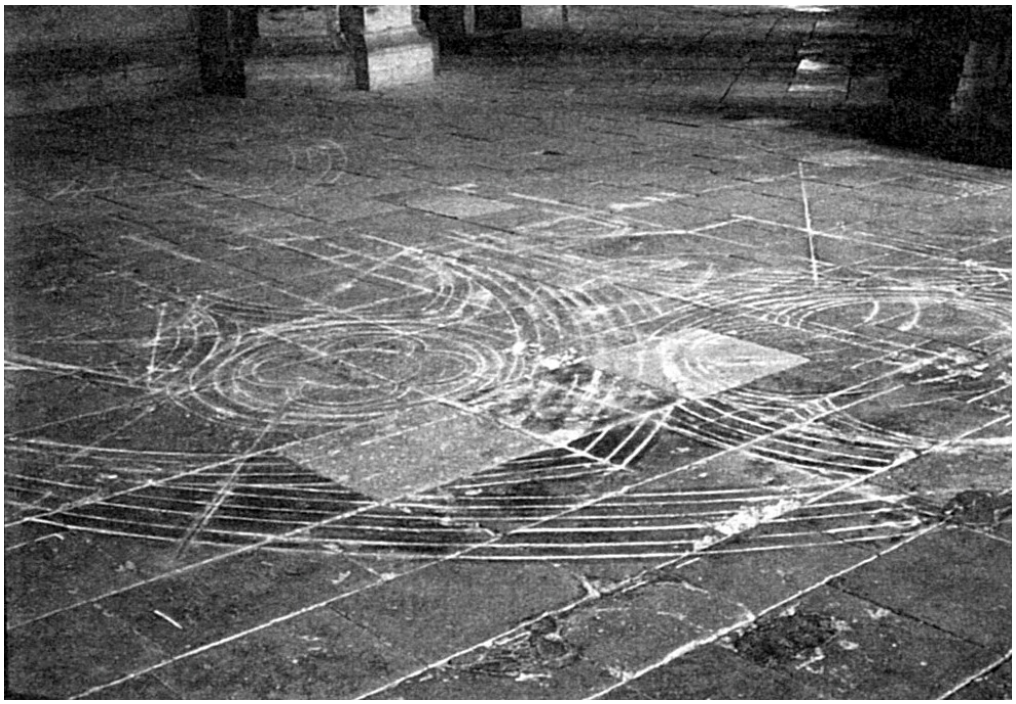

Figure 2: South Tower Épure located in the Crypt of the Cathedral of Bourges.

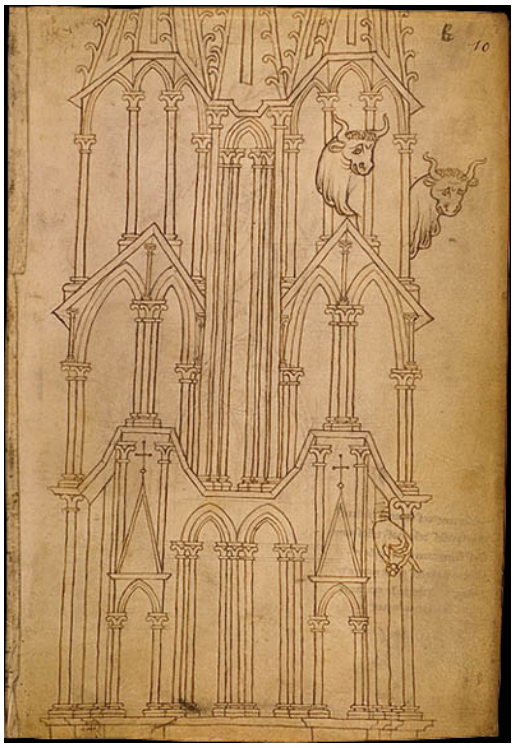

Figure 3: Laon Tower Drawing from the Sketchbook of Villard d'Honnecourt, Paris, Bibliothèque Nationale, 19093, p. 19.

