THE ORTHOGRAPHIC SET:
MAKING ARCHITECTURE VISIBLE

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ABSTRACT

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The meaning of term "representation" has shifted in both relevancy and definition in the discipline of architecture with the introduction of computational design technologies. The assumption of this study is that the selected mode of representation has the power to affect the process of design and even the production of architecture. At the present time, while the discipline is witnessing a change in its tendencies and terminologies, such as from drawing to 3D modeling, from construction to fabrication, and from geometry to topology, it is crucial to look at the "conventions" of architectural representation that are identified through "projections," and particularly the "orthographic set". This study aims to challenge the prejudices against the "orthographic set" that consider it to be an ineffective or inadequate tool for representation in the contemporary practice of architecture following the emergence of "digitization". It is the claim of this thesis that the "orthographic set" is actually a methodology that is still powerful in the visualization of the "rational" thinking processes of design, and is still a highly pertinent technique in the representation and production of architecture. With the arrival of computational design technologies to the practice of architecture, the "visibility" of its representations have started to blur; and considering the dialectics between architectural representation and the architectural object, while Modern Architecture can be assessed as the transformation of the orthographic set into a declaration of a stylistic manifesto, in the digital age the question arises of what makes architecture visible, and whether it is possible to come up with a "new" definition of style.

Keywords: architectural representation, orthographic set, projection lines, digital media

ÖZ

ORTOGRAFİK SET:
MİMARLIĞI GÖRÜNÜR KILMAK

Türkay, Seray
Yüksek Lisans, Mimarlık Bölümü
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Hesaplamalı tasarım teknolojilerinin mimarlığa etkisinin görüldüğü en önemli alanlardan biri temsildir ve tanım gerektiren bu sözcüğün anlamı ve gerekliliği mimarlığın kendi içinde sorgulanmaya başlamıştır. Bu çalışmanın temelini oluşturan varsayım, seçilen temsil yönteminin tasarım sürecini olduğu kadar mimarlığın üretim biçimlerini de doğrudan etkilediği yönündedir. Kullandığı dili çizimden üç boyutlu modellemeye, inşa etmekten imal etmeye ve geometriden topolojiye doğru her gün değiştiren mimarlık disiplini için, mimari temsilin (gelenekselleşen) ön kabullerinin ve özellikle de yansıtmalar ve ortografik setin yeniden düşünülmesi gerekmektedir. Bu tezin amacı, sayısallaştırmanın ortaya çıkmasından sonra ortografik setin etkisiz ve önemini yitirmiş bir araç olduğunu söyleyen yorumları sorgulamaktır. Bu çalışmanın savı, ortografik setin hala tasarım sürecinin rasyonel düşünceyi görselleştirmede gücü olan bir metodoloji ve mimarlığın temsili ve üretiminde hala geçerli bir teknik olduğudur. Hesaplamalı tasarım teknolojilerinin mimarlık uygulamasına girmesiyle beraber, temsillerinin "görünürlüğü" bulanıklaşmaya başlamıştır. Mimari temsil ve mimari nesnenin diyalektiği düşünüldüğünde, Modern Mimarlık ortografik setin biçimsel bir manifestoya dönüşmesi gibi değerlendirilebilirken, dijital çağda mimarlığı neyin görünür kıldığı ve yeni bir "stil" tanımının mümkün olup olmadığı soruları ortaya çıkmaktadır.

Anahtar kelimeler: mimari temsil, ortografik set, yansıtma çizgileri, sayısal ortam

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CHAPTER 1

INTRODUCTION

The advent of computer graphics was a key development for the architectural profession in the 1960s, bringing about a shift in the concept of “representation” and a change in its relevancy and definition for the discipline. Contemporary architecture has, since that time, come under the growing influence of the “screen,” which has arguably replaced the long-established association of the pencil and paper. Through the discovery of the potentials of the “new” media, the shift to an “information age” has been “undeniable”.[1] The influence of digital media continued to evolve not only in representation, but also as a means of design and even physical production. As digital media influenced the representation and production of architecture, both the discipline and theory were subjected to a change in their tendencies and terminologies to include new terms and phrases such as 3D-modeling, parametric design, associative geometry, fabrication, and topology.

The “conventions” of architectural representation are identified by “projections,” and the “orthographic set” can be found at the center of most criticisms. Plans, sections and elevations are accused of being limited tools of representation that restrain the conceptual elaboration of the design and its object.[2] It has been suggested that the use

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[1] See, The Virtual Dimension: Architecture, Representation, and Crash Culture, Ed. by John Beckman, New York: Princeton Architectural Press, 1998; Digital Tectonics, Ed. by Neil Leach, David Turnbull, Chris Williams, Chichester, West Sussex, U.K. ; Hoboken, NJ : Wiley-Academy, 2004; Patrick Beaucé, Bernard Cache, Objectile: Fast-Wood: A Brouillon Project, Wien: Springer Wien, 2007; Architecture in the Digital Age: Design and Manufacturing. Ed. by Branko Kolarevic. London and New York: Spon Press, 2003; New Normal: Post-Professional @ Penn Design 2010-2011, by Winka Dubbeldam (director), Roland Snooks, Ferda Kolatan.

[2] Alberto Pérez-Goméz and Louise Pelletier. “Architectural Representation Beyond Perspectivism,” Perspecta, vol.27, 1992: 21.

of a set of projections to represent and construct a building is merely a preconceived assumption of a formalistic approach. As a result of being "parts of a dissected whole relying on syntactic relations," the orthographic set, comprising a plan, elevation and section, is considered to be "reductive".[3] The relationship between design and representation is recognized as being predictable and deterministic and the conventional process static due to the hierarchical organization and execution of orthographic projection.[4]

Contemporary architecture labels the "orthographic set" – the set of two dimensional architectural projections – as a "convention," in that it disregards the theoretical aspects of this mode of representation in the discipline of architecture. This study claims that the premises of the digital age, for the profession of architecture, are based on the above-mentioned criticisms of the orthographic set. The intention here is not to come up with another definition, but to "shift" the perception of this tyranny into an "awareness" of the improvements of the "new" without denying the impacts of the so-called "conventions". It is crucial to look at the roots, or rather, conventions of graphics that have been criticized as being "limited," "reductive," "static," "hierarchical," "linear," "compartmentalized/fragmented" or "old".[5]

The discipline of architecture is seeking to define a "new normal,"[6] which would appear to be a departure from the conventions of representation. As one of the key concepts of this study, "representation," the culture of "exposing ideas" and thus the very premise

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[3] Ibid.

[4] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age, 2003: 13.

[5] There is a wide use of terms such as "generative," "flexible," "responsive," "n-dimensional," "non-linearity," "integrated design processes," and "non-standard," and a certain emphasis on the term "new" in attempts to express the "great advantages" of the digital age. A detailed discussion will be made in Chapter IV, considering the visual and conceptual effects of the so-called "conventions" on the construction of digital modeling and visualization tools.

[6] The expression "new normal" is borrowed from the title of the studio-book: New Normal: Post-Professional @ Penn Design 2010-2011, by Winka Dubbeldam (director), Roland Snooks, Ferda Kolatan.

to "visuality" of architecture, is assessed as an act of design and production. Starting with the assumption that the selected mode of representation has the power to affect the processes of design, and even the production of an "object," the dialectics between representation and the object to be represented is discussed. Focusing on the distance between the "ideal" and the "object," the "orthographic set," as a tool of representation, gains significance on the strength of its capacity to represent the "objectness" of the object of representation. The intention in this study is not to present the history of the orthographic set, nor to analyze orthographic projection as a technical method for engineering, however tracing the origins and influences of this "convention" is crucial if one is to understand its contemporary significance. By referencing key figures such as Robin Evans, Alberto Pérez-Goméz and James Ackerman, and drawing upon their readings of such important contributors as Albrecht Dürer, Piero della Francesca, Leon Battista Alberti and Gaspard Monge, the development of architectural representation and projection will be analyzed, thus providing a theoretical basis for the discussion.

Robin Evans claims that architecture is reliant on its images.[7] The emergent modes and techniques of representation have always dealt with the problem of visual correspondence between the drawing and the building. Therefore, "representation," as the realm of the ideal; and architecture, as the real, should be scrutinized with particular focus on the "critical distance" between the orthographic set and its object. Here, the term "distance" does not denote "a break between" the processes of architectural production and its representation, but rather "a space within" that is to be investigated. To attain the distance between a mental conception and its material expression, a process of translation is employed. The "translational space," as indicated by Evans, between the "representational" and the "real" is explored in respect to the term "projection"; and the orthographic set is assessed as the field of projection wherein the translation is visible.

[7] Robin Evans. "Architectural Projection," Architecture and Its Image: Four Centuries of Architectural Representation: Works from the Collection of the Canadian Centre for Architecture. Eve Blau; Edward Kaufman; Robin Evans; *Centre Canadien d'architecture*.; et al. Montreal: *Centre Canadien d'Architecture*/Canadian Centre for Architecture ; Cambridge, Mass.: Distributed by the MIT Press, 1989: 21.

What enables articulation from the ideal to the real is “representation”. Since representation by definition is only possible through the non-existence of its object of representation, it requires a certain degree of abstraction. Dependence on the concept of “abstraction” identifies representation as “a symbol that expresses or stands for something else, very often a reality, or another representation”.[8] In architecture, representation signifies a reality that as yet does not exist, and thus, is an “ideal”. Abstraction also means “to take away, to isolate, to remove”.[9] Since abstraction indicates a “distance” between the object to be represented and the subject that it represents, it can be claimed that the production of architecture has been based on “abstraction” right from the very beginning. The distances or intervals created through abstraction are overcome by means of translation. Hubert Damisch explains the linkage between the conception of architecture and its material realization, suggesting that the connection induced by projection actually creates an interval, a critical “distanciation,” which is closely dependent on the modes of production.[10]

Robin Evans first addressed the issue of “transmitting ideas” in his essay “Translations from Drawing to Building”.[11] After publishing his seminal work “Architectural Projection,”[12] in which he conceptualized the role of “projection lines” in the production of architecture, Evans explored the nature of translational processes by means of “projection lines” in “The Projective Cast: Architecture and its Three Geometries”.[13] He

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[8] Ömer Akın. Psychology of Architectural Design. London: Pion Limited, 1986: 186.

[9] Bernard Cache. Earth Moves: The Furnishing of Territories. Translated by Anne Boyman, edited by Michael Speaks. Cambrdige, Mass.: The MIT Press, 1995: 81.

[10] Hubert Damisch. “Anything But?” Anything. Ed. by Cynthia C. Davidson. New York: Anyone Corporation. 2001: 249-54.

[11] Robin Evans. “Translations from Drawing to Building.” Translations from Drawing to Building and Other Essays. Cambridge, Mass.: The MIT Press, 1997: 153-193. First published in AA Files 12, Summer 1986: 3-18.

[12] Robin Evans. “Architectural Projection.” Architecture and Its Image, 1989: 19-35.

[13] Robin Evans. The Projective Cast: Architecture and Its Three Geometries. Cambridge, Mass.: The MIT Press, 1995.

states that: “Projection operates in the interval between things. It always implies an active, transitive condition”.[14] For Evans, “to translate is to convey”.[15] Coming from the Latin term *translatio*, translate means to remove or carry from one place to another, in other words, “it is to move something without altering it”.[16] However, Evans opposes the assumption that there is “a uniform space through which meaning may glide without modulation,” seeing this as a “naive delusion”.[17] Deriving from the uneven and discontinuous processes of translations from one coding system to another, Evans compares the way that architecture is, arguably, divided between drawing and building with the division of writing and speech. He states that architecture has nevertheless been thought of as an attempt at maximum preservation, in which both meaning and likeness are transported with minimum loss from the idea through drawing to building. Evans points out the prejudice against drawing in a striking way, emphasizing the delusion thus, “Likeness is not identity; orthographic projection is not orthography; drawing is not writing and architecture does not speak”.[18]

Architecture requires a distance from the building; and the “distanciation” defined in the early stages of realization, which is actually the representation of the conceptualized idea, has never been overcome. Unlike a sculptor or a painter, the architect never works on the “object” that is intended to be produced, which is confirmed by Evans[19] in his belief that, “Architects do not make buildings; they make drawings for buildings”.[20] Architects develop and work on various techniques and methods to accomplish the distance in the processes of translation from the ideal to real. Although different modes

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[14] Ibid. 366.

[15] Robin Evans. “Translations from Drawing to Building”, 1997: 154.

[16] Ibid.

[17] Ibid.

[18] Robin Evans. The Projective Cast, 1995: xxxvi.

[19] Robin Evans. “Translations from Drawing to Building.” 1997: 156.

[20] Robin Evans. “Architectural Projection,” 1989: 21.

and instruments of representation are used, such as sketches, maquettes, collages, renderings, etc., the "drawing" retains the most crucial place in the discipline of architecture, and becomes the "real repository of architectural art".[21]

Among the different modes through which architecture is produced, namely drawing, writing, building and models, the drawing is historically assessed as the key element.[22] Walter Benjamin defines architectural drawing as a "marginal case," since "it precedes the building that it is produced without reference to an already constituted object in the world".[23] Drawings serve for the development of an idea by surrogating both for concepts and for physical realities.[24] Terrence Riley states that, "At the time of its making, the drawing is part of a private process wherein an idea is given form".[25]

Architectural drawings imply an intimate relationship between the image and its maker; they guide and generate the architectural design process by acting as a medium of thought, rather than a simple medium of expression.[26] The significance of drawing in

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[21] Robin Evans. "Translations from Drawing to Building," 1997: 157.

[22] Diana Agrest states that architecture is produced in different registers through three different texts: drawing, writing and building. However, in the footnotes she recognizes models as a fourth register. Diana Agrest. "Representation as Articulation Between Theory and Practice." Practice: architecture, technique, and representation / essays by Stan Allen; commentary by Diana Agrest. Australia : G+B Arts International, 2000: 164.

[23] Walter Benjamin as referred in Anthony Vidler. "Diagrams of Diagrams: Architectural Abstraction and Modern Representation." Representations. University of California Press No.72, Autumn 2000: 6.

[24] Matilda McQuaid. "Acquiring Architecture: Building a Modern Collection." Envisioning Architecture: Drawings from The Museum of Modern Art. Ed. by Matilda McQuaid, with an Introduction by Terrence Riley. New York : Museum of Modern Art ; London : Thames & Hudson, 2002: 19.

[25] Terrence Riley. "Drawn into a Collection: A Context of Practices." Envisioning Architecture: Drawings from The Museum of Modern Art, 2002: 11.

[26] Mark Hewitt. "Representational Forms and Modes of Conception: An Approach to the History of Architectural Drawing." Journal of Architectural Education vol. 39, no. 2, Winter 1995: 2-9.

architectural design is emphasized by Anthony Vidler, who, referring to Durand words, claims,

> Drawing serves to render an account of ideas, whether one studies architecture or whether one composes projects for buildings, it serves to fix ideas, in such a way that one can examine a new at one's leisure, correct them if necessary; it serves, finally to communicate them afterwards, whether to clients, or different contractors who collaborate in the execution of buildings: one understands, after this, how important it is to familiarize oneself with it [drawing].[27]

Mark Wigley identifies architects as "dreamers" that "commit their ideas to paper".[28] In this way, paper becomes a "support of dreams" through the representation of an idea by materializing it, which at the same time paradoxically results in the immaterialization of the paper. Wigley demonstrates the oscillation of representation between the material and the immaterial, i.e. the real and the ideal, by focusing on "paper" as the context of "drawing":

> Paper is treated as if it is not really there, as if it occupies a liminal space between material and immaterial. This allows it to act as a bridge across the classical divide between material and idea. Drawings are seen as a unique form to access to the thoughts of the people that make them. Indeed, they are simply treated as thoughts. It is as if the materiality of the medium is transformed by the quasi-immateriality of the support rather than simply exposed by it. A certain way of looking at paper, or rather a certain blindness to it, allows physical marks to assume the status of immaterial ideas. To exhibit any groups of drawings side by side is already to construct an idealized world of collective fantasy.[29]

Bernard Cache, in focusing on the term "frame," claims that it "reduces architecture to its most basic expression".[30] He defines architecture as "the art of the frame"[31] and

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[27] Durand as quoted in, Anthony Vidler. "Diagrams of Diagrams: Architectural Abstraction and Modern Representation." Representations. University of California Press No.72, Fall 2000: 9.

[28] Mark Wigley. "Paper, Scissors, Blur." The Activist Drawing: Retracing Situationist Architectures from Constant's New Babylon to Beyond. Ed. by Catherine de Zegher and Mark Wigley, New York: Drawing Center and Cambridge, Mass.: The MIT Press, 2001: 29.

[29] Ibid.

[30] Bernard Cache. Earth Moves: The Furnishing of Territories, 1995: 22.

[31] Ibid. 2.

states firmly that “architects design frames”.[32] In this respect, the orthographic set becomes the “interlocking of frames in every dimension: plans, sections and elevations”.[33] Yet, the potential of the “frame” and the “act of framing” in drawing gained by the virtue of reduction through the processes of exclusion and inclusion is observed by Wigley as:

> The effect of the frame is to dematerialize the paper, to take it out of three-dimensional space. The frame acts as a window frame through which the image is seen; paper becomes like glass, a special kind of glass because one sees “through” it to the marks on its surface. The mechanism takes away a section of the world and replaces it with a now idealized image.[34]

Evans defines architectural drawings as “projections” and unfolds the processes of translation through projection, “What connects thinking to imagination, imagination to drawing, drawing to building, and buildings to our eyes is projection in one guise or another, or processes that we have chosen to model on projection”.[35] Accordingly, the focus of this study is the orthographic set, and claims that it is the representation of “visibility” itself, wherein the concentration is set on the “object” and the act of projection is visualized in a literal way. The essence of architectural production is inherent in orthographic projection since it is constructed to “produce” an object that as yet does not exist. Regarding the statements of Evans and Wigley, the orthographic set is a collection of images which constructs and visualizes a space of translation from imagination to building through drawing.

With the introduction of computational technologies, the drawing has been left behind, and is no longer accorded the status of the “translational space” between imagination and building. The necessity of “projection” is abandoned because the translation has become irrelevant. The division between drawing and building has been thought to be

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[32] Ibid. 22.

[33] Ibid.

[34] Mark Wigley. “Paper, Scissors, Blur,” 2001: 40.

[35] Robin Evans. The Projective Cast, 1995: xxxi.

destroyed, thus, there is no “distance” that has to be overcome through the translational stages of projection; and consideration has shifted from the end product to the process. What Evans defines as translations from drawing to building, of which the drawing is actually the translator of the imagination into the building, has disappeared, along with everything included in the process of thought. It is believed that a delusion of translation without modulation has become possible.

The orthographic set and orthographic projection as a methodology, after emerging to address the practical problems of visualization and construction, became a “scientific approach” to visuality during the Era of Enlightenment. This led to a field of visual studies and gave birth to new visual theories that developed existentially to become a tool for architectural education, and finally a symbol of the “rational” thinking that opened way to the declaration of a stylistic manifesto.[36]

By providing an analysis of the digital media in the production of architecture, it is claimed that the means of “orthography” and the premises of the “orthographic set” are still prevalent in digital media, and continue to effect architectural representation and production. In this respect, it is scripts and algorithms that should be assessed as the “new” orthography of design in the sense that they constitute a standardization of a system of production. The so-called n-dimensional space of the digital media should be questioned within the scope of the “objective space” that is formalized by descriptive geometry and visualized by axonometric projection. The authority of the “surface” should be scrutinized as the means of representation, as in the orthographic set; and production, which is realized by Modern Architecture. The “point,” on the other hand, as the “non-dimensional” miracle of location and transformation, should be presented as the “definer” of the “object” in the realm of computation.

Therefore, the achievements in the challenge to represent the “object,” such as the elimination of the “subject” in perspective construction to achieve an objective

[36] Statement based on discussions with Assoc. Prof. Dr. Ayşen Savaş throughout this study.

representation in orthographic projection; the separation of the object from the method of projection, which led to the notion of "mapping;" and even the exclusion of the "object" itself from consideration to discover the "objective space," is discussed with reference to the terms "orthography," "space," "surface," and "point". The stated "shift" that occurred with the entry of the computer into the studios of architecture is always critically referred as "new"[37] in the discipline.

"New" is a term that has always been at the root of Modern Architecture, as by definition, every modernist design needs to be "new". This study claims that what is "new" today is no different from its modernist conception, which has been the subject of much discussion.[38] In Modern Architecture the creation of the "new" has been associated with the achievement of "objective products," achieved through adaptations to the modes of representation as the methodology in the design of the object. It has not been necessary for digital media to seek a correspondence between representation and production, since design has been reduced to a process of scripting. According to Modern Architecture, the desire to be absolutely new was only possible through the abstraction of architecture from its history. In this respect, what is presented as new today should be questioned by asking whether it is new because design has been reduced into an "invisibility" through the integration of its processes and elimination of the subject, the mode of representation and even the object itself, or whether it is a modernist dream come true.

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[37] The term "new" will always be expressed in quotation marks. The use of quotation marks is "critical" in calling attention to the question of whether or not the digital media "shifts" the stated "conventions" of the orthographic set, the notion of space, and the use of surface and the effect of point.

[38] See, Charles Jenks. "The Death of Modern Architecture." The Language of Post-modern Architecture. 3rd enlarged and revised edition, London: Academy Editions, 1978: 9-54; Frederic Jameson. "Postmodernism and Consumer Society." The Cultural Turn: Selected Writings on the Postmodern, 1983-1998. New York: Verso, 1998: 1-20; Paolo Portoghesi. Postmodern, the Architecture of the Post-Industrial Society. New York: Rizzoli, 1982: 7-13.

CHAPTER 2

THE ORTHOGRAPHIC SET:
OBJECTIFICATION OF ARCHITECTURAL DRAWING

2.1. True Expression

The term "orthography" in linguistic theory specifies "a standardized way of using a specific writing system," actually a "script," to write a text. Etymologically, the English word "orthography" comes from Greek *orthós,* which means "correct," and *grápheín* meaning "to write".[39] Deriving from these definitions, "orthography" means "correct writing," "proper spelling," and thus "true expression," denoting the specification of a system that enables one to write, tell or expose his ideas correctly by obeying the rules of that system in such a way that his idea is accurately represented to others. In this case, if drawing is a visual language, then the "orthographic set" is its *Esperanto*.[40]

In his historical and informative book of reference "A History of Engineering Drawing," Peter Jeffrey Booker discusses developments in various disciplines, with the main theme being the "representation" of three-dimensional objects on a two-dimensional surface.[41]

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[39] Online Etymology Dictionary. 11 Sep.2011
<http://www.etymonline.com/index.php?search=orthography&searchmode=none>.

[40] Sarah Williams Goldhagen and Réjean Legault make an analogy between architecture and language by stating that what Modern Architecture aimed at was "an architectural Esperanto, an internationalism," and the analogy between drawing and language is impressed from that statement. Sarah Williams Goldhagen and Réjean Legault eds. "Introduction: Critical Themes of Postwar Modernism," Anxious Modernisms: Experimentation in Postwar Architectural Culture. Cambridge, Mass.: The MIT Press, 2000: 12.

[41] Peter Jeffrey Booker. A History of Engineering Drawing. London: Chatto & Windus, 1963.

He goes back in history to offer an account of man's earliest ideas of projection. In his study of shadows,[42] Booker states that:

> There was shadows cast by the sun's rays which were the same size as the object when thrown upon a surface parallel to the object; and there were shadows cast by a candle, effectively a point source of light with diverging rays, giving shadows larger than the objects illuminated. The two lighting systems represent the fundamental types of projection – parallel and conical.[43]

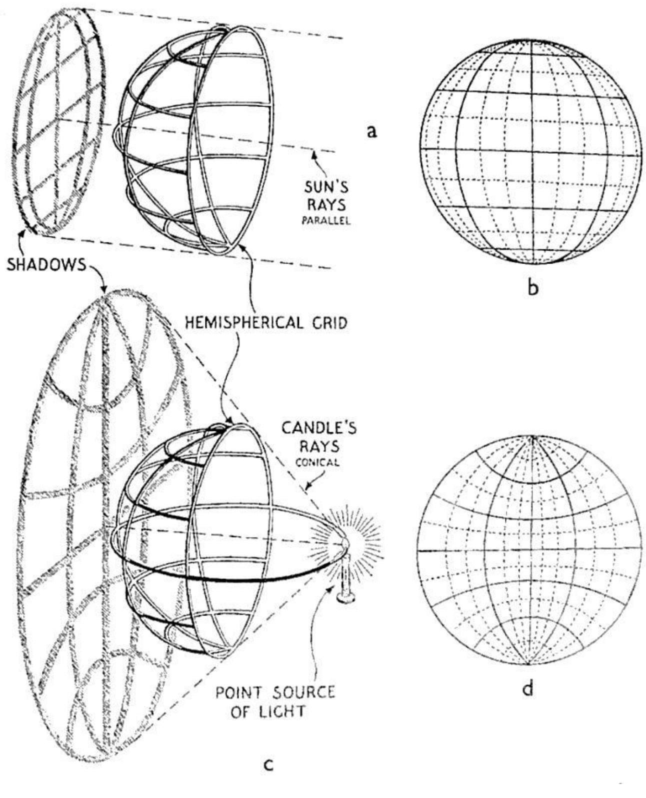

Figure 2.1 (a) A hemispherical grid used to demonstrate the orthographic projection of a sphere by parallel light rays; (b) An orthographic projection of a sphere; (c) A hemispherical grid used to demonstrate the stereographic projection of a sphere by a system of conical rays emanating from a point source; (d) A stereographic projection of a sphere to the same scale as that in (b).

Source: Peter Jeffrey Booker. A History of Engineering Drawing. London: Chatto & Windus, 1963: 4.

[42] See, Peter Jeffrey Booker. "Introducing Shadows and Projection." A History of Engineering Drawing. 1963: 1-7.

[43] Ibid. 3.

Booker refers to Samuel Marolois's book on perspective[44], which opens with concise definitions of the known ways of making drawings:

> *Perspective* is the art which views any object through something transparent, upon which the penetrating visual rays to define it.
> *Scenography* or Painting is the representation of the appearance of the object on a plane which we call the section.
> *Iconography* is the picture on the ground plane, or the level, on which the scenographic figure is naturally standing, or thus
> *Iconography* is the representation of the base, or plane of somebody in the section when it is parallel with or equidistant from the plane.
> *Orthography* is the picture of the front or side of a building, edifice or body, which is also called the profile, or thus
> *Orthography* is the picture of the side of the edifice directly opposite the eye or the section, in such manner that two surfaces, that of the section and that of the object, are parallel and equidistant to one another, which representation is also called the profile.[45]

2.1.1. Constructing the Orthographic Set: Discovering the Projection Lines

Orthographic projection is a method of representing an object with a line drawing on a projection plane that is perpendicular to the parallel projectors. In order to represent an object using lines on a plane, imaginary projection lines emanating from characteristic points on the object are extended until they intersect a picture plane or projection plane. The projectors may be thought of as visual rays that extend from the object to infinity. In orthographic projection, the size of the view of the object does not vary with the distance between the object and the projection plane. Actually, it can be claimed that orthographic projection eliminates the observer, and by removing the conception of an "observer" or "spectator," orthographic projection provides a level of abstraction that enables one to concentrate only on the "object" to be depicted, rather than on the observing "subject". Thus, if there is no "observer," or rather no "subject" to look at the "object," then the orthographic set cannot be subjective. Accordingly, it is the claim of

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[44] See, Samuel Marolois. *La Perspective contenant tnat la théorie que la prancique et instruction fondamentale d'icelle, etc.*, Amsterdam, 1629.

[45] As quoted in Peter Jeffrey Booker. A History of Engineering Drawing, 1963: 39-40.

this study that the "objectness" of the "object" to be depicted is preserved by "projection lines". Robin Evans illustrates this with an analogy between projection lines and light rays,

> These parallels – conservers of true measure – are most readily understood to be representations of light paths, and understood thus they emphasize remoteness, one way another, because either the light source projecting the information or the eye receiving it has to be imagined at an infinite distance.[46]

Obeying this method of projection, in which the right angles of all points upon a building's surface are projected onto a plane parallel to that surface, a horizontal plane of projection produces a plan, while a vertical plane produces either an elevation, or, if sliced through the building, a section. While individually a plan, elevation or section represent only one aspect of a three-dimensional organization, when scanned together their points of intersection can be synthesized into an overall understanding of the building. It is thus an abstract but analytically powerful method of representation.

The "orthographic set" is the name that has been given to the set of drawings constituted by bringing together these three kinds of drawings – the plan, section and the elevation, by virtue of "orthographic projection," which is rational and non-distorting, as opposed to the perspectival illustration method of architectural representation. The bringing together of these three kinds of drawings has been accepted as a revolutionary step, however Evans points out that "what really matters is what holds them together,"[47] being the "projections lines". Evans defines these as "the invisible lines that relate pictures to things,"[48] and declares that projections are directional, and call attention to the active character of projection in the drawing: "Drawings arrest and freeze these vectors, but even in this fixed state projected

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[46] Robin Evans. The Projective Cast. 1995: 108.

[47] Ibid.

[48] Robin Evans. "Architectural Projection." 1989: 19.

information can be mobilized by the imagination of the observer".[49] To understand "how architectural spaces arose out of the deployment of depthless designs and how architectural space was drawn into depthless designs," one needs to consider projection lines as "the agency through which the space outside the surface of the drawing is brought into it".[50] The statement can also be re-interpreted as "the space inside the surface of drawing are transmitted outside by the agency of projection lines," since orthographic projections are not only produced to represent an architectural object which is built, but also represent an object that is yet to be built.

2.1.2. Invisible Lines of "Objectness"

Erwin Panofsky publication of his thesis "Life and Art of Albrecht Dürer" brought Dürer's efforts to form a theory of art that combine practical skill with theoretical knowledge into common knowledge. Dürer's record of his accomplishments in three books published between 1525 and 1528 in Nuremberg[51] began with a work on geometry entitled *Underwysung der Messung* (Manual on Measurement by Means of Compass and Ruler). This was followed by *Etliche Underricht zu Befestigung der Stett, Schloß und Flecken* (Various Instructions in the Fortification of Cities, Castles and Towns), dealing exclusively with fortifications; and later, a third book, published posthumously, studying the proportions of the human body entitled *Vier Bücher von Menschlicher Proportion* (Four Books on Human Proportion). In Messung, Dürer dwelled upon linear, two-dimensional and three-dimensional geometry by tracing points of forms in separate books, and devoted an entire volume to the application of geometric principles to architecture, engineering and typography.

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[49] Ibid.

[50] Robin Evans. The Projective Cast. 1995: 108.

[51] Jeanne Pieffer. "Constructing Perspective in Sixteenth-Century Nuremberg." Perspective, Projections, and Design. 2007: 65-75. See also Erwin Panofsky. Life and Art of Albrecht Dürer. Princeton, NJ: Princeton University Press. 1945 and subsequent editions.

Apparently, Dürer applied the studies contained within his first book while dealing with the problems of fortifications in his second book. Robin Evans draws attention to one plate in particular, representing the "Design for a Bastion at the Angle of a Town-Wall" from *Etliche Underricht zu Befestigung*, which he cites as the first occasion the plan, section and elevation were shown together. He says that the plate represents the origin of what "we have come to regard, this set of three, as fundamental".[52]

The illustrated set of the plan, section and elevation crucially expresses the necessary togetherness of these three kinds of drawing. As stated by Evans, to grasp the architectural space that has been designed, all three drawings are required. When a drawing is missing, the information is insufficient both for the conception and the construction of the architectural space. There is no way to comprehend the characteristics of an architectural space with only one of the drawings. When the section is eliminated, information about the relation with topography and the inclined formation of the curved wall is lost. If the elevation is missing, the heights of the arches and other elements on the inclined curved wall and material information is lacking. Although from the elevation the effect of foreshortening the curved form of the wall may be observed; but without the plan, information on the exact shape of the semi-circular form with the attached rectangular mass is missing. All three architectural drawings are necessary if one is to not only perceive the space, but also construct the drawings, which are interdependent. The drawings are constructed by projection, however the projection lines of Dürer are not visible on the plate.[53]

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[52] Robin Evans. "Architectural Projection." 1989: 22.

[53] Ibid.

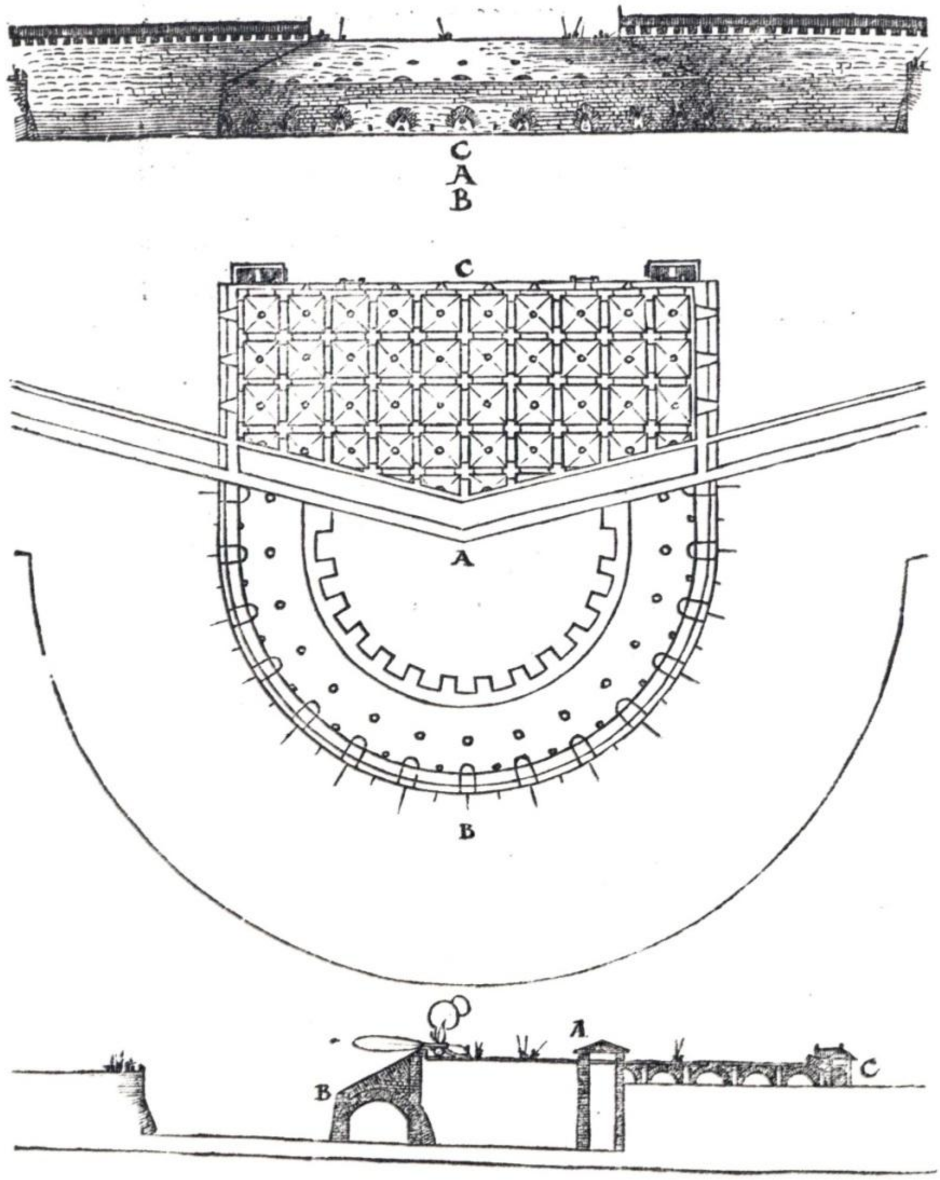

Figure 2.2 Design for a Bastion at the Angle of a Town-Wall from *Etliche Underricht zu Befestigung*, by Albrecht Dürer, Nuremberg, 1527.

Source: Robin Evans. "Architectural Projection," Architecture and Its Image: Four Centuries of Architectural Representation: Works from the Collection of the Canadian Centre for Architecture. Eve Blau; Edward Kaufman; Robin Evans; Centre Canadien d'architecture.; et al. Montreal: Centre Canadien d'Architecture/Canadian Centre for Architecture ; Cambridge, Mass.: Distributed by the MIT Press, 1989: 22.

An analysis of the following plate in Dürer's book showing a magnified elevation of the wall, on which the projection lines are again not indicated, clarifies the constructive approach executed by projection. The foreshortening of the inclined and battered arches indicates that they follow the curvature of the wall, with the changes in their size from the center towards the edges of the wall determined by projection.