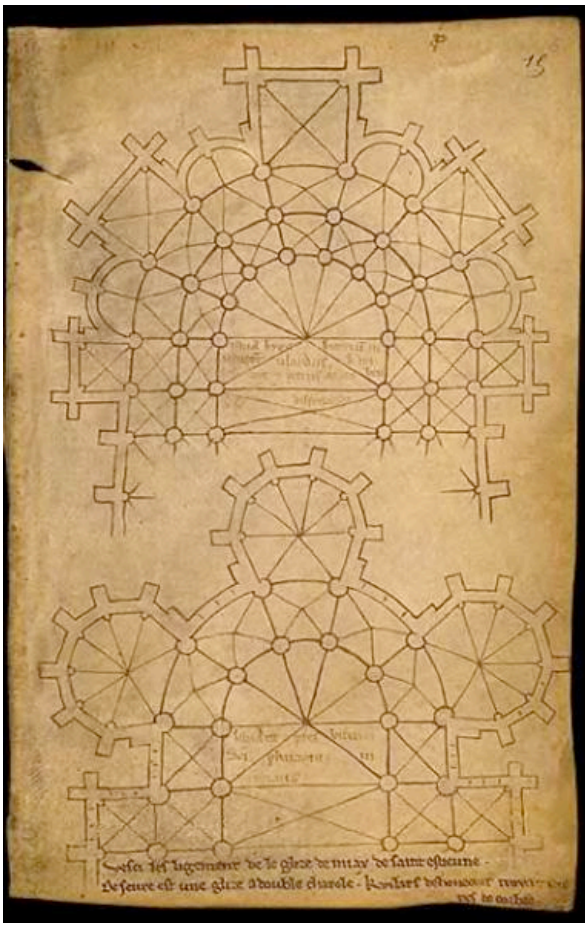

Figure 4: “Ideal” Plan (Upper Figure) from the Sketchbook of Villard d'Honnecourt, Paris, Bibliothèque Nationale, 19093, p. 29.