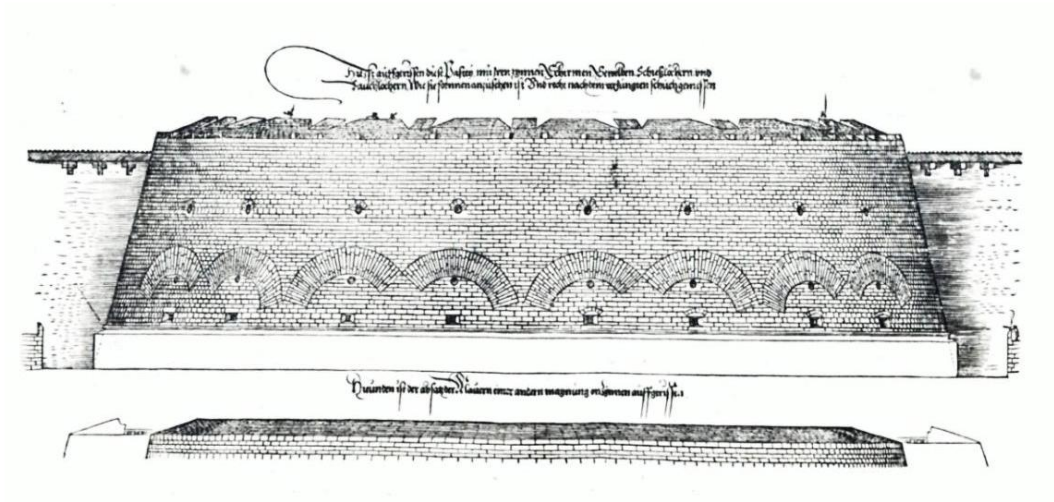

Figure 2.3 Elevation of a Bastion from from *Etliche Underricht zu Befestigung*, by Albrecht Dürer, Nuremberg, 1527.
Source: Ibid.

The drawings are constructed by projection, yet Dürer's lines of projection are not visible on the plate. In the following figure, Dürer's projection lines are indicated for two specific reasons: first, to allow an understanding of the above-mentioned relationship between the plan, section and elevation so as to achieve a complete expression of the true shape and understanding of the architectural space; and second, to make visible the imaginary projection lines that preserve and transmit the information about the shape by interlocking the plan, elevation and section. It is with their visibility that this study becomes possible.

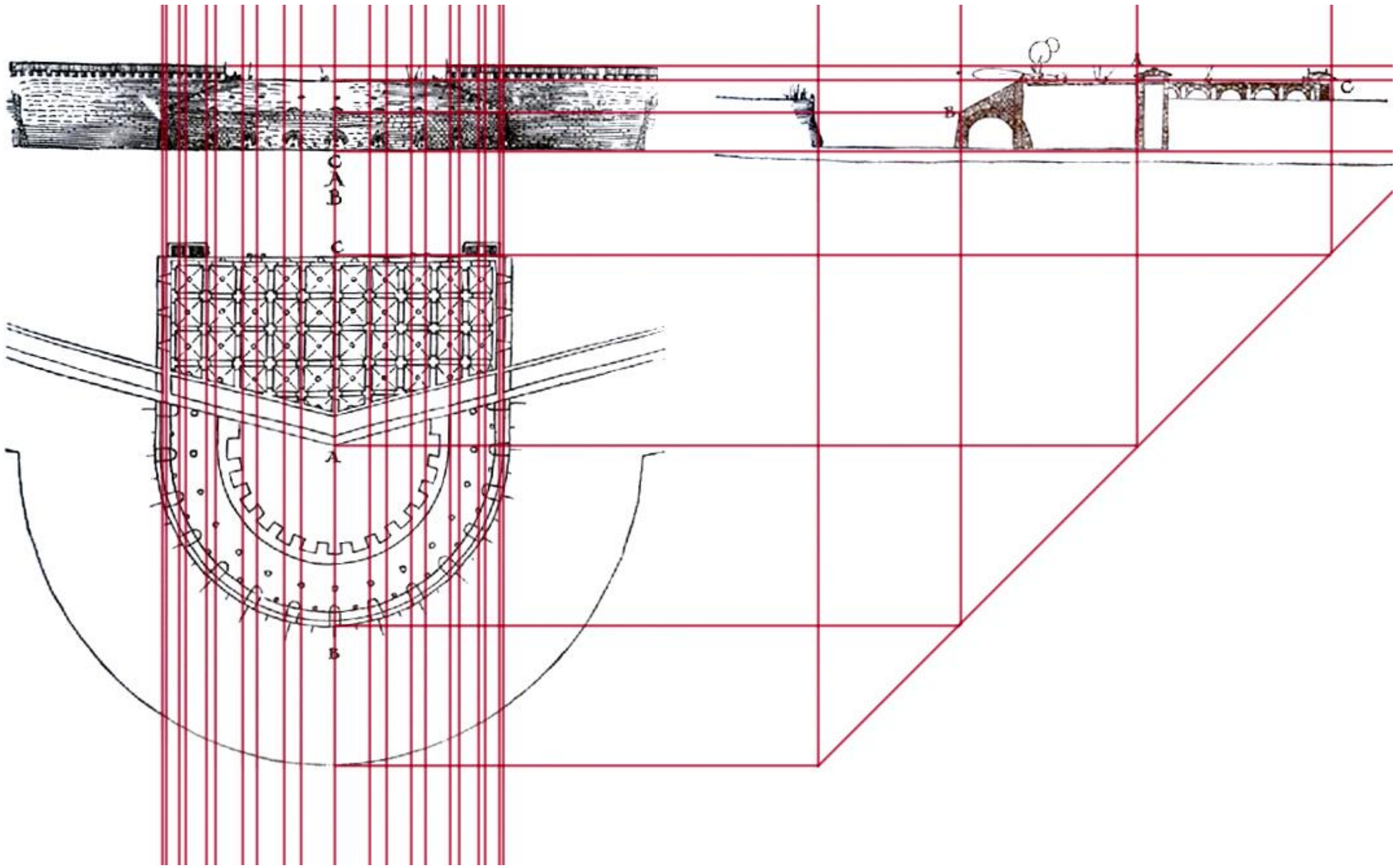

Figure 2.4 Reconstruction of the orthographic set drawn by Dürer by making “projection lines” visible.

The orthographic set is recomposed and the projection lines are emphasized by the author.

Evans describes the procedure of projection, and calls attention to the complexity of the depiction of the curved and inclined surface:

> The simplest procedure would be to divide the circumference into a number of equal parts to locate the arches on the plan and then push this information up; but a moment's further reflection is required in this case, because the surfaces from which the projectors are transmitted, and onto which they are received, are not box-like and orthogonal. The surface of the fortress wall is a thin slice of a cone, curving and inclined at the same time.[54]

In Evans' analysis of *Underwysung der Messung* (1525)*,* Dürer illustrates the method used in his fortress drawing, that is, the plotting of information from a circular plan onto a conic elevation via orthographic projection. Dürer studies a truncated cone and tries to find the "true shape" of the surface obtained by an oblique section plane, which is indicated in the elevation. He slices the cone with closely-spaced horizontal cuts, each of which is represented in plan by a circle of corresponding parts.

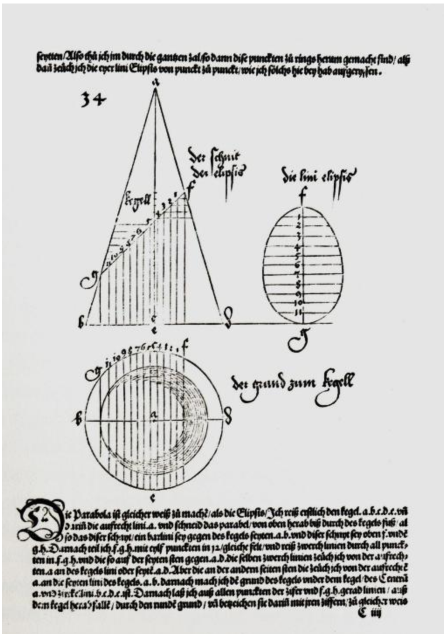

Figure 2.5 Geometric Drawings of a Cone, Sectioned to Produce an Ellipse from *Underwysung der Messung,* by Albrecht Dürer, Nuremberg, 1525.
Source: Robin Evans. "Architectural Projection," 1989: 23.

[54] Ibid.

As an alternative method, one can divide the circular plan into equal slices by drawing lines from the center to the circumference, with the length of each line being equal to the radius of the circle. According to the angle of a slice, which is defined by two lines and the arc across the angle, one can gain the number of slices necessary for the precise creation of the “true shape”. The points at which the lines intersect with the circle are then transferred to the oblique section line; and the intersections of the vertical projection lines with the section line are projected back upon the plan. As a final operation, the horizontal dimensions from the plan and vertical dimensions from the oblique line on the elevation are projected in such a way that projection lines from the two drawings meet perpendicularly. The result is an ellipse that is the “true shape” of the truncated cone’s cap surface, which is actually the area delineated by the intersection points of the section plane and the cone.

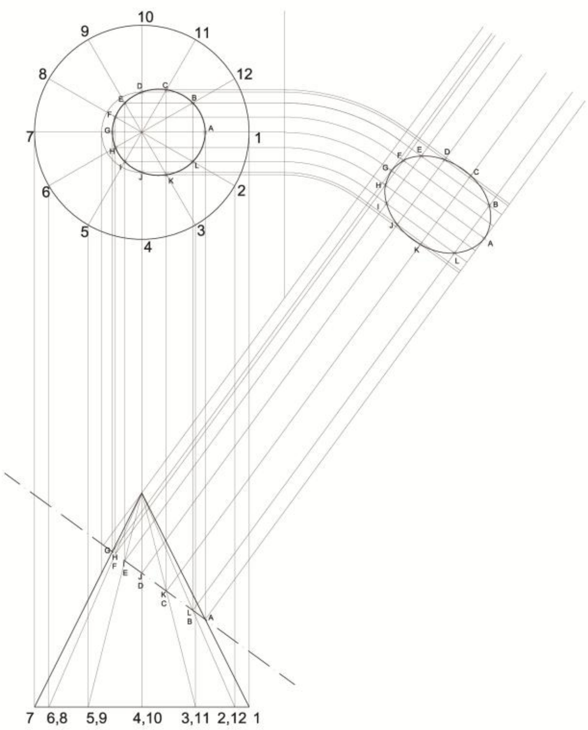

Figure 2.6 The alternative method of dividing the circular plan of the cone into equal slices by drawing lines from the center to the circumference and the exposition of the “true shape” using projection lines.
Drawn by the author.

What these operations reflect is that in attempts to attain information about the accurate measurements and "true shape," projection lines create additional planes on the drawing surface. These planes are defined as "translational spaces" by Evans, in that the information is recorded, processed and projected upon other planes. Referring to Dürer's drawing of the curved and inclined surface of the fortification wall mentioned previously, Evans states that translational spaces occur through and within the projection lines in the process of exploring the "true shape" prior to construction:

> In order to know the shape of the arch we need the shape of the wall of which it will be a fundamental part: we cannot find the shape of the arch until we have the wall, and we cannot have the wall until we find the shape of the arch. The virtual surfaces constructed through orthographic projection make it possible to open this vicious circle: the measurements of all parts can be known before a thing is made or modeled in three dimensions.[55]

2.1.3. The "Objectification of Space": Descriptive Geometry

> Descriptive geometry is a mathematically rigorous formulation of a set of rules, the acceptance of which makes it possible to describe any conjunction or intersection of geometrically consistent forms in space, with a minimum of information and a minimum of construction.[56]

Alberto Pérez-Gómez states that Gaspard Monge's *Géométrie Descriptive* (1795) provided for the "functionalization of geometry," in which geometry is reduced to the realm of algebraic analysis,[57] presenting "the first possibility of an effective and precise mathematical description of reality".[58] For Evans, on the other hand, it was "a radical statement of solid geometry" in which the form has become more abstract through the

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[55] Ibid. 22-23.

[56] Ibid. 28.

[57] Alberto Pérez -Gómez. Architecture and the Crisis of Modern Science. Cambridge, Mass.: The MIT Press, 1983: 279.

[58] Ibid.

loss of its illustrative character as a solid body, and has dissolved into a nexus of trace lines.[59]

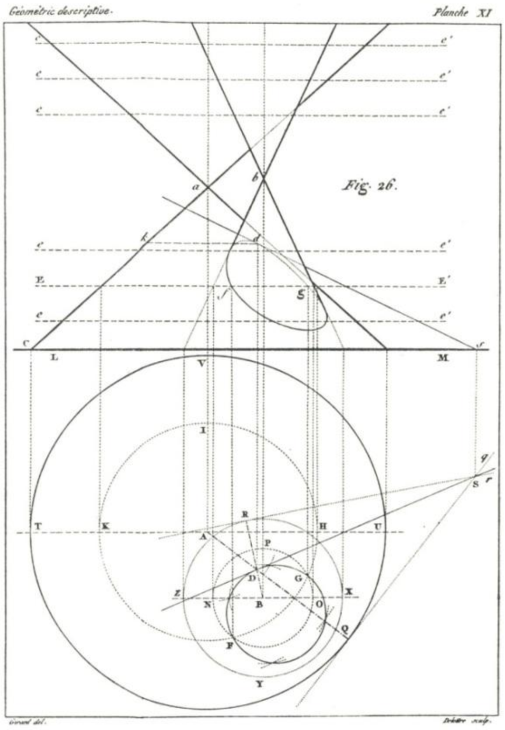

Figure 2.7 Plate XI, from Monge's *Géométrie Descriptive*, 1795, showing the method used for determining the curve of intersection of two cones.

Source: Peter Jeffrey Booker, A History of Engineering Drawing, 1963: 99.

Regarding the explanations of Evans and Pérez-Gómez, while Euclidean geometry had been dealing with two dimensions, Monge's descriptive geometry was about the comprehension of space in three. The attainment of mathematical precision and specification was essential, and it was Monge's desire to come up with a system by which any geometrical construction could be translated into algebra. He provided a definition of a system that was independent of the object to be represented, and the resulting descriptive geometry defined "an ideal space" that was actually a three-

[59] Robin Evans. The Projective Cast. 1995: 324.

dimensional matrix that extended to infinity. The three-dimensional space was defined as "ideal" because the system was isolated from the material reality and was disassociated from the object. In Monge's abstract and homogenous space of descriptive geometry, any "object," or combination of objects, could be located in any direction or scale. The abstracted space would absorb the information coming from the "object" of representation, in other words it would receive the projection of the object onto its surfaces, and expose it in two dimensions. It can be claimed that Monge had taken a step backwards, shifting attention from the "object" to the "space" in which the object exists. His descriptive geometry was a "scientification of representation" through the "objectification of space," regardless of the shape, size and orientation of the "object" to be represented.

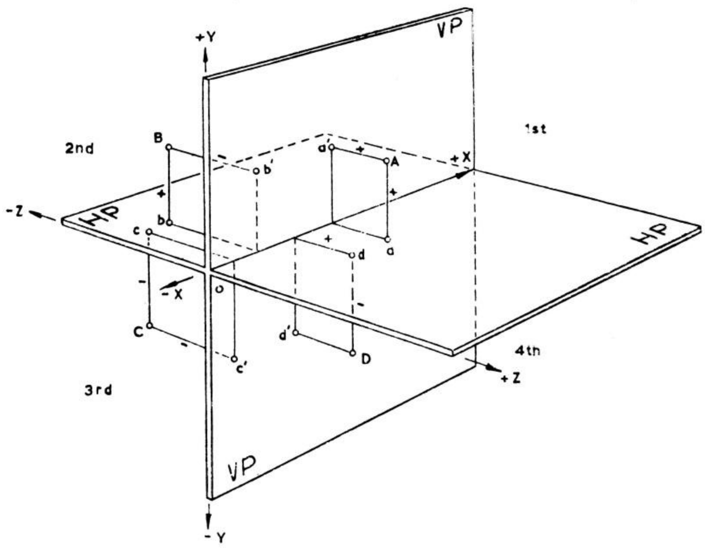

Figure 2.8 The orthogonal planes and quadrants of modern descriptive geometry.
Source: Alberto Pérez -Gómez. Architecture and the Crisis of Modern Science. Cambridge, Mass.: The MIT Press, 1983: 281.

What is significant about Monge's descriptive geometry, and what differentiates it from orthographic projection, is that the technique defines configurations in space. It again used orthographic projection, but only on two fixed and perpendicular "reference planes". Evans unfolds the complex task of processing the object in two planes of projection, and how they leave the object behind and rather concentrate on the "space" in which it exists:

> Descriptive geometry was not concerned to show what things were actually like; it was concerned only to determine relations between geometrically defined bodies and surfaces. Monge demostrated that this could be accomplished with reference to points and lines and nothing else. And so the bodily constitution of things drawn disappears. Often, all that is left is a confusing web of dotted and solid lines, many of which are imaginary, bearing no immediately obvious formal relation to the object represented. Because there are only points and lines, everything is rendered transparent. And this is why only two projection planes are required; so long as you know how the projection is made, two points on two surfaces will determine a third, unique point in space from which they were projected. The fundamental set of drawings in descriptive geometry is therefore quite different to that of architectural drawing. For convenience the two planes of projection, called *reference planes*, are perpendicular to one another, but they do not have to face what is drawn. Monge's system did away with frontality as well as substance.[60]

Pérez-Gómez and Pelletier claim that descriptive geometry is the "agency of precise coincidence between the representation and the object".[61] The systematization of drawing methods enables the process of translation between drawing and building,[62] with the inception of descriptive geometry being the paradigmatic tool. Pérez-Gómez and Pelletier state that the École Polytechnique, founded after the French Revolution, had descriptive geometry as its core subject, which allowed for the first time the systematic reduction of three dimensional objects into two dimensions and permitted the control and precision demanded by the Industrial Revolution.[63] What is more important for this discussion is that the "descriptive geometry became the 'assumption' behind all modern architectural endeavors, from the often superficially artistic drawings of the École des Beaux-Arts to the functional projects that embodied technological symbolism of the Bauhaus".[64]

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[60] Robin Evans. "Architectural Projection," 1989: 28-29.

[61] Alberto Pérez- Gómez and Louise Pelletier. Architectural Representation and the Perspective Hinge, Cambridge, Mass.: The MIT Press, 1997: 85.

[62] "translation between drawing and building": Borrowed from the title of Robin Evans' essay "Translations from Drawing to Building", AA Files 12, Summer 1986: 3-18.

[63] Alberto Pérez- Gómez and Louise Pelletier. Architectural Representation and the Perspective Hinge, 1997: 84.

[64] Ibid.