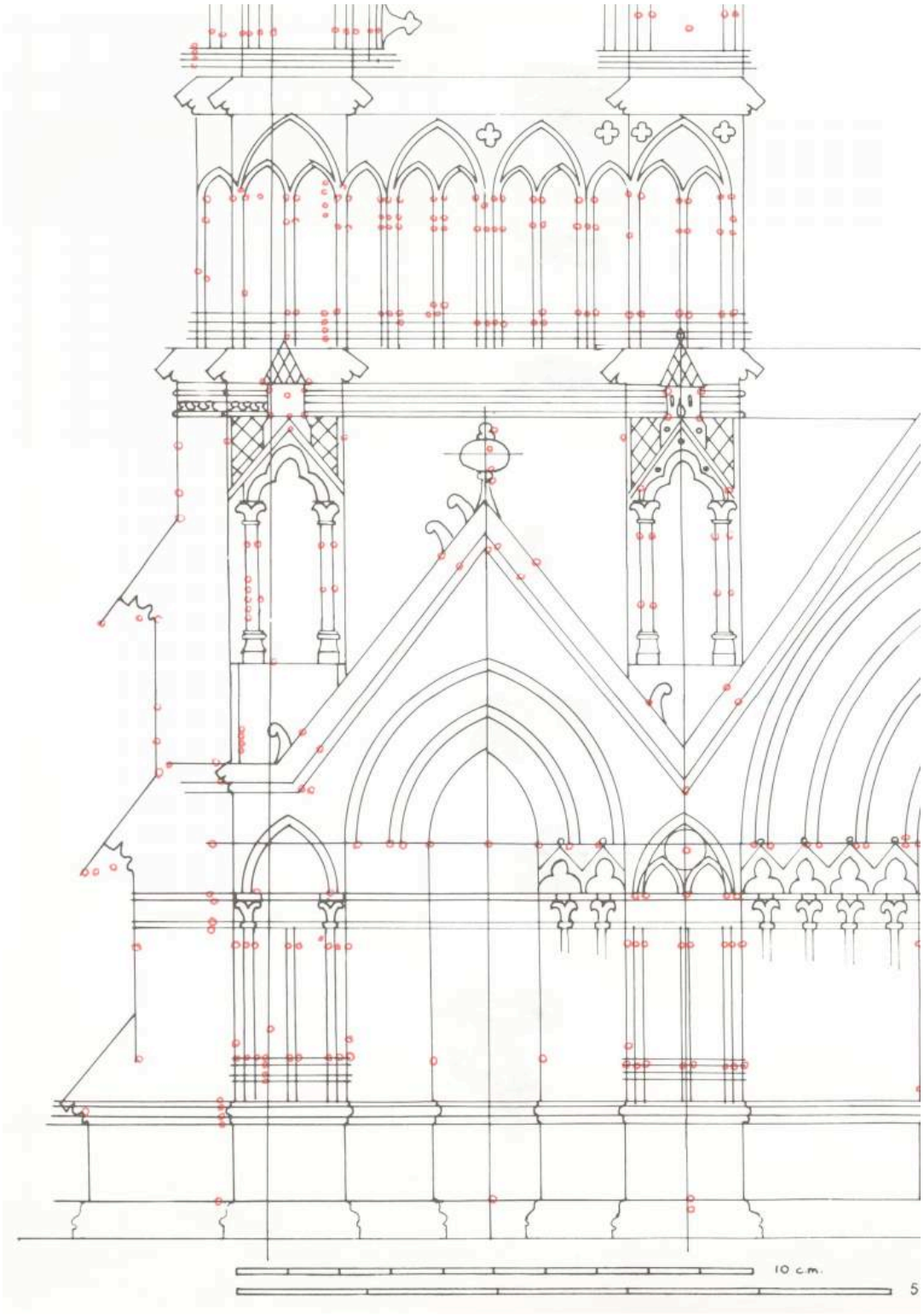

Figure 5: Detail from Façade Project A, the Reims Palimpsest, before 1270, Book G661, Dépot Annexe des Archives Départmentales de la Marne, Reims, France.

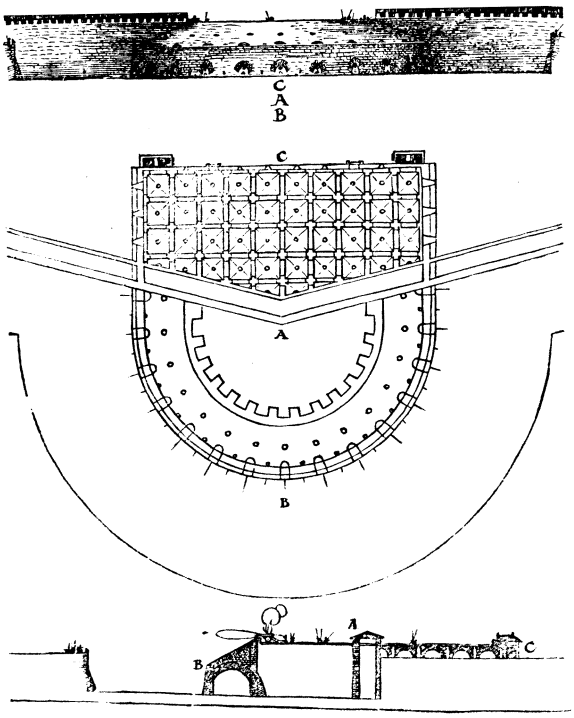

Figure 6: Albrecht Dürer, Etliche underrrict zu befestigung der Stett Schllosz und flecken, 1527.