2.2. The Orthographic Set under the Shadow of Perspective

Robin Evans defines architectural drawings as projections, "which means that the organized array of imaginary straight lines pass through the drawing to corresponding parts of the thing represented by the drawing".[65] Though the perspectival images seem familiar, the kind of drawings used in the professional design, production and even illustration of architecture are not perspectival, being rather "orthographic projections". A conflict exists between the perspective projections and orthographic projections which, as stated by Evans, can be explained by the very existence of a building. While orthographic projections are encountered "*on the way* to buildings," perspectives are more commonly encountered "*coming from* buildings".[66]

In perspectival projection, the array of imaginary lines converges on a single point; while in orthographic projection they remain parallel. Lines, or rather projectors, work in exactly the same way as light rays converging on the eye, and thus allow perspective projections to mimic the real. Orthographic projections, on the other hand, do not correspond to any aspect of our perception of the real world. The great advantage of orthographic projection over perspective is that the building's major measurements are accurately transcribed and can be unambiguously recovered from the drawing by the use of scale. Robin Evans, emphasizing the advantage of orthographic projection, says: "It preserves more of the shape and size of what is drawn. It is easier to make things from than to see things with".[67]

Right from the outset of his work, Alberti singled out the conflict between drawings that simulate vision (the painter's task, according to Alberti) and those that should provide accurate measurements for builders, and from that point onwards architects were obliged to choose between what have been called central and parallel projections. The traditional tools for representing architectural design to a great extent acquired their

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[65] Robin Evans. "Architectural Projection," 1989: 19.

[66] Ibid. 21.

[67] Ibid. 19.

modern form and mode of use following the inventions and redefinitions developed during the Renaissance. Mario Carpo recalls Leon Battista Alberti's treatise[68] in which he set out the geometrical principles of the central perspective, yet he steered architects away from their use, or suggested they be used only with great care since such perspectival drawings do not provide the precise measurements required for architectural design. Alberti suggested the geometrical drawings that architects should employ in plans and elevations, while Raphael added a definition of the "section" as a means of rendering the inside of the building. Carpo states that consensus cannot be reached on when parallel projections were invented – or rather geometrically defined,[69] and it is not the aim of this study to discover the origins of projection, whether parallel or conical. The aim is rather to discover the intricacies and potentials of parallel projection in producing and reproducing space through leading figures, and to trace the key developments singled out in the history of drawing.

In his pioneering study "The Rendering of the Interior in Architectural Drawings of the Renaissance" (1956)[70] Wolfgang Lotz traces the evolution of the representation of the interior of projected or executed buildings during the Renaissance. He shows how architecture followed the lead of painting – in part due to the fact that almost all of Renaissance architects were trained as painters or sculptors – and how, as a consequence, paintings (and especially those representing buildings) can be used as evidence of different approaches to architecture. Italian architects were prone to use perspectives and struggled with the insoluble conflict between renderings that satisfied the desire for a convincing illusion and those that provided accurate measurements for builders. Perspectives give only partial views of the inside of a building, and a particular

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[68] Mario Carpo and Frédérique Lemerle. "Introduction" Perspective, Projections, and Design: Technologies of Architectural Representation. Ed. Mario Carpo and Frédrique Lemerle. New York: Routledge. 2007: 2.

[69] Ibid.

[70] Wolfgang Lotz, "*Das Raumbild in der Architekturzeichnung der italienischen Renaissance*", *Mitteilungen des Kunsthistorischen Instituts in Florenz*, 1956, 7, 193-226. Republished in Wolfgang Lotz. "The Rendering of the Interior in Architectural Drawings of the Renaissance" Studies in Italian Renaissance Architecture. Cambridge Mass.: The MIT Press, 1977: 1-65.

viewpoint would result inevitably in distorted proportions. He discussed this struggle through two methods by which the interior was rendered in the architectural drawings of the Renaissance: the perspective section, and the section with orthogonal projection. As described by Lotz:

> Both methods represent the building as if bisected by an imaginary plane. As a rule the perspective view uses a single vanishing point and assumes a single viewer. The floor, walls, and vaults beyond the section plane appear foreshortened, as if seen from either above or below, just a viewer from a vantage point on this side of the section plane would see them. On the other hand, the orthogonal view gives an unforeshortened representation of those parts of the building that lie beyond the section plane and are parallel to it. Curved or slanting walls or vaults are projected on the sectional plane with their foreshortening represented as if an imaginary viewer were seeing every part of the building straight on. The orthogonal section is generally shaded – to help distinguish the degree of recession of the planes represented – indicating in most cases that light enters from the left of the viewer. The use and development of both methods in the Italian Renaissance are closely allied with the conception and form of the interior.[71]

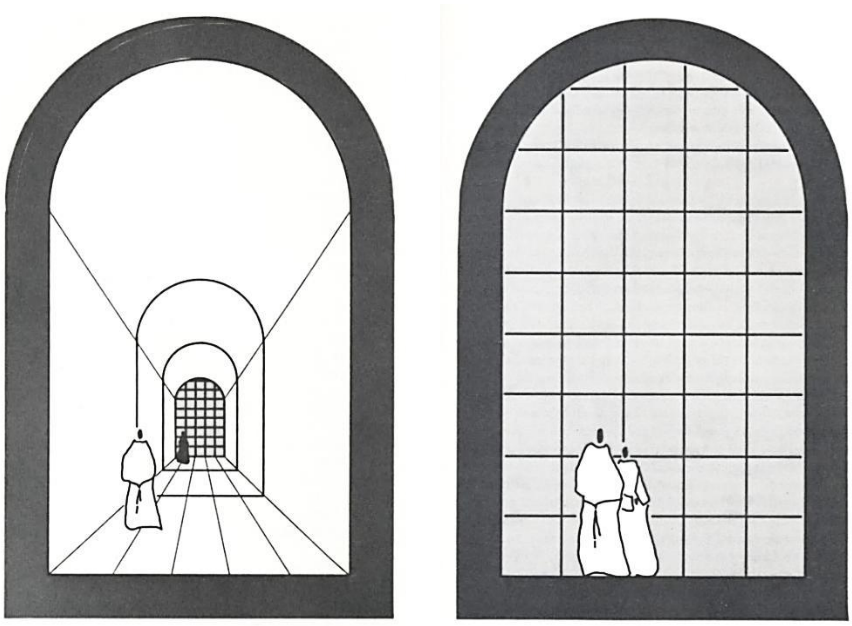

Figure 2.9 Perspective and orthogonal renderings of an interior.
Source: Wolfgang Lotz. "The Rendering of the Interior in Architectural Drawings of the Renaissance." Studies in Italian Renaissance Architecture. Cambridge, Mass.: The MIT Press, 1977: 2-3

[71] Ibid.

Lotz demonstrates how the drawings reveal the changing attitudes toward space, mass and movement, from Leonardo, through Bramante, Peruzzi and Raphael. He concludes that a decisive change of practice occurred in the first decades of the sixteenth century, and that Raphael was the one who provided a solution to the partial perspective views with distorted proportions. In a letter from Raphael to Pope Leo X of 1519 he suggested that if such drawings "do not diminish at the extremities, not even in round buildings,"[72] they would be better adapted to the purpose of the architect. Lotz concluded that this discovery had been made by taking a step backwards in such a way that the imagined viewpoint of the observer was withdrawn further and further from the building; in this way, foreshortening was reduced and eventually eradicated. The orthographic method provided a detached representation of multiple views, which Lotz, not unlike Evans, interpreted as being "more professional and less visual".[73]

The orthographic set helps to overcome the problem of preserving and representing accurate measurements of the object to be drawn, and was more professional in that it was easier to make things from, however things became flatter. By nature, a drawing had to be flat since it was applied to a paper surface, but now it was even depthless in itself.[74] Architecture had to take "information from flat representations to create embodied objects"[75] and projection lines were the agents for the preservation of information for the translation of imagination to realization. Robin Evans notices a "subordination of orthographic projection to perspective".[76] In the early 1470s, Piero della Francesca launched a series of studies to describe geometrical figures in the set of a plan, section and elevation, resulting in "the first explanatory account of orthographic

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[72] As quoted in Robin Evans. The Projective Cast. 1995: 107.

[73] Wolfgang Lotz. "The Rendering of the Interior in Architectural Drawings of the Renaissance," 1977: 32.

[74] Ayşen Savaş. "Notes on Depth and Architectural Representation." A presentation at the Hacettepe University, 14 January 2002.

[75] Robin Evans. "Architectural Projection," 1989: 19.

[76] Robin Evans. "Architectural Projection," 1989: 24.

projection". However, according to Evans his treatment of parallel projection was incidental, since the treatise *De Prospectiva Pingendi* was about perspective.[77] Concentrations on perspective and the depreciation of orthographic projection, as an extra operation introduced to theorize perspective, can be detected in the works of such architectural writers as Leon Battista Alberti, Sebastiano Serlio and Giacomo Barozzi da Vignola; while orthographic projection remained as an undiscovered realm since it was preponderantly treated as a means of locating buildings on the ground by mapping the necessary information on a "plan," for the making of sundials and ships, or for cutting stone.[78]

Evans noted that hundreds of treatises on perspective were published, whereas none dealing exclusively with orthographic projection appeared until the very end of the eighteenth century, which corresponds to the lucid work of Gaspard Monge: *Géométrie Descriptive*.[79] Whether serving to systematize perspective drawings, determine the shape and dimensions of stone pieces for vaults and arches, build ships or geometrize drawing, orthographic projections are a means of attaining a "true shape".

2.3. Arrested in Projection: Contingencies of the Orthographic Set

The orthographic set presents an integrated and consistently scaled three-dimensional representation of a building through a set of independent but related projections. However, the projection lines that link the different views together in a coherent set by providing an interwoven system of references remain "invisible". Evans, speaking about the unnoticed domain of projection lines, claims that, "Few things had greater historical significance for architecture than the introduction of consistent, coherent parallel

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[77] Ibid. 23.

[78] Peter Jeffrey Booker. A History of Engineering Drawing. 1963: 5-7, 37-78.

[79] Robin Evans. "Architectural Projection," 1989: 24.

projections into architectural drawing, and few things have been more transparent to critical attention than its effects".[80]

An orthographic drawing requires a set of projections, a net of projection lines and a system of rules to regulate the act of projection. Within these conditions, an orthographic projection exhibits a strict attitude as a technique of representation. The aim is set, right from the very outset, to draw the object of representation in its exact formation. In other words, the orthographic set aims at projecting the "objectness" of the object. It has to be strict, because it has to translate everything as it is, and this can be achieved only by "standardization". Remembering Evans's analogy between language and drawing, translation could never be successful without loss, however orthographic projection did its best in this regard, the conception of the object being the objective. Nevertheless, the result is considered to be "unresponsive" since it actually ignores how the object is, contradicting the main goal of representing the object as accurately as possible. Orthographic projection provides a system of anchored planes of projection, and thus anchored planes of representation, with no consideration of how the object will be represented within. The projection planes should be placed as if they are facing the surfaces of the object in such a way that the surface of the object to be represented is seen without distortion. In theory, the system was constructed as "responsive," but in practice this was not the case in a variety of circumstances, and it also turned out to be "restrictive" and "reductive".

The three components of the orthographic set, the plan, section and elevation, are the result of the rational location of projection planes. The horizontal plane provides a view of the object from the top, or on rare occasions, below, and show how much space the object of representation occupies on the ground; the vertical plane, generally facing the most important side of the object, gives information about the height and shape; and finally a second vertical projection plane cuts through the object to show what is hidden inside. In professional practice today there is no limitation in the number of plans,

[80] Robin Evans. The Projective Cast. 1995: 108.

elevations and sections that may be drawn, as an architect needs to draw as many as is necessary to represent the design in all of its aspects.

The architectural profession has generally identified architectural drawing with a conventional set of projections; however drawing is not the only means for communicating architectural form. For centuries designs and buildings were represented using models, which were more convenient for representation to the client, the public, the mason or the woodworker, or studied before the construction over rough diagrams. This method was prevalent even in the High Renaissance, or as James Ackerman prefers to call it, the "Roman Renaissance" in the first half of the sixteenth century.[81] Through an examination of a surviving collection of early sixteenth-century drawings, James Ackerman states that very few were intended for use in the construction of a building, or to be representative to anyone other than the architect. He observes that nearly all were "rapidly sketched studies of tentative ideas, sometimes for specific buildings, and sometimes for ideal structures".[82] The tradition of verbal communication between the architect and craftsman was still observable in the High Renaissance.[83]

It was Wolfgang Lotz who first highlighted the major achievement of the Renaissance architects in establishing the convention of orthographic drawing for architecture. James Ackerman points out Leon Battista Alberti's prescriptions for drawing as the first citations of a call for a change:

> Between the drawing and that of an architect there is the difference that the former seeks to give the appearance of relief through shadow and foreshortened lines and angles. The architect rejects shading and gets projection from the ground plan. The disposition and image of the façade and side elevations he shows on different [sheets]

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[81] James Ackerman. "The Conventions and Rhetoric of Architectural Drawing." Origins, Imitation, Conventions: Representation in the Visual Arts. Cambridge, Mass.: MIT Press, 2002: 361.

[82] Ibid. 370.

[83] Ibid. Ackerman refers to Sangallo's drawings of which the left side of the sheet is filled with instructions.

> with fixed lines and true angles as one who does not intend to have his plans seen as they appear [to the eye] but in specific and consistent measurements.[84]

Alberti opposed the long-established rules that predominated among Italian architects to represent the building in perspective, and argued that representation in perspective was to be left to the painters. Architects had to create their drawings orthogonally so that measurements could be taken from them. Ackerman, tracing the roots of the three projection convention, shows that Alberti's advice was followed by Raphael in his "Letter to Leo X" written towards the end of the sixteenth century:

> And because, by my way of thinking, many people mislead themselves about drawing buildings by emulating the Painter rather than the Architect, let me say how one ought to proceed so that one can understand all the measurements properly, and locate that all the elements of buildings without error. The drawings of buildings is divided into three parts: first the plan, or flat drawing; second the exterior wall with its ornaments, and third the interior wall, also with its ornaments … Indeed, with these three means one can minutely examine all the parts of every building, inside and out.[85]

The three types of architectural drawing had been described by Vitruvius as *ichnographia* (plan), *orthographia* (elevation) and *scaenographia,* which was a version of perspective.[86] When considered independently, Evans claims that the plan, section and elevation are almost prehistoric and could exist as separate representations or all together, with or without projection. He evaluates the technique of representation – the orthographic set – with respect to object of representation:

> Thus projection was a late, extra ingredient grasping more or less cautiously at the imaginary space behind the three drawings. What, though, is the simplest, most effective relation among projective plan, elevation, and section? The answer is dependent on what is being depicted. Yet if we take a representative sample of architectural drawings from the sixteenth to the nineteenth centuries a strong pattern quickly emerges: one of each type does maximum service.[87]

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[84] Alberti as quoted in Ackerman. Ibid. 28.

[85] Raphael as quoted in Ackerman. Ibid. 50.

[86] Vitruvius as cited in Ackerman. Ibid. 49.

[87] Robin Evans. The Projective Cast. 1995: 118.

The plate containing the plan and elevation/section of the Villa Rotanda by Andrea Palladio provides an illustration of what Evans meant by “maximum service”. The plate exemplifies Palladio’s attempt to convey information with clarity and an economy of means. The plan and the elevation/section are directly associated by their relative position on the page and by being shown at the same scale. Thus, any part of the plan may be immediately recognized in its three-dimensional resolution since the plan and elevation/section employ a proportional correspondence. Corresponding parts in the drawings are also indicated by numbers and letters which tie the plan and section into one harmonious whole. The Villa Rotonda’s biaxial symmetry enabled Palladio to combine the elevation and section into one drawing without sacrificing information. As indicated by Evans, the components of the set were not new, but the innovative character of Palladio lies in his treatment of architectural representation, achieving uniformity of presentation by using the orthographic projection method in a rigorous manner.

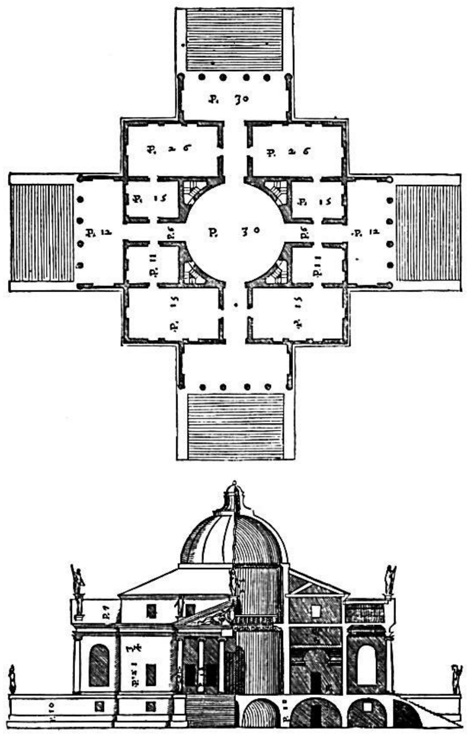

Figure 2.10 Plan and Elevation/Section of the Villa Rotonda by Andrea Palladio, 1570.
Source: “Architecture in Three Dimensions,” Architecture and Its Image - Catalogue, 1989: 161.

A similar powerful example in the treatment of architectural representation is the cut-away perspective view of the Palazzo Farnese at Caprarola by Francesco Villamena. In the illustration, Villamena combines the plan, section and elevation with a perspective view in an effort to acknowledge the subtle complexity of the interrelationships among them. This hybrid approach conveys in a single image the three-dimensional relationships contained within the three orthogonal drawings. If the pentagonal based mass were to be depicted as a perspective view, the image would remain appealing to the non-professional viewer. With the removal of a part from the mass, decided upon through the critical choice of position, direction, and distanciation of section planes, the massive perspectival image would be dissolved into a plan, section and elevation without losing its sculptural identity or appealing pictorial quality.