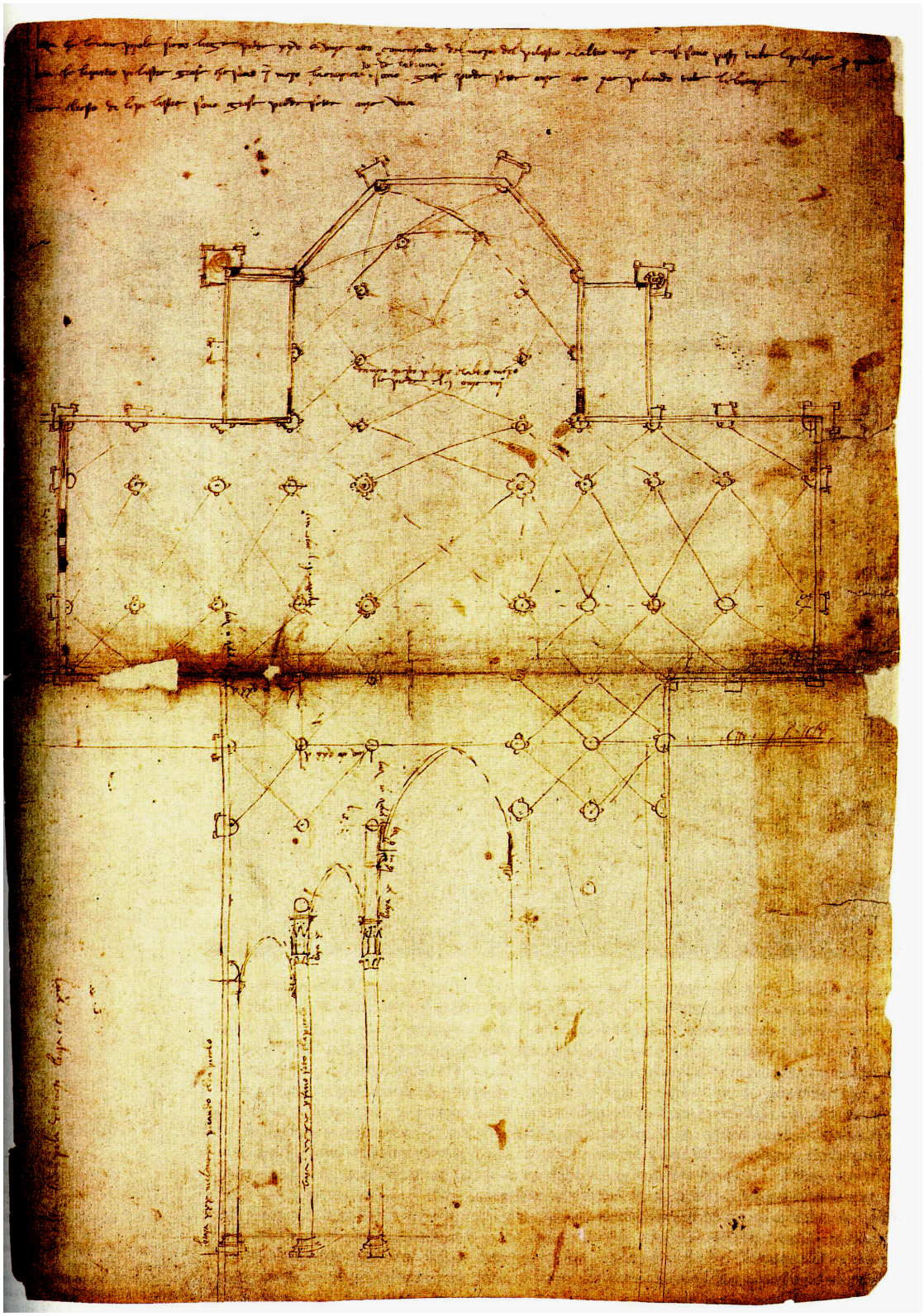

Figure 7: Milan Cathedral Plan and Section, Antonio di Vincenzo, Bologna, Museo di S. Petronio, Archivio della Fabbrica di San Petronio, cartella 389, no. 1, Cat. No. 6.

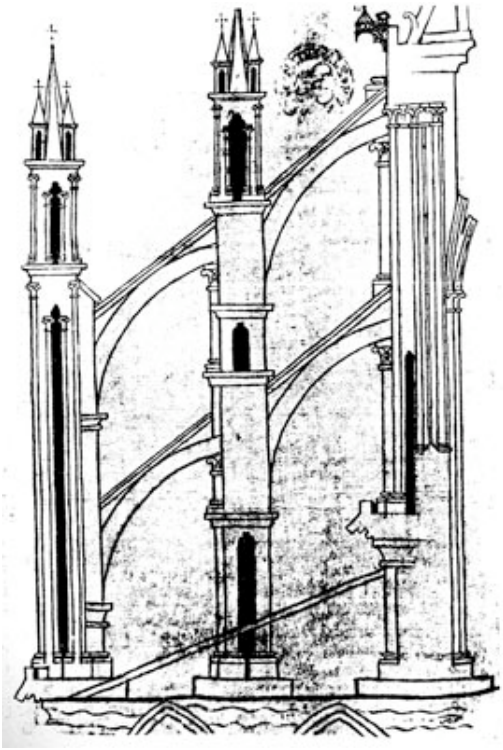

Figure 8: Reims Apsidal Choir Section from the Sketchbook of Villard d'Honnecourt, Paris, Bibliothèque Nationale, 19093, p. 64.

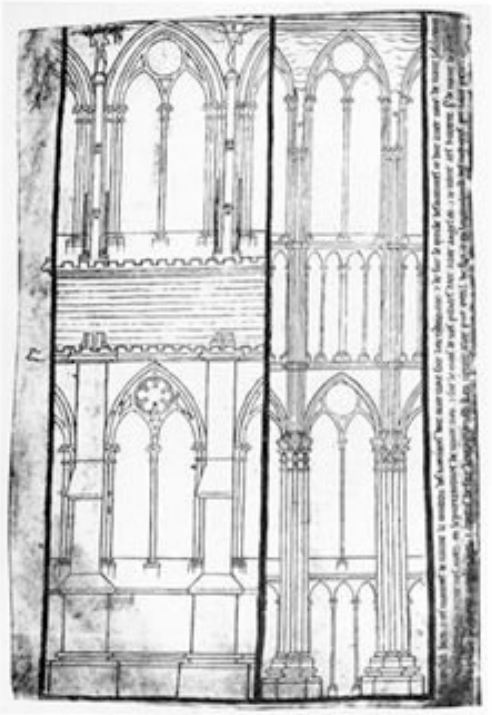

Figure 9: Reims Interior and Exterior Elevations from the Sketchbook of Villard d'Honnecourt, Paris, Bibliothèque Nationale, 19093, p. 62.

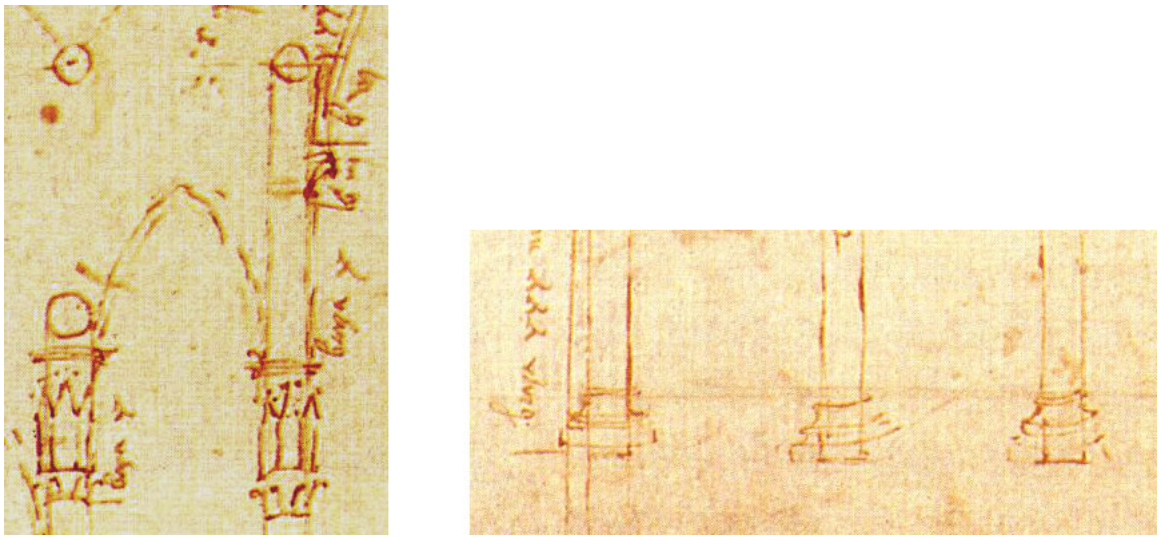

Figure 10: Section Details from the Milan Drawing showing the Pier Capitals (left) and Bases (right).

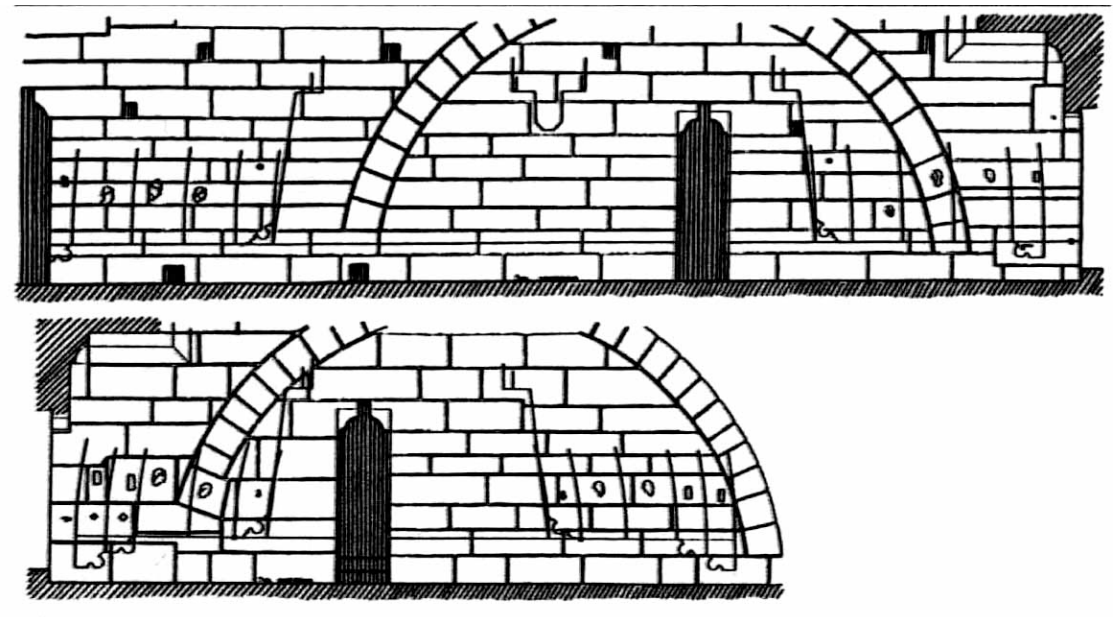

Figure 11: Trace of Reims Wall Épures.