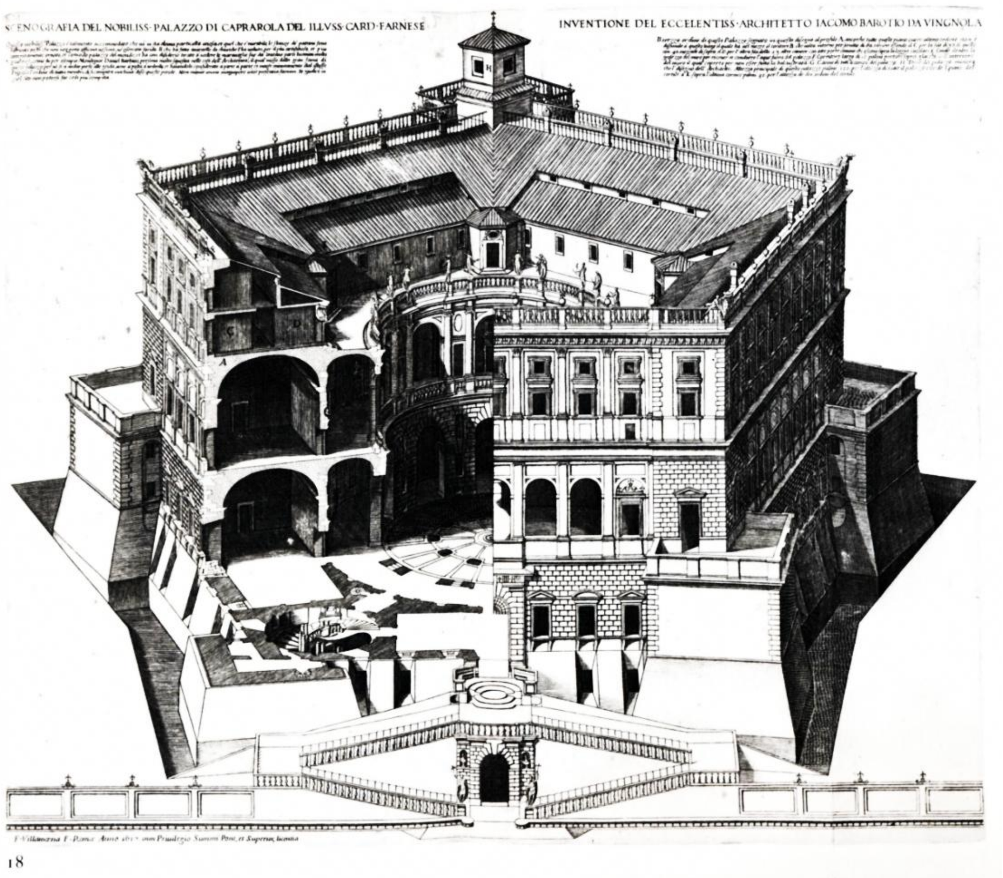

Figure 2.11 Cut-Away Perspective View of Palazzo Farnese at Caprarola by Francesco Villamena, 1617.
Source: Ibid. 182.

Evans provides a clear explanation of why forms designed following the classical ideal were economical within the confines of the technique of representation and resulted in powerful expressions with maximum information:

> The three drawings are not just plan, elevation, and section, but ground plan, front elevation, and axial section. That is why in most classical architecture, design and building are in a near perfect accord. Maximum descriptive power is obtained at minimum price – a good bargain, so long as what is required is frontal, symmetrical, axial, and predominantly orthogonal. [88]

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[88] Ibid. 119.

CHAPTER 3

READING MODERN ARCHITECTURE
THROUGH THE ORTHOGRAPHIC SET

3.1. Codes of a Paradigm: Drawing Modern Architecture

The idea that the orthographic set became a declaration of the stylistic manifesto of Modern Architecture is not a new one.[89] A description of Modern Architecture as a "style-based paradigm"[90] was put forward recently by Sarah Williams Goldhagen and it is discussed that it should be considered as a paradigm constituted under the influence of the stylistic aspects of the orthographic set. Remembering the definition of the term "orthography" as the "standardized way of using a specific writing system," briefly, as the "script," it can be claimed that both the orthographic set and Modern Architecture, the former being a technique of representation and the latter resulting in an architectural style, are codified systems of "standardization". In this chapter, a re-

[89] See, Anthony Vidler. "Diagrams of Diagrams: Architectural Abstraction and Modern Representation." Representations. University of California Press No.72, Fall 2000: 1-20; Yves-Alain Bois "Metamorphosis of Axonometry." Daidalos, 1981: 40-58.

[90] The conceptualization of the "style-based paradigm" in this study is based on the discussion of the terms "paradigm" and "style" generated in Arch 513 - Architectural Research course, with reference to the following articles: Sarah Williams Goldhagen, "Something to Talk About: Modernism, Discourse, Style" JSAH, vol. 64, June 2005, 144-167; Heinrich Wölfflin, "Principles of Art History," in The Art of Art History: A Critical Anthology, Oxford: Oxford University Press, 1998, 115-126; E. H. Gombrich, "Norm and Form: The Stylistic Categories of Art History and Their Origins in Renaissance Ideals," in Norm and Form: Studies in Art of the Renessaince 1, Chicago: University of Chicago Press,1966, 81-98; E. H. Gombrich, "Style," in The Art of Art History: A Critical Anthology, ed. Donald Preziosi Oxford: Oxford University Press, 1998, 150-63; James Ackerman, "Style," in Distance Points: Essays in Theory and Renaissance Art and Architecture, Cambridge Mass.: The MIT Press, 1991, 3-22; Meyer Schapiro, "Style," in The Art of Art History: A Critical Anthology, ed. Donald Preziosi, Oxford: Oxford University Press, 1998, 143-149 and Thomas S. Kuhn, The Structure of Scientific Revolutions, 2nd Ed., Chicago, 1970, originally published in 1962, 10, 23, 17 and 52-56.

reading of Modern Architecture in respect to the constitution of the orthographic set is provided, focusing on three key concepts: abstraction, geometry and *sachlichkeit*. The approach employed to Modern Architecture is as a paradigm constituted by the "rationale" behind the orthographic set.

As defined by Thomas S. Kuhn, a "paradigm" is "an accepted model or pattern" that works as a framing device for the attainment of coherence in a discipline by restricting its field of vision to problems of elaboration, expansion and critique.[91] By functioning as a frame, a paradigm "need not, and in fact never does, explain all the facts with which it can be confronted"[92]. To understand the limits of Modern Architecture's frame, in other words what this frame includes and excludes, the inception of the term "modern" is critical. Rooting back to the etymological meaning of the word "modern," Hilde Heynen identifies three basic levels of meaning:

> In the first and oldest sense it means present, or current, implying as its opposite the notion of earlier, of what is past. It is in this sense, for instance, that the term is used in the expression *modernus pontifex*, referring to the man who at present occupies the throne of St. Peter. The term modern was employed in this sense as long ago as the Middle Ages. A second meaning of the word is the new, as opposed to the old. Here the term modern is used to describe a present time that is experienced as a period, and which possesses certain specific features that distinguish it from previous periods. It was this sense of the term that began to prevail in the seventeenth century. During the course of the nineteenth century yet a third level of meaning became important. The notion of modern then acquired the connotation of what is momentary, of the transient, with its opposite notion no longer being a clearly defined past but rather an indeterminate eternity.
>
> The current, the new, and the transient: all three of these levels of meaning refer to the peculiar importance that is ascribed to the present in the concept of modernity. Modernity is what gives the present the specific quality that makes it different from the past and points the way toward the future. Modernity is also described as being a break with tradition, and as typifying everything that rejects the inheritance of the past.[93]

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[91] Thomas S. Kuhn. The Structure of Scientific Revolutions. 1970: 23.

[92] Ibid. 17.

[93] Hilde Heynen. Architecture and Modernity: A Critique. Cambridge, Mass.: The MIT Press, 1999: 8-9.

The premise of being "absolutely new" required a return to the point of inception; and since there was nothing in hand to start with, Modern Architecture employed rules and standards to regulate the upcoming whole. In the formation of a new architecture, Adolf Behne includes H.P. Berlage among the first generation of leaders,[94] referring to Berlage's book *Grundlagen und Entwicklung der Architektur* (The Foundations and Development of Architecture)[95] in which Berlage defines:

> [The path] that we must now adopt, the path that will be available for the future, and that will lead us to a new art:
> 1. A geometric scheme should once again provide the basis of architectural composition.
> 2. The characteristic forms of earlier styles should not be used.
> 3. Architectural forms should be developed in the spirit of *Sachlichkeit*.[96]

The path drawn out by three principles connotes the above-mentioned three key terms to consider Modern Architecture as a paradigm: abstraction, geometry and *Sachlichkeit*. The return to the very beginning meant that the paradigm of Modern Architecture excluded everything, and thus the frame includes nothing at all aside from the object yet to be designed. Drawing upon this "tabula rasa," and operating within the boundaries of the frame that excludes historical precedent enabled Modern Architecture to focus on its object. Modern Architecture approached its object with, in Allen Forte's words, a "phenomenological virginity". By separating the object of study from the "contingencies

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[94] Adolf Behne lists three architects in the first generation of leaders in the fight for the renewal of architecture: H.P. Berlage, Alfred Messel and Otto Wagner, with an indication that Arthur [Louis Henry] Sullivan, as America's first modern architect, belongs to the same generation. Adolf Behne. *Der Moderne Zweckbau* / The Modern Functional Building. Introduction by Rosemarie Haag Bletter, translation by Michael Robinson. Santa Monica, CA: Getty Research Institute for the History of Art and the Humanities, 1996: 91.

[95] Hendrik Petrus Berlage. "The Foundations and Development of Architecture," in Hendrik Petrus Berlage: Thoughts on Style, 1886-1909. Santa Monica: The Getty Center for the History of Art and the Humanities, 1996. Original edition, *Grundlagen und Entwicklung der Architektur*. Berlin: Julius Bard, 1908.

[96] Berlage as cited in Behne. The Modern Functional Building. 1996: 93.

of historical context,"[97] Modern Architecture managed to carve out a level of architectural abstraction that led to the concentration of "form".

Rejection of the historical precedent, in other words "abstraction," determined the object of architecture as architecture itself, and this severance from history turned Modern Architecture into "a style which represents and symbolizes history, in which case history is not deterministic".[98] Sarah Williams Goldhagen and Réjean Legault claim that the Modern Movement aimed to create "an architectural Esperanto, an internationalism".[99] The object of architecture had to be produced following certain standards and rules, and thus had to be autonomous in constructing an international language. When architecture is re-defined from the rules within, it possesses a meaning that advocates propagation based solely on form. "Architectural form," says Michael Hays, "is understood to be produced in a particular time and place, of course, but the origin of the object is not allowed to constrain its meaning".[100] In other words, Modern Architecture accepted that meaning in architecture is not dependent on the memory of its own past.

Stanford Anderson points out the ignorance of "tradition" – illustrating modernism's urge for the "new" by drawing upon a quote from Reyner Banham, that "for the first time in history the world of what is suddenly torn by the discovery that what could be is

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[97] Allen Forte defines the "formal analysis" obeyed in his study of Stravinsky's "The Rite of Spring." The method of analysis is referred in Robert D'Amico. Historicism and Knowledge. New York: Routledge, Chapman and Hall Inc., 1989: ix-xiv.

[98] Alan Colquhoun. "Introduction: Modern Architecture and Historicity." Essays in Architectural Criticism: Modern Architecture and Historical Change. Cambridge, Mass.: The MIT Press, 1981: 17-18.

[99] Sarah Williams Goldhagen and Réjean Legault eds. "Introduction: Critical Themes of Postwar Modernism." Anxious Modernisms: Experimentation in Postwar Architectural Culture. Cambridge, Mass.: The MIT Press, 2000: 12.

[100] K. Michael Hays. "Critical Architecture: Between Culture and Form." Perspecta, 11, 1981: 16.

no longer dependent on what was".[101] In the absence of "what was," architecture began to occupy a place that was distracted from reality, and in this autonomous abstract space, architecture had to find a way of representing itself. Yet, the "self" was actually nothing. Modern Architecture emerged from scratch, thus, there was only a "tabula rasa" to represent this identity.

A striking criticism of modern architecture as a style-based paradigm[102] was made in Wigley's book entitled "White Walls, Designer Dresses," with the almost reductionist inclusion of the statement "The Fashioning of Architecture". Using the analogy of the logic of clothing, he suggested that dress, thus, fashion, had been used to oppose the idea that although Modern Architecture is a style, "it must resist degeneration into just another fashionable outfit".[103] In the fashion terminology adapted by Wigley, the modern dress was white, and architects[104] did not hesitate to put it on. For Wigley, the identity of Modern Architecture cannot be separated from its "white walls".[105] He states that if there is something as "modern architecture" as a system, which is composed of a set of principles to command distinctive architects in achieving a unity of the buildings to be designed, the variety of interpretations are conjoined under the umbrella of "white walls." The very doctrine of the modernist effort was to discard anything inessential in favor of the naked-type form, and the "white wall" served as the very figure of this project.[106] In other words, "white walls" are the tabula rasa of Modern

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[101] Reyner Banham as cited in Stanford Anderson. "Architecture and Tradition that isn't 'Trad, Dad'," in Marcus Whiffen ed., The History, Theory and Criticism of Architecture. Cambridge Mass, 1965: 71.

[102] "style-based paradigm": Sarah Williams Goldhagen. "Something to Talk About," 2005: 154.

[103] Mark Wigley. White Walls, Designer Dresses: The Fashioning of Modern Architecture. Cambridge, Mass.: The MIT Press, 1995: xix

[104] The term "architects," refers to three architects, namely, Wager, Hoffman and Loos in the chapter "White Lies" of Wigley's book White Walls, Designer Dresses: The Fashioning of Modern Architecture, 1995: 163-165. The reason for not declaring their names in this study is that the focus is on a particular work of another architect who has obviously put the same white dress on: Le Corbusier.

[105] Ibid. xxii-xxiii.

[106] Ibid. 185.

Architecture, becoming a concretized representation of the withdrawal from the conventions and attributions of the historical precedent. Painting onto white so as to avoid any introjections from the context is similar to the principle in "painting". In the Renaissance, painters applied a procedure of layering the canvas with white paint – the more the layers applied, the smoother and glossier the canvas became. By painting onto white, the painter ensured that none of the texture of the canvas came through the painting, and the painting thus became abstracted from its canvas through the application of "white".

In "Something to Talk About: Modernism, Discourse, Style,"[107] Sarah Williams Goldhagen criticizes the concept of style, as it is conceived to be "modernism's unifying feature"[108]. She states that Modern Architecture is identified via "formal tropes":

> [F]lat roofs; transparency and lots of glass; reinforced concrete or metal buildings, tough-edged and stark; compositions controlled with geometric rigor; structural armatures split off from building skins, opening up free-flowing spaces articulated lightly with space dividers that barely touch the horizontal planes; a dynamically asymmetrical distribution of spaces; an absence of ornament or historical reference Calvinist in its rigor, an abstraction, and a resulting emphasis on the compositional play between elements or volumes.[109]

Goldhagen's use of the term "trope" can be interpreted as a synonym of the word "style". Her conception of the term resembles Meyer Schapiro's definition of style as "an essential object of investigation".[110] For Schapiro:

> Style is a system of forms with a quality and a meaningful expression through which the personality of the artist and the broad outlook of a group are visible. It is also a vehicle of expression within the group, communicating and fixing certain values of religious,

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[107] Sarah Williams Goldhagen. "Something to Talk About: Modernism, Discourse, Style", JSAH, 64:2, June 2005: 144-167.

[108] Ibid. 146.

[109] Ibid. 144.

[110] Meyer Schapiro. "Style", in Donal Preziosi ed., The Art of Art History: A Critical Anthology, Oxford: Oxford University Press, 1998: 143.

> social, and moral life through the emotional suggestiveness of forms. It is, besides, a common ground against which innovations and the individuality of the particular works may be measured. [111]

In Schapiro's definition of style she refers to the three main aspects of art: formal elements or motives, form relationships and qualities.[112] To achieve a unity in terms of form, to define the rules about different types of relationships and to enable the fluent communication between relative parties, style acts as the constant. Shapiro says, "A style is like a language, with an internal order and expressiveness, admitting a varied intensity or delicacy of statement".[113]

In the construction of an international language, the "formal tropes"[114] of Modern Architecture, as stated by Goldhagen, form a comprehensive list of its canonical presentations. These are "prescribed" in various different ways by heterogeneous modernist architects, such as in the three principles of "The International Style"[115] determined by Philip Johnson and Henry-Russell Hitchcock; or in the "Five Points of a New Architecture" defined by Le Corbusier.[116] All referred to certain "types" of elements, forms and relations to achieve a coherent whole in which a style is codified in the form of a visual language.

Modern Architecture severed itself from the past, and thus achieved an architectural abstraction which can be represented by a tabula rasa, enabling concentration on the "object" itself. As a result, the conditions for generating an abstract(ed) object are codified over form. The notion of "abstraction" also influenced the visual qualities of the

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[111] Ibid.

[112] Ibid. 145

[113] Ibid. 148

[114] Sarah Williams Goldhagen. "Something to Talk About: Modernism, Discourse, Style," 144.

[115] Henry Russell Hitchcock, Philip Johnson. The International Style. New York: Norton, 1966.

[116] Le Corbusier. *Vers Une Architecture* / Toward An Architecture, Introduction by Jean-Louis Cohen, translation by John Goodman. Los Angeles, Calif.: Getty Research Institute, 2007 (first published in 1923).

object. In other words, “abstraction,” for Modern Architecture, not only implied the severance of the architectural object from the historical context, but also acquired a strong meaning with emphasis on the purification of form. Concentration on the object itself necessitated the stripping of its form of all applied ornamentation and preconceived practices of history. In doing so, compositions of primary forms are controlled by means of geometry, providing an understanding of proportions, references and relations.

Modern Architecture aimed to drive an understanding of “architecture beyond styles,” but resulted, ironically, in a style that was full of prescriptions and codifications. One of Modern Architectures great manifestations, namely the “International Style,” stands as the most spectacular proof of this, in which the three defining principles were “architecture as volume,” “concerning regularity” and “the avoidance of applied decoration”.[117] While the title of the third principle speaks for itself, the second requires interpretation. “Concerning regularity” referred to the “balance” in composition that should be achieved in the consistency of structure and in the arrangement of spaces through the dynamically asymmetrical distribution of parts rather than a preconceived symmetry as the organizing principle.

Here it can be claimed that Modern Architecture adopted the rules of “geometry,” a mathematical science that is visual in nature, for the perfection of this purified form. In his work “*Vers Une Architecture*,” Le Corbusier explained the vitality of geometry for the determination of regularity and inner relations:

> Primary forms are beautiful forms because they are clearly legible.
> The architects of today no longer make simple forms.
> Relying on calculations, engineers use geometric forms, satisfying our eyes through geometry and our minds through mathematics; their works are on the way to great art.
> …
> The great problems of modern construction will be solved through the geometry.[118]

[117] Henry Russell Hitchcock, Philip Johnson. The International Style. 1966: 69-89.

[118] Le Corbusier. Toward An Architecture, 2007 (originally in 1923): 85-86.

The Primary forms are desired since they have a universal validity, meaning that they have definite characteristics that represent a clear and tangible image. Modern Architecture embraced a new aesthetic taste that appreciated the pure and primal forms of geometry, which are fairly accepted as the "archetypes" of design. Colin Rowe's article "The Mathematics of the Ideal Villa" offers a clear understanding of the effect of the primary forms and geometry as means of achieving the "ideal". Rowe sets "beauty" as the paradigm of his evaluation, alongside a comparison of Palladio's Villa Rotonda and Le Corbusier's Villa Stein. In making a comparison of these two distinct examples of different periods he analyzes the two "objects" with an abstraction that focuses only on how forms emerge strictly in geometrical and mathematical terms. Rowe refers to the definition of "natural beauty" put forward by Christopher Wren, who claims that it occurs from "geometry consisting in uniformity that is equality and proportion". He continues as follows:

> Geometrical figures are naturally more beautiful than irregular ones: the square, the circle are the most beautiful, next the parallelogram and the oval. There are only two beautiful positions of straight lines, perpendicular and horizontal, this is from Nature and consequently necessity, no other than upright being firm. [119]

Orthographic projection, being a technique for representing an object with a line drawing, actually assumes that the object to be represented is a "geometrical figure" that can be reduced to a composition of "lines". The main rule in orthographic projection is that the form of the object should be depicted through the use of "projection lines" radiating from the surfaces of the object onto the "projection planes" in such a way that the projection lines remain parallel to each other, and thus intersect the projection plane at a 90 degree angle. Following Wren's assertion that the most beautiful positions of straight lines are "perpendicular" and "horizontal," it can be claimed that the orthographic set, which is constructed upon the "perpendicularity" and "horizontality" of the "straight lines," gains an aesthetic quality.

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[119] Christopher Wren as quoted in Colin Rowe. "The Mathematics of the Ideal Villa." *Mathematics of the Ideal Villa and Other Essays.* Cambridge, MA: MIT Press, 1976, 1–27: 2. First published as "The Mathematics of the Ideal Villa: Palladio and Le Corbusier Compared," in Architectural Review 101, March 1947.

Geometry is also accounted for in the regulations of the relations between primary forms, being assigned as the executer of the practice of design. Admiring the precision of mathematics and the directionality of geometry, Le Corbusier refers to the references as “regulating lines”:

> Of the fateful birth of architecture.
> The obligation to order. The regulating line is a guarantee against arbitrariness. It brings satisfaction to the mind.
> The regulating line is a means; it is not a formula. Its choices and its expressive modalities are integral parts of architectural creation.[120]

This study claims that it is the “projection line” that relates the architecture to representation. The means of guaranteeing “order” in architecture is determined by these “regulation lines,” based on the conception that they are actually the “projection lines” of the orthographic set as the basis of the representation of an object in the particular technique of orthographic projection. It is the application of “projection lines” that secures the presence of “order” in architecture.

The orthographic set emerged in response to the need to represent architecture, with concentration on the geometrically controlled abstract object. “Abstraction” is accepted as the aesthetic quality, both in the sense of disregarding the past and in the use of pure geometric forms; and “White” represents the starting over from scratch, the clearing away of every excess. Both started with a tabula rasa, and traced their regulating lines and placed their objects accordingly. Every line, every shape, every idea drawn on the white paper is directly translated into a reality, with the “white” internalizing each and every piece of data inserted upon it. Modern Architecture, and thus orthographic drawing, conceive and depict the abstract object as having been assembled out of geometrical forms according to the principles of geometrical relations.

Anthony Vidler, highlighting the pitfalls in the correspondence of Modern Architecture and modernist drawing, claimed that they are a result of their conception and

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[120] Le Corbusier. Toward An Architecture, 2007 (originally in 1923): 86.

concentration on the "object," referring to modernist drawings as "abstractions of abstractions".

> This apparent identity of the modernist drawing and its object, both informed by a geometrical linearity that tends toward the diagrammatic, has, throughout the modern period, led to charges that the one is the result of the other, that architecture has too-slavishly followed the conventions of its own representation. Modern architecture, concerned to represent space and form abstractly, avoiding the decorative and constructional codes of historical architectures, is thus accused of reductivism, of geometrical sterility, and thence of alienation from the human.[121]

Focusing particularly on the orthographic set, Robin Evans also criticized modernist architects for not taking the dominant means of representation into consideration[122] in the formation and production of new architecture. Modern Architecture rejected history, but not its technique of representation. Opposing the statements of Vidler, and even Evans, Pérez-Gómez and Pelletier stated that Modern Architecture "subverted the reductive instrumentality"[123] of the techniques of architectural representation, and reconsidered the relationship between a drawing and a building to envision an "international architecture".

Modern Architecture established a key rule that would lead to the generation of purified forms that were abstracted from the contingencies of history with a geometric rigor. The

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[121] Anthony Vidler. "Diagrams of Diagrams: Architectural Abstraction and Modern Representation." Representations. University of California Press No.72, Autumn 2000: 8. Vidler referred to the criticisms of Victor Hugo and Henri Lefebvre on the issue of the object and its representation in Modern Architecture. He states that both ground their indictments on what they consider the root cause of the "fall" of architecture is actually "representation" as "too easy translation of the new graphic techniques used by modern architect into built form." In other words, "architecture, that is, looked too much like the geometry with which it was designed and depicted." While for Hugo architecture had become no more than "a caricature of geometry," for Lefebvre architects "fetishized the graphic representations as real." See, Victor Hugo, "*Guerre aux démolisseurs!*" (1825-32), in *Oeuvres complétes: Critique*, ed. Pierre Reynaud, Paris, 1985: 187; Henri Lefebvre. "From Absolute Space to Abstract Space," in The Production of Space. Translated by Donald Nicholson-Smith, Oxford, 1991: 361.

[122] Robin Evans. The Projective Cast, 1995: 119. For Evans, a dominant means of representation was an issue for modern painters, but not, apparently, for modern architects. He states that modern painters attacked perspective vociferously, dubbed it a mere convention, removed evidence of it from their work and claimed that vision itself was not perspectival.

[123] Alberto Pérez- Gómez and Louise Pelletier. Architectural Representation and the Perspective Hinge, 1997: 85.

practice adopted the word “functionalism,” however Berlage provides a more substantial definition, “Architectural forms should be developed in the spirit of *Sachlichkeit”.* Though misconceptualizations and easy translations into “function” dominated the discipline of architecture, the German word *sachlichkeit* actually contains and has the power to represent the true essence of Modern Architecture.

Alan Colquhoun states that a re-evaluation of the significance of artistic expression in a world revolutionized by the machine has been at the root of all avant-garde movements. Reyner Banham expressed the shift in the sources of the development of new forms and the evolution of aesthetic theory in the title of his skeptical book: “Theory and Design in the First Machine Age”. Banham, however, does not assert that early modernism was a machine style, claiming rather, as cited by Colquhoun, that the aim was to arrive at perfected final forms, especially those based on the Phileban solids, which were accepted as a logical result of machine technologies. This closed the door on the natural evolution of mechanical forms and arrived at a premature academicism.[124] Colquhoun accuses Banham of oversimplification, and thus falsification, of the ideas behind the theories which led to functionalism. Banham gave the concluding chapter of “Theory and Design in the First Machine Age” the title “Functionalism and Technology,” in which the first paragraph was devoted to the roots of the word “functionalism”. Entering the dispute around who actually coined the term in International Architecture, Banham attributes the honor to Alberto Sartoris in his “*Gli Elementi dell’architettura Funzionale*”. He ends the paragraph by claiming that the responsibility for the term was laid on Le Corbusier’s shoulders as the result of a letter reprinted as a preface to the book originally entitled *Architettura Razionale*, in which Le Corbusier wrote:

> The title of your book is limited: it is a real fault to be constrained to put the word *Rational* on one side of the barricade, and leave only the word *Academic* to be put on the other. Instead of Rational say *Functional*…[125]

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[124] Alan Colquhoun. “The Modern Movement in Architecture.” Essays in Architectural Criticism, 1981: 22.

[125] Reyner Banham. “Conclusion: Functionalism and Technology” in Theory and Design in the First Machine Age. Cambridge, Mass.: The MIT Press, 1992: 320.

Louis Sullivan's famous dictum "form follows function" remained incommensurate for the demands and aims of new architecture. Modern Architecture exaggerated the idea of functionalism by interpreting the process of designing a building as a problem-solving project, of which the final form is just an outcome of the functional program required for the building. However, if this was the case, then, the ultimate "box" was just one of the infinite possibilities that one functionally designed space could be formed into. Besides the already-set dominance of geometry in the description of form, the term "modern," recalling Heynen's definition citing three levels for the meaning of the term, connoted the momentary, the transient, which necessitated the consideration of the present, and thus, the awareness of the "today". Consequently, the impression of the new world revolutionized by the "machine" obligated Modern Architecture to carry the load of the term "standardization" for the sake of becoming "international".

Colquhoun raises a crucial question in his attempts to understand the dilemma at the root of Modern Architecture, "If buildings are to retain their quality of uniqueness as symbols, how can they also be the end products of an industrial system whose purpose is to find general solution?"[126] To answer this, one can draw upon the example of an industrial product, such as a car, where a particular model is unique however many times it is and can be repeated; and this was exactly what Le Corbusier did in Domino House. Thus, Modern Architecture's abstract forms gained function and evolved from "formal tropes" into "types". Colquhoun unfolds his exemplification of the problem by suggesting that the genetic connotation of the term "type," as "the essence that has been stamped on the original version," is recalled in each subsequent form with further connotations as "a de facto form that is rich in meaning, and can be reinterpreted again and again under different historical circumstances".[127]

[126] Alan Colquhoun. "Symbolic and Literal Aspects of Technology." Essays in Architectural Criticism, 1981: 29.

[127] Alan Colquhoun. "Introduction: Modern Architecture and Historicity." Essays in Architectural Criticism, 1981: 15.

The dilemma of something being at the same time unique and a type can be unraveled through an understanding of the meaning of the word "*sachlichkeit*". In the introduction to Adolf Behne's *Der Moderne Zweckbau*, Rosemarie Haag Bletter clarifies the ambiguity raised from his frequent use of the terms *sachlichkeit* and *zweck* by providing an explanation of their different meanings – *zweck* meaning purpose or function, while *sachlichkeit*, although sometimes translated as function, literally meaning "thingness".[128] To elaborate, *sachlichkeit* may be more properly translated as "the simple, practical, straightforward solution to a problem," "a matter-of-factness" and occasionally "objectivity".[129]

Leaving any personal references, emotional tendencies and historical precedents aside, by abstracting the form and painting it onto a white background to glorify its purification; suppressing it through the universal visualization of mathematics; and assigning this form to function, Modern Architecture managed to symbolize the "thingness" of "architecture" and legitimized its premise to become an architectural Esperanto, an international "paradigm" representing a "symbolic objectivity".[130] In this sense, it is possible to claim that Modern Architecture is "a codification of a visual language," and this is what makes its composition through techniques of representation possible. Both the orthographic set and Modern Architecture is codified by the rationale of "orthography," with the rules being dominated by means of "abstraction," "geometry" and "*sachlichkeit.*"

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[128] Rosemarie Haag Bletter. "Introduction" to *Der Moderne Zweckbau* / The Modern Functional Building by Adolf Behne, 1996: 47.

[129] Ibid.

[130] William H. Jordy. "The Symbolic Essence of Modern European Architecture of the Twenties and Its Continuing Influence." JSAH, vol. 22, October 1963: 177-187.

3.2. "Volume of Surfaces": Le Corbusier and the Orthographic Set

Le Corbusier was the only modern architect to prescribe architectural rules for the new architecture.[131] Colquhoun states that Le Corbusier could do this "because he took as his starting point the rule system of the academic tradition (in contrast to the majority of modern architectural theorists, who based their arguments on matters of content rather than form, or on physiognomic, expressionist aesthetics)".[132] The demonstration of these rules can be regarded as his "Five Points," which Colquhoun explains to have been the result of Le Corbusier's creative process in the "displacement of concepts" – in other words, a process of reinterpretation.

Le Corbusier started to formulate the "Five Points" of new architecture in "*Vers Une Architecture,"* wherein he set down the "three reminders for architects" that were evident in his work *"Une Petite Maison"* .[133] The reasons for the selection of this building will be revealed in respect to the previously mentioned key concepts of abstraction, geometry and *sachlichkeit*. How the issue of abstraction affected production and geometry's predominant role in design, and how Le Corbusier embraced objectivity in his conception of the "house as a machine for living in," will be demonstrated with reference to the employment of the orthographic set as a means of designing with the aid of visual documents. What enables this reading is the idea of "surface," being the basis of Le Corbusier's "classicizing tendencies" in Colquhoun's words, and the ultimate representation of the two-dimensionality of the orthographic set. The term "surface" will be accepted as the element of production in Modern Architecture. Recalling the first

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[131] Alan Colquhoun. "Displacement of Concepts in Le Corbusier." Essays in Architectural Criticism, 1981: 51. Colquhoun credits Leonardo Benevolo with the suggestion that Le Corbusier was the only modern architect to prescribe rules for the new architecture. See, Leonardo Benevolo in History of Modern Architecture, 2 vols. Cambridge, Mass.: The MIT Press, 1971.

[132] Ibid.

[133] *Une Petite Maison* is one of the initiators of this study. The plans, elevations, and sections of this project have been sent to different architects. This study would be constructed on the 3D models based on the orthographic set of *Une Petite Maison*. Although, due to the busy schedule of the architects only few of them have been responded, *Une Petite Maison* has remained as the major illustration of this thesis.

principle of the International Style, which is “architecture as volume,” the power of “surface” in the new definition of the “volume” will be presented. “The effect of mass, of static solidity, hitherto the prime quality of architecture, has all but disappeared; in its place there is an effect of volume, or more accurately, of plane surfaces bounding a volume. The prime architectural symbol is no longer the dense brick, but the open box”.[134]

The new definition of “volume” as “immaterial and weightless, a geometrically bounded space,”[135] meaning that the effect of a single clear volume with continuous surfaces, or rather, the surfaces that are unbroken in effect, is described as the principle of “surface of volume”[136] by Henry-Russell Hitchcock and Philip Johnson. The principle of “architecture as volume,” which is expressed as the principle of “surface of volume,” will be shifted to an understanding of a “volume of surfaces”. A parallel reading of Le Corbusier’s “three reminders to architects,” namely the “volume,” “surface” and “plan,” as stated in his manifestation of a new architecture “*Vers Une Architecture*,” alongside the three fundamental components of the orthographic set, being the plan, elevation and the section, will be presented to provide an understanding of the effect of “surface” on the “private will to form”.[137]

3.2.1. *Une Petite Maison*: Designing by the Orthographic Set

Une Petite Maison is a rarely-known work of Le Corbusier, and yet it is the only project to which he dedicated a book. Also entitled “*Une Petite Maison,*” the book sets down the design process for the work, and “tells the story of the little house” [138] Le Corbusier

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[134] Henry Russell Hitchcock, Philip Johnson. The International Style. 1966: 58.

[135] Ibid. 59.

[136] Ibid. “A First Principle: Architecture as Volume.” The International Style. 1966: 55-63.

[137] Alan Colquhoun. “Symbolic and Literal Aspects of Technology.” Essays in Architectural Criticism, 1981: 28.

[138] Le Corbusier. *Une Petite Maison* 1923. Basel; Boston; Berlin: Birkhäuser - Publishers for Architecture, 1954. The quoted expression is from the inside of the front cover.

built in 1923, near Vevey on the shores of Lake Geneva, for his mother. The book contains Le Corbusier's designs for the layout of the building, and provides images of the building form through preliminary sketches alongside his perspective impressions of the house drawn twenty-five years after its construction. He tells the story of *Une Petite Maison* with interesting anecdotes, and personal ideas and experiences from throughout the process of its design and construction.

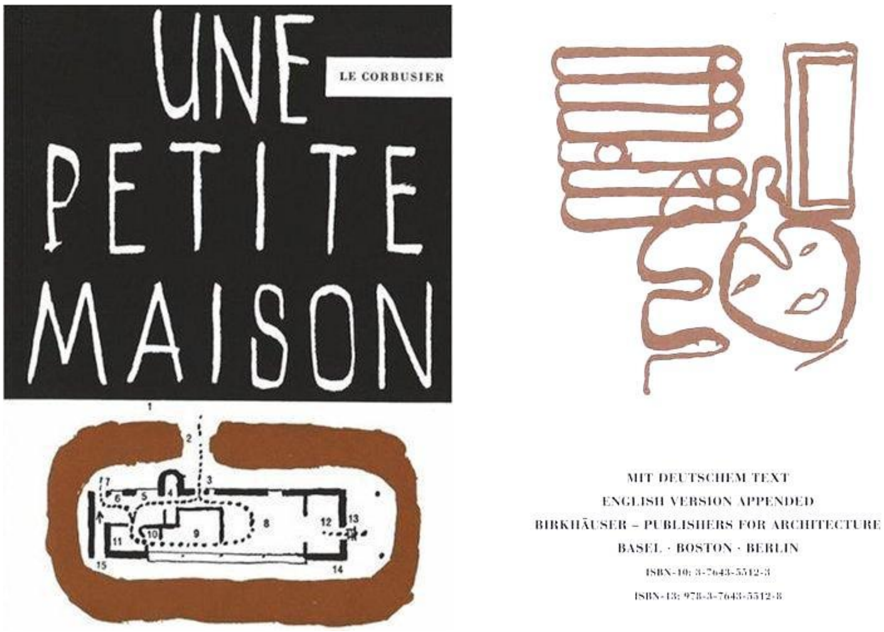


Figure 3.1 Front and back covers of the book *Une Petite Maison*.
Source: Le Corbusier. Une Petite Maison 1923. Birkhäuser - Publishers for Architecture, 1954.

Though *Une Petite Maison* never gained the popularity of Villa Savoye, it was appreciated as one of the key protests against the imitation of historical styles through the use of a new formal language, new building types and spatial concepts in the exhibition "*Neues Bauen International* 1927 | 2002," in which it featured in the section "Detached Houses and Villas," considered as the "playground of the avant-garde".[139]

[139] Institut für Auslandsbeziehungen. 11 Sep. 2011 <http://www.ifa.de/en/exhibitions/exhibitions-abroad/ architecture/neues-bauen-international-1927-2002/ detached -houses-and-villas/>

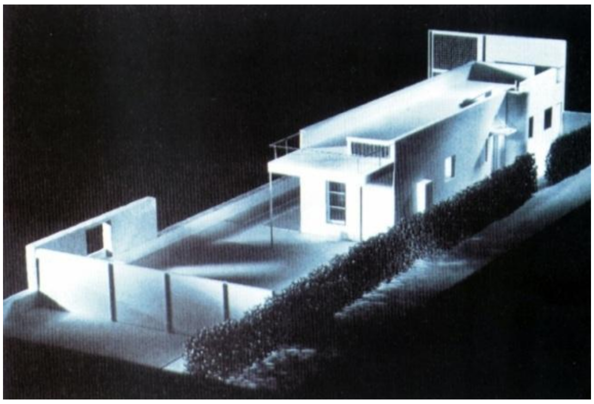


Figure 3.2 (left) The exhibition poster of *Neues Bauen International* 1927 | 2002.
Source: Institut für Auslandsbeziehungen. 11 Sep. 2011
<http://www.ifa.de/en/exhibitions/exhibitions-abroad/ architecture/neues-bauen-international-1927-2002/ detached -houses-and-villas/>.