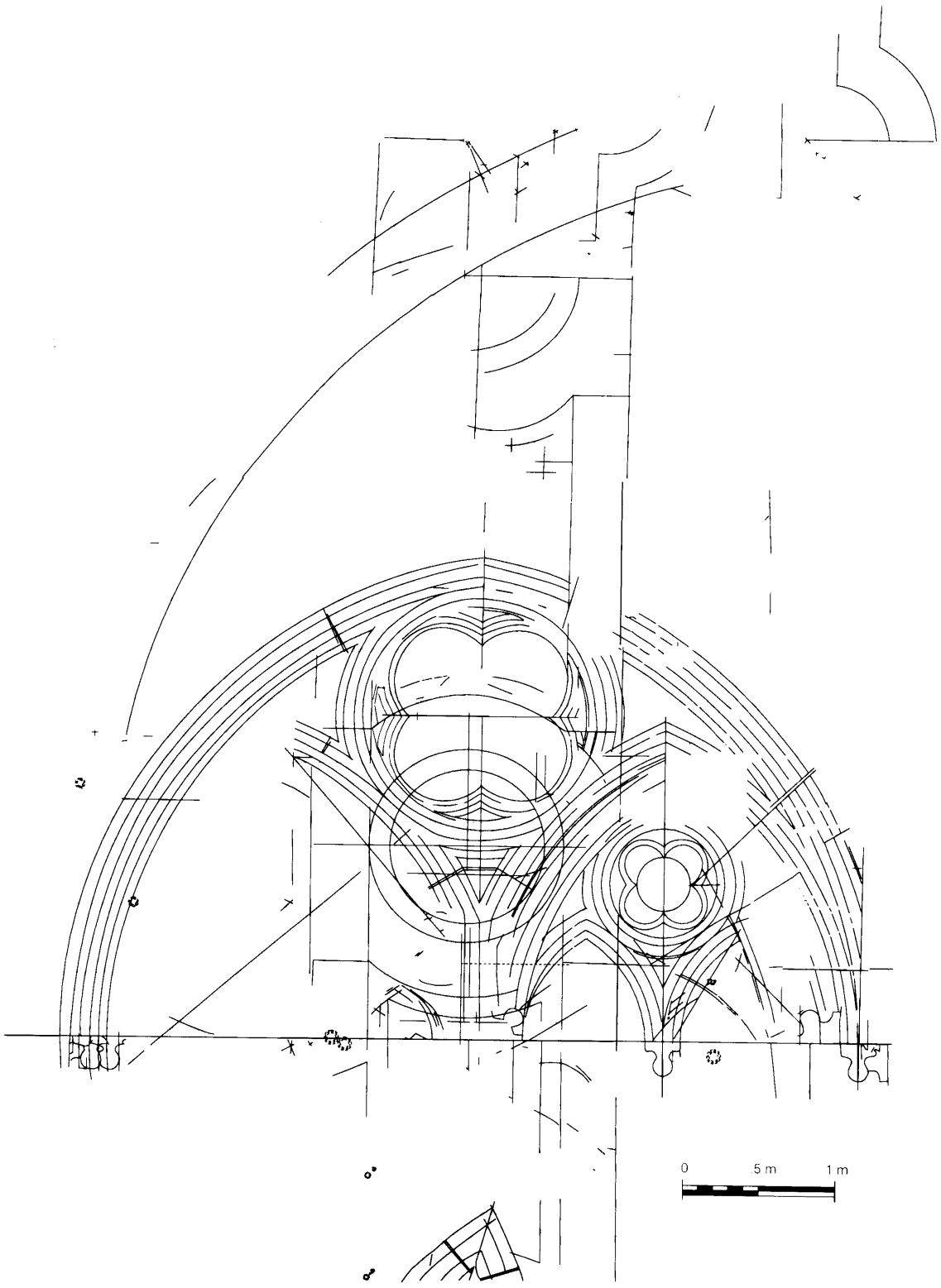

Figure 12: Trace of the South Tower Épure, Crypt of the Cathedral, Bourges, France.

Figure 13: Detail of Molding Plans from Right Side of the South Tower Épure, Crypt of the cathedral, Bourges, France.

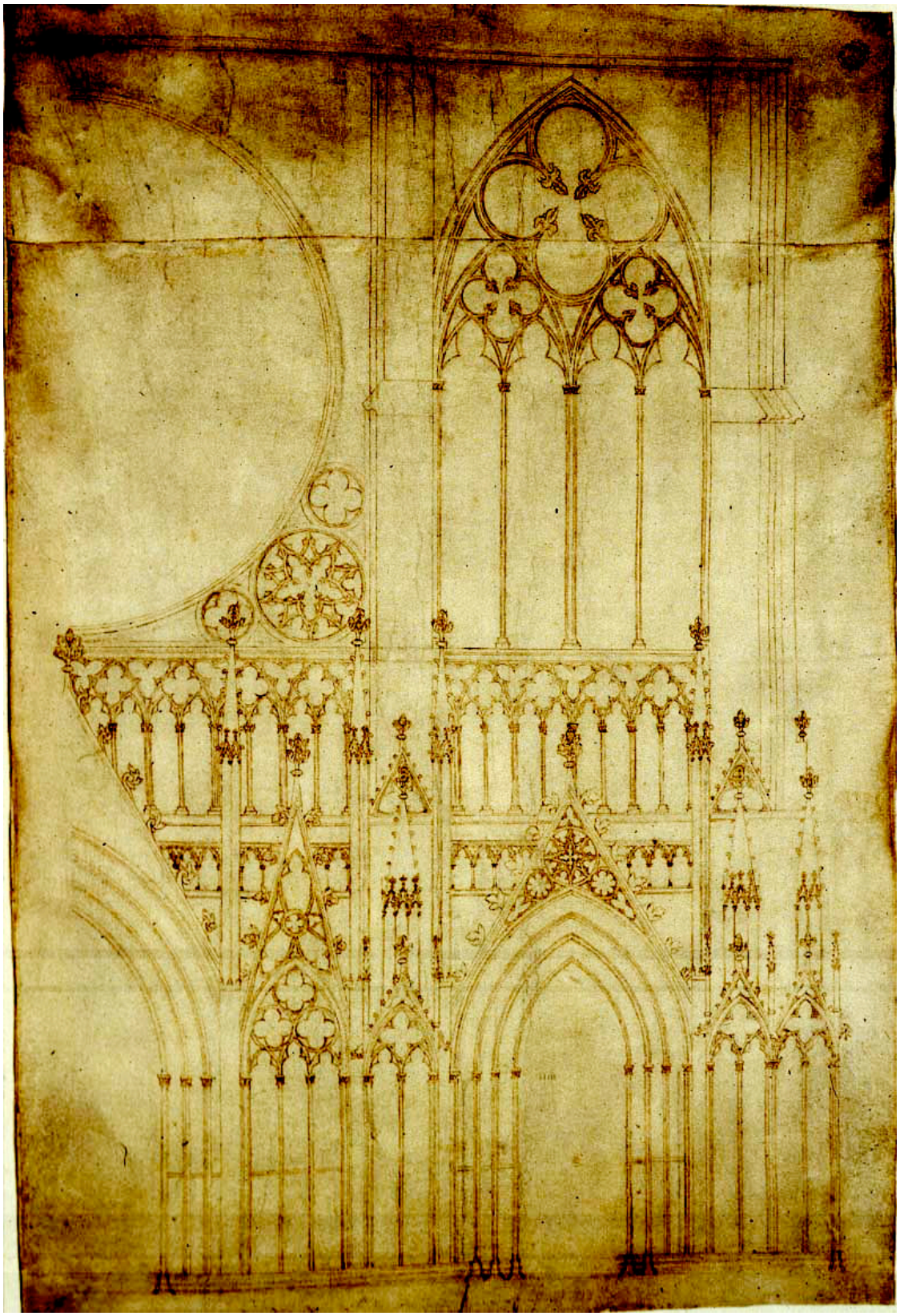

Figure 14: Strasbourg Plan A, c. 1260, Musée de l'Oeuvre Nortre-Dame, inv. 1, Strasbourg, France.