Figure 3.3 (right) Model of *Une Petite Maison* in the exhibition *Neues Bauen International* 1927 | 2002.
Source: *Uluslararası Yeni Yapı Sanatı* 1927 | 2002, TMMOB Ankara, 2006: 29.

Le Corbusier begins the book with a description of the site, or rather, the region of Lake Geneva, where the "exact location" of the house had not yet been decided. The "story" draws interest right from the outset, with Le Corbuiser stating, in his own words: "In my pocket was the plan of a house. A plan without a site? The plan of a house in search of a plot of land? Yes!"[140] His mentioning of "a plan without a site" provides a spectacular example of Modern Architecture's literal severance from the context. The house, or more accurately, the plan of a house, is "abstracted" from its ground, and thus from its context. It can be claimed that Le Corbusier later symbolized the concept of severance from the context with his "*pilotis*" in "Five Points," however in this case the "abstraction," rather than being symbolic, is real. In this sense, the plan can be considered as a perfect combination of the "ideal" and the "real". The main points of the ideal plan were explained by Le Corbusier:

> The main points of the plan. First: the sun is to the south (that's something!). The Lake spreads out to the south, backed by the hills. The Lake and the Alps mirrored in it are in

[140] Le Corbusier. *Une Petite Maison*, 1954: 5.

front, lording it from east to west. That is some sort of setting for my plan: facing south, its length is a living-room four metres in depth, but sixteen metres long. The window by the way, is eleven metres long (one window, mind you!).
Point number two: "The dwelling machine". Dimensions precisely adapted to individual functions permit maximum exploitation of space. The arrangement is practical and spatially economical. Through a minimum use of space for each function the total surface area was fixed at 50 square metres. The finished plan of the single-storeyed house, including all approaches, covers a surface of sixty square metres.[141]

Though it can be inferred from his descriptions of the site and his statements regarding the main points of the plan that Le Corbusier knew, or at least had an idea, on which side of the lake the house would be built. As the exact location of the house was not definite, this "absence" of a real site provided Le Corbusier with a perfect opportunity for the realization of the ideal. The gridded hatch on his sketch of the region can be accepted as evidence of his ideas for the location of the house.

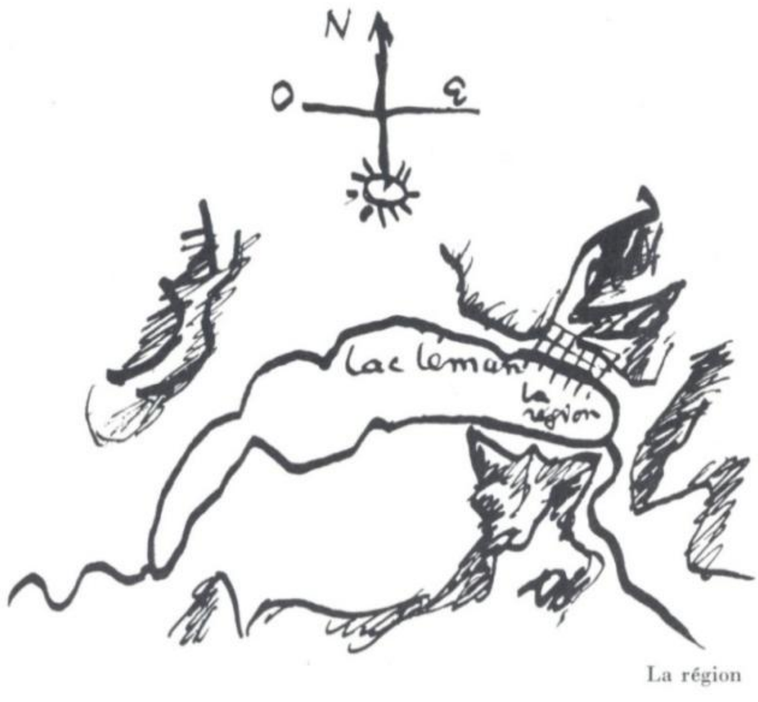
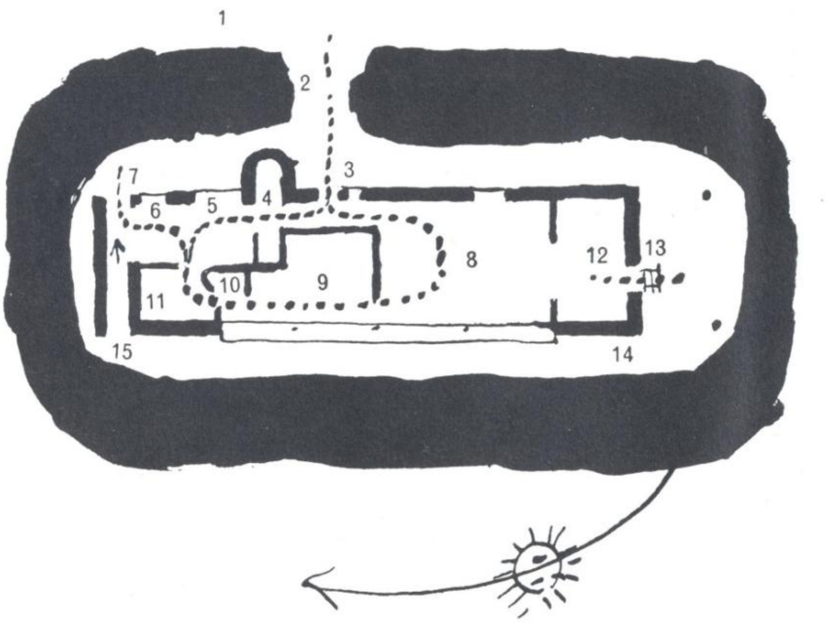


Figure 3.4 Sketch of the region Lake Geneva by Le Corbusier.
Source: Le Corbusier, *Une Petite Maison*, 1954: 4.

[141] Ibid. 6.

The sketch showing the plan and "a circuit" indicates that Le Corbusier had a clear idea of the position of the sun, the view, and the orientation of the house, once again indicating that the plan was completed in his mind with a consideration of an "ideal" site that was yet to be found. Figure 3.5, showing Le Corbusier's sketch of his distribution of spaces on the plan, may have been regarded as an architectural plan drawing had it been drawn using a ruler. On the other hand, the plan can be considered as "living" in the sense that it was designed by Le Corbusier with much consideration of the life that his mother and father would experience. That said, without a site, not only this house, but any project without any reference to the physical world may be regarded as an expression of the "ideal" in the architect's mind. In the same sketch, the bold hatching around the plan can be read as a representation of the "abstraction of the house from its context," and as the boundary which preserves the inherent "ideal".



1. the road; **2.** the garden gate; **3.** the front door; **4.** the cloak-room (with the oil-heating aparatus); **5.** the kitchen; **6.** the wash-house (with cellar-stairs); **7.** the exit to the courtyard; **8.** the living-room; **9.** the bed-room; **10.** Bath; **11.** drying- and linen-room; **12.** Small bed-sitting room four guest; **13.** roofed loggia looking out on to the garden; **14.** the front of the house and the window of eleven-metres; **15.** the staircase to the roof.

Figure 3.5 Sketch of the plan of *Une Petite Maison* entitled "*un circuit*" by Le Corbusier.
Source: Ibid. 6.

Le Corbusier records:

> With the plan in our pockets we spent a long time looking for a site. After considering several, one day we discovered the right one from the top of a hill (1923).
> It was on the lakeside and might be said to have been waiting specially for the little house. The vine-grower and his family who sold it were obliging and agreeable. The sale was toasted.[142]

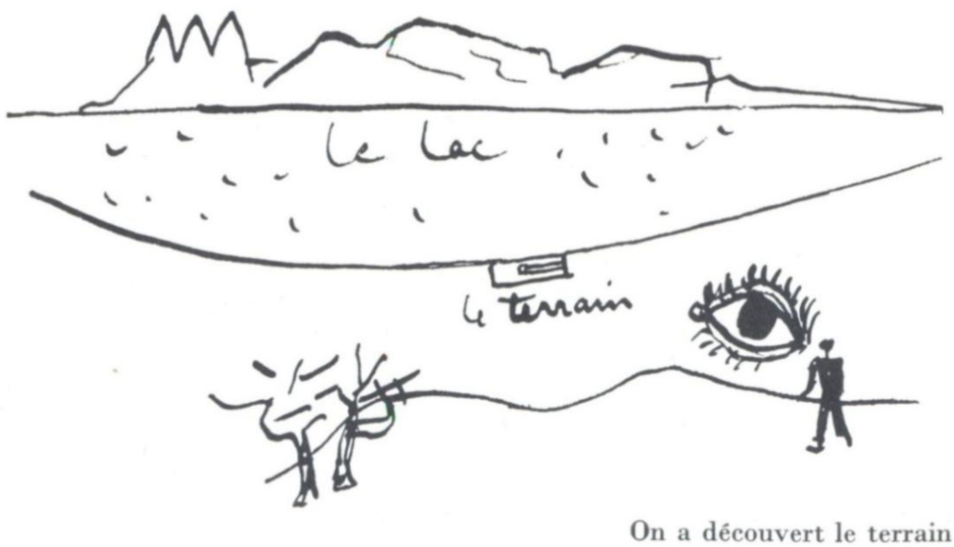


Figure 3.6 Sketch of the site found for *Une Petite Maison*, by Le Corbusier.
Source: Ibid. 7.

From the sketch above, in which Le Corbusier represents his impressions after the discovery of the site, it can be understood that although he has started the design process with the "plan," he had always had the elevation in his mind. This hybrid sketch showing how the house fits in with the shoreline in "plan" also displays how the "eye," as the representation of a person standing on the plot of the house and drawn as a figure in the elevation, sees the view from the house, but this time in "elevation". The compact, or arguably, economic composition of the plan and elevation may even be

[142] Ibid. 7.

interpreted as resembling Egyptian depictions in which the inconsistent combination of the elements are a result of the desire to show each and every element in their particular shapes so as to give the necessary and correct information about the parts of a whole in an economical manner.

Le Corbusier says:

> The plan is tried out on the site and fits it like a glove. Four metres from the window is the lake and four metres behind the front door is the road. The area to be kept up measures three hundred square metres and offers an unparalled view, which cannot be spoilt by building, of one of the finest horizons in the world.[143]

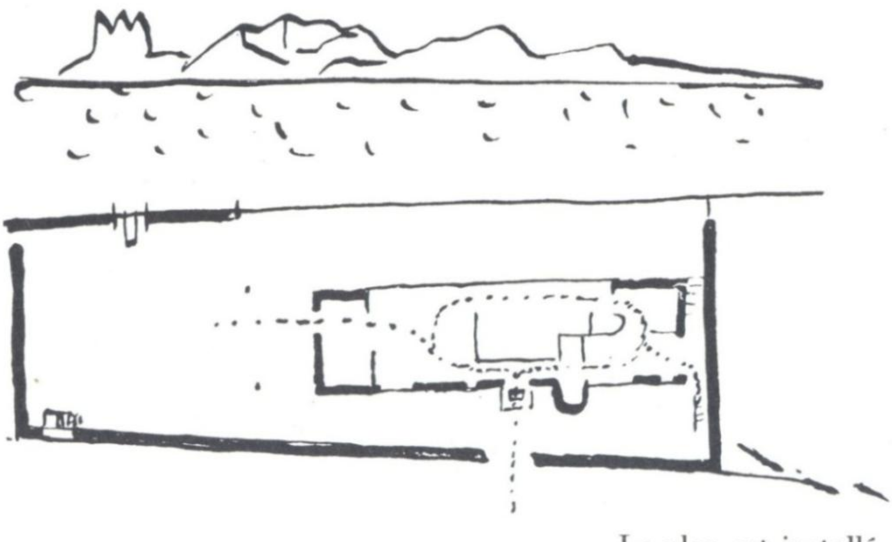


Figure 3.7 Sketch showing the installation of the plan of *Une Petite Maison* to the site, by Le Corbusier.
Source: Ibid. 9.

Although the sketch is developed and almost mature enough to be considered as an architectural plan drawing, Le Corbusier's insistence on combining the plan and the elevation continues. This can be regarded as proof of Le Corbusier's simultaneous

[143] Ibid. 9.

consideration of three dimensions in the process of design of *Une Petite Maison*, although he practices in two, or in combinations of two, dimensions. The combination of the "plan" with the view seen from the eleven-meter window of the house drawn in "elevation" is a powerful and unique method of representation discovered by Le Corbusier.

After showing the installation of the plan to its site, Le Corbusier provides a sketch of the building in a third dimension, which will lead to the final "volume". Le Corbusier indicated that:

> The height of the house is two and a half meters (the regulation minimum). It resembles a long box lying on the ground. The rising sun is caught at one end by a slanting skylight, and for the rest of the day it passes on its circuit in front of the house.
> Sun, space, and greenness – what more could be wanted?[144]

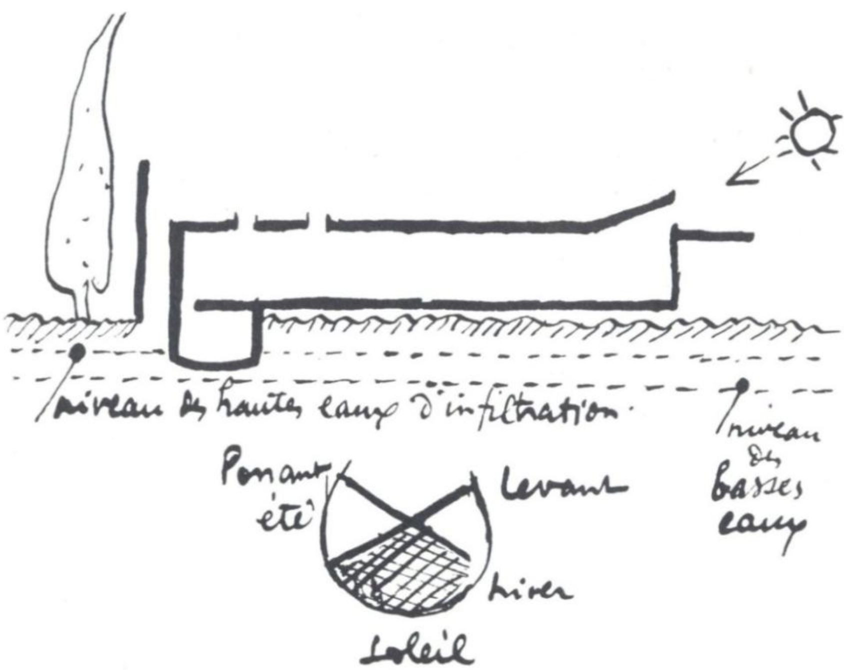


Figure 3.8 Sketch of the section of *Une Petite Maison* entitled "*la coupe*" by Le Corbusier.
Source: Ibid. 10.

[144] Ibid. 10.

Although it was obvious from the plan that the resulting house would be a "box," Le Corbusier also expresses the fact; and his admiration of the primary forms of geometry would lead him to transform the house into "the ultimate box". The dimensions of the final volume are determined, giving information of the height in section after the determination of the dimensions in the plan drawing. Thus, the final volume of the house is "geometrically bounded" in the form of a box according to its functions, considering the minimum of "standards" to achieve a practical and spatial efficiency in the arrangement of spaces. It can be claimed, drawing upon Le Corbusier's explanations of the main points of the plan and the statements on the regulation of the section, that the house has been designed in the spirit of *sachlichkeit*. Just before ending the book, and thus the story of the little house, Le Corbusier states that:

> Twenty-five years after this little house was built I indulged in the relaxation of making some drawings of it. They confirm the architectural features implied in the simple solution of 1923, a period when the search for a suitable form of house was not a question which exercised people's minds very much.[145]

Figure 3.9 Sketch showing the north elevation of *Une Petite Maison* by Le Corbusier.
Source: Ibid. 64-65.

[145] Ibid. 63.

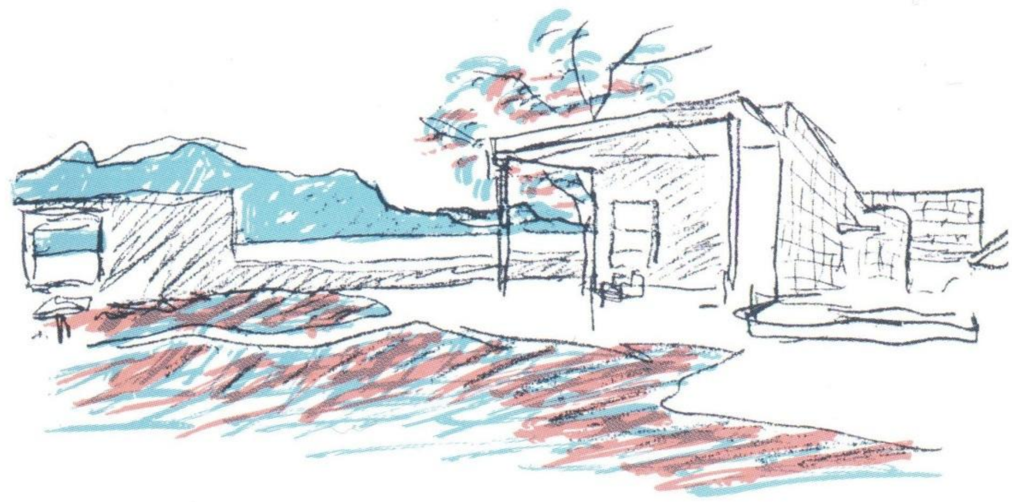


Figure 3.10 Sketch of *Une Petite Maison* by Le Corbusier.
Source: Ibid. 67.

Figure 3.11 Sketch of *Une Petite Maison* by Le Corbusier.
Source: Ibid. 74-75.