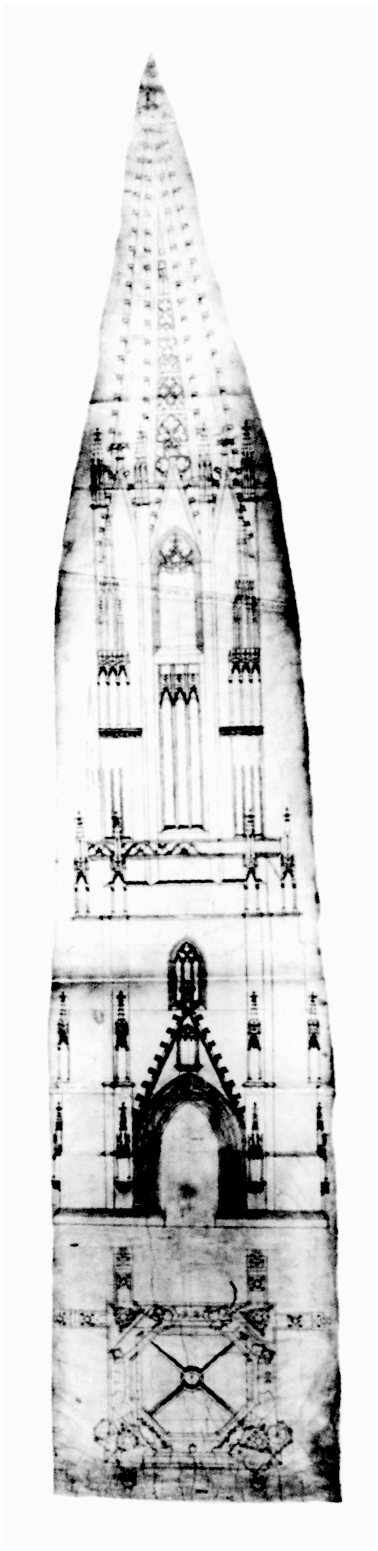

Figure 15: The Tower Elevation and Ground Plan of Freiburg Münster, c. 1380, Kupferstichkabinett der Akademie der Künste, Vienna, Austria, Inv. Nr. 16.874.

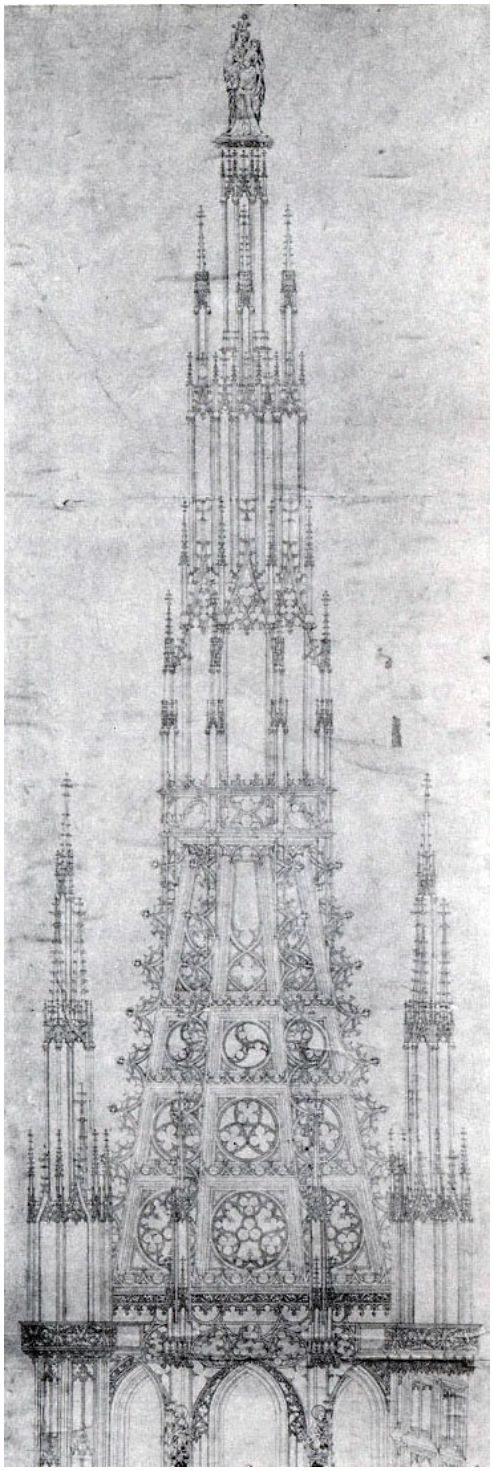

Figure 16: Johann Hültz, Drawing of north spire project for Strasbourg cathedral, c. 1419, Musée de l'Oeuvre Notre-Dame, Strasbourg, France.