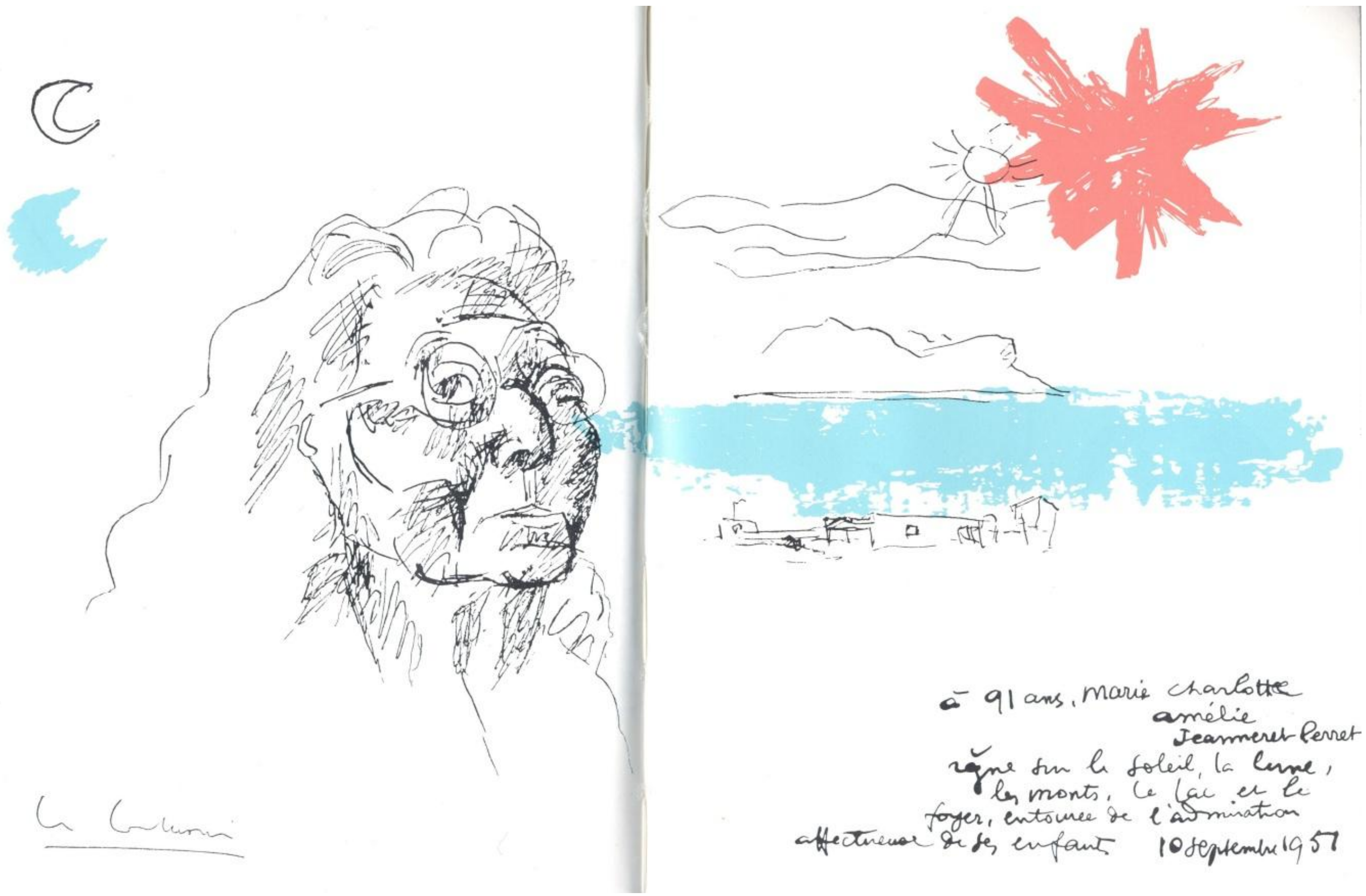


Figure 3.12 Sketch of Le Corbusier's mother with *Une Petite Maison* by Le Corbusier.

Source: Ibid. 76-77.

3.2.2. Plan, Surface, Volume: Plan, Elevation, Section

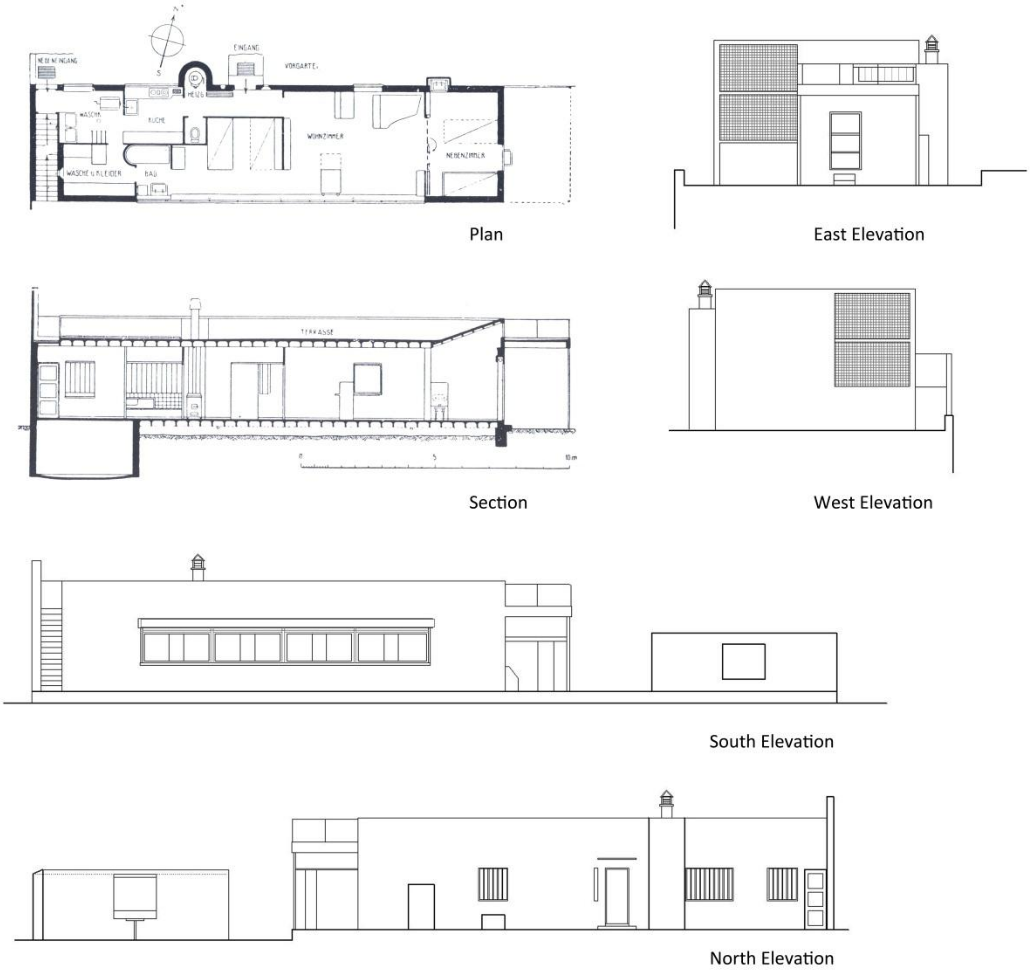


Figure 3.13 Orthographic set of *Une Petite Maison*.

Sources:

Plan and Section: Willy Boesiger, Oscar G. Storonov, Le Corbusier [pseud.] et Pierre Jeanneret, *Œuvre complète de* 1910-1929. Zurich: Girsberger, 1960: 74.

South and East Elevations: (Redrawn by the author) *École Polytechnique Fédérale De Lausanne, Laboratoires de Théorie et D'Historie*: a pdf publication entitled "LE CORBUSIER, La petite maison, Corseaux, Suisse, 1923-1924." 9 Sep.2011.
<http://ltha.epfl.ch/enseignement_lth/theorie/exemples_th1/reg_irreg_1/M_01_Le_Corbusier_Petite_maison_du_Lac/CORBU_TH1_Petite_Maison_Du_Lac_mise_en_page.pdf>.

North and West Elevations: Drawn by the author.

The orthographic set represents the building according to the initial ideas of Le Corbusier in 1923. There is later addition to the North Façade of the building which requires a further inquiry.

A parallel reading of Le Corbusier's "three reminders to architects," namely the "volume," "surface" and "plan," with the three fundamental components of the orthographic set, being the "plan," "elevation" and "section," is possible through an analysis of the orthographic set of *Une Petite Maison*.

It is surprising that Le Corbusier did not include any kind of architectural drawings of *Une Petite Maison* in his book. Although published after the house was built, Le Corbusier chose only to publish his sketches, which were almost diagrammatic in the sense that they could be interpreted as schematic representations of the architectural drawings of the house that was yet to be done, those made in the early processes of design, the photographs after construction, and sketches that he made after the house was built. However, the first volume of Le Corbusier's *Œuvre complète*, which documents his works between 1920–1929, presents a plan and a section drawing of the house accompanied by photographs. Though very rare, there are compilations of Le Corbusier's works[146] that include *Une Petite Maison* in which photographs of the building, sometimes alongside Le Corbusier's sketches, are included. If any drawing is added to the information on the building, only the plan and the section drawing published in *Œuvre complète* are presented. The absence of elevation drawings in the same technical format of orthographic projection is noteworthy. Though it is possible to find elevation drawings in later studies[147] that have been conducted to provide a survey of the building, only a sketch of the south elevation by Le Corbusier, including the eleven-meter window providing a view of the Alps (which can be accepted as the first

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[146] See, Jose Baltanas. Walking through Le Corbusier: A Tour of His Masterworks. London: Thames & Hudson, 2006; Deborah Gans. Le Corbusier Guide. Princeton, NJ: Princeton Architectural Press, 1987; Adolf Max Vogt; translated by Radka Donnell. Le Corbusier, The Noble Savage: Toward an Archeology of Modernism. Cambridge, Mass.: The MIT Press, 1998; David Duster. Key Buildings of the Twentieth Century. London: Architectural Press, 1985; Edward R. Ford. The Details of Modern Architecture, vol2 with the subtitle 1928-1988, Cambridge, Mass.: The MIT Press, 1990.

[147] See, A+U, Special Issue "Visions of the Real: Modern Houses in the 20th Century: I," March 2000; *École Polytechnique Fédérale De Lausanne*, *Laboratoires de Théorie et D'Historie*: a pdf publication entitled "LE CORBUSIER, La petite maison, Corseaux, Suisse, 1923-1924." 9 Sep.2011. <http://ltha.epfl.ch/enseignement_lth/theorie/exemples_th1/reg_irreg_1/M_01_Le_Corbusier_ Petite_maison_du_Lac/CORBU_TH1_Petite_Maison_Du_Lac_mise_en_page.pdf>.

application of his *fenetre en longeur*), can be found in "Le Corbusier le grand,"[148] alongside a sketch of the plan of the house and the garden.

A plan is usually considered as a horizontal cut, and is actually a section in nature, drawn as the object's projection onto a plane assumed to intersect at a particular vertical position. As stated previously, in Classical Architecture the plan was not just a plan, but a plan of the ground floor, and actually a "non-existent footprint"[149]. In Modern Architecture, however, the "plan" has become a confrontation of architecture with its function. Modern Architecture achieved an apprehension of the "plan" to be accepted as the ultimate "order" dependent on the laws of practical distribution of spaces. Starting the design process with, or rather, by the "plan" was not incidental for Le Corbusier. *In Vers Une Architecture*, he expresses his devotion to the "plan":

> The plan is the generator.
> Without a plan, there is disorder, arbitrariness.
> The plan carries within the essence of the sensation.
> The great problems of tomorrow, dictated by collective needs, pose the question of the plan anew.
> Modern life demands, awaits a new plan for the house and for the city. [150]

The plan drawing of *Une Petite Maison* clearly expresses the distribution of both primary and secondary spaces. In the early stages of the design, all spaces were clearly thought out and recorded by Le Corbusier, with the scenario, or rather, the most practical route to be experienced, starting from the entrance. Obviously, Le Corbusier applied his ultimate "free plan" in the house. The appreciation of the house as "a machine for living in" is emphasized by the dimensioning of spaces according to their individual functions, however it is clear from the "plan" that the house is actually a single "space," a single "volume". The arrangement of spaces with different functions has been achieved using the minimum of standards for each. The house is economical and practical in its

[148] Le Corbusier le grand. London: Phaidon, 2008.

[149] James S. Ackerman. Origins, Imitation, Conventions, 2002: 296

[150] Le Corbusier. Toward an Architecture, 2007: 86.

adaptation of "standardization" within each space, or rather "sub-space". In *Une Petite Maison* the plan has been freed from the traditional "room" as a result of Le Corbusier's consideration of sub-spaces as corresponding to different functions as parts of a machine. There is no left over space. The house actually operates like a machine, working properly due to the rational integration of each and every part.

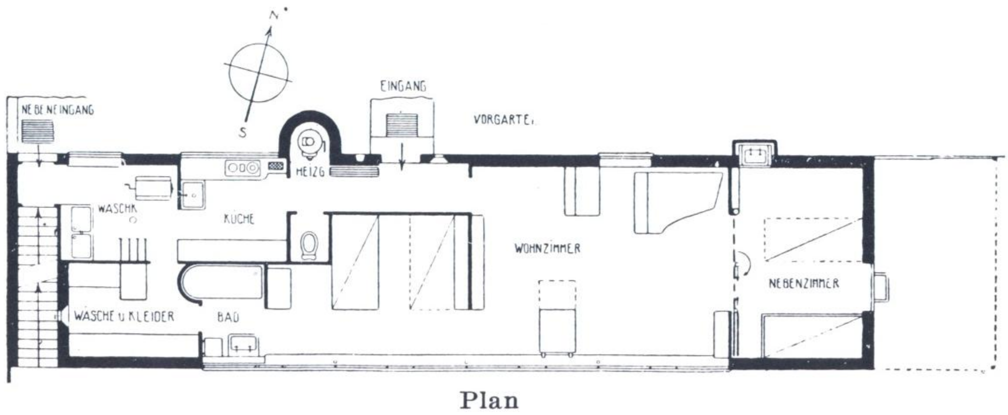

Figure 3.14 The plan of *Une Petite Maison*.
Source: Willy Boesiger, Oscar G. Storonov, Le Corbusier [pseud.] et Pierre Jeanneret, *Œuvre complète de* 1910-1929. Zurich: Girsberger, 1960: 74.

Although not explicitly mentioned by Le Corbusier, it can be seen that any function according any kind of space, regardless of whether it is the living room or the wash house, is no more important than any other; and the core of his architectural expression of the house as a "machine for living in" is based on this principle. Instead of concealing relatively less expressive spaces or elements such as the bath or the wash basin, Le Corbusier makes them an integral part of his architectural expression. He goes even further in the case of *Une Petite Maison* by making protrusions from the rectangular plan of the perfect box to accommodate a wash basin and a chimney, and designing divisions within the single space to provide particular sub-spaces for the accommodation of certain elements or functions, such as a bath, a cloakroom or a bed on the "plan". In the "plan," the "generator" of Le Corbusier's design, he makes no distinctions between the spaces that have a high potential to reflect his "architectural expression" and those that are necessary for the practical functioning of the building and life. Colquhoun makes an analogy between the Cubist paintings and Le Corbusier's plans of his houses:

> The principle is closely related to the procedures of Cubism, in which a representation must include all the space within the pictorial volume, and not merely the space between objects. Just as a Cubist painting is a description of the structure of the pictorial space, so Le Corbusier's houses are descriptions of the structure of the architectural space.[151]

The "plan," as one of the three constituents of the orthographic set, has gone beyond being a mere illustration, having become an architectural tool for "creation". Especially for Le Corbusier, it is the method of constructing a "system" rather than just an expression or projection of an idea. The plan has been considered as a means of design that enables the visualization of architectural creation. It is actually a field of experimentation, since it does not give all the information about the three-dimensionality of the object to be represented, but contains a certain degree of information to guide the formation of the elevation and the section. Yet a "plan" needs to be interpreted to allow spaces to take shape. Without rendering the totality of the object, the "plan" actually contains different possibilities for the creation of architectural space. If the plan is the "generator," then the design process starts with the "plan," while also determining the starting point of this parallel reading. Following Le Corbusier's conception, if, then, the volume is enveloped by surfaces, the "surfaces" are then necessary as a second component, rising from the plan to form the "volume," and thus "space."

As the second determinant, this study suggests that it is possible to read Le Corbusier's conception of "surface" as corresponding to the "elevation" in the orthographic set. Although the two particular constituents are not in perfect correspondence, as in the case of the "plan," it is necessary to understand what is essential for both as components of a system, and how they are actually related within to their particular positions in their respective systems.

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[151] Alan Colquhoun. "Displacement of Concepts in Le Corbusier." Essays in Architectural Criticism, 1981: 62.

As a kind of orthographic projection, an “elevation” is a two-dimensional depiction of the required side of the object projected upon a vertical plane. In architectural drawing, elevations are drawn to give information about the appearance of a building, most commonly from the exterior. Elevations of a building are typically labeled giving reference to the compass direction it faces; i.e. if a façade is looking north, then it is referred to as the north elevation. Elevations can be regarded as the most common type of orthographic projection since they deal with the basic problem of how the object “looks,” but do not how the object is “seen” by an observer. As an “elevation” depicts the appearance of an object, it is actually the most realistic component of the orthographic set. Neither the plan nor the sections are real because they are not conceivable, or rather they are not visible to an observer. The orthographic set is not about the “vision,” since it principally eliminates the very existence of an “observer” or the “subject,” which is what makes the orthographic set “ideal,” being “practical” rather than “visual”. The “elevation” can be regarded as the agent that relates the orthographic set to “reality” by means of its “visibility”.

Architecturally, the term “elevation” actually corresponds to “façade”. Although the “façade” can refer to all or any of the faces of a building, up until the advent of Modern Architecture it was recognized as the “front face” of the building on which a special architectural treatment would be applied. In Classical Architecture, it can be claimed that the notion of “frontality” is at the root of the concept of the façade, which was in turn reflected in Modern Architecture as a “façade problem”. In Modern Architecture, the building has to be “non-frontalized,” in that buildings should not have faces, as an extension of a logic that necessitates the “surface being merely the edge condition of an internally generated organization”.[152] As the external form of a building in Modern Architecture was supposed to be the result of its internal organization, it defined “façadism” as an “architecture of false rhetoric”.[153]

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[152] Ibid. 55-57.

[153] Ibid. 69.

In contrast, Le Corbusier retained the façade and its attributed function of frontality as part of his architectural language. For Le Corbusier, the "façade" was more than just the depiction of the appearance of the building from outside as he considered it to be "the critical boundary" between two phenomenologically and actually distinct spaces[154] – the "inside" and "outside". The conception of the "elevation" as the "critical boundary" also implies its becoming a "space of and for transition" and an "interface" between the public and the private. As the agent that relates the orthographic set to the reality by its "visibility," the "elevation" is, for architecture, the component that enables a building to become a part of the real world and the agency through which it constructs relations.

Le Corbusier explains his conception of "surface" as:

> A volume is enveloped by a surface, a surface that is divided according to the generators and the directing vectors of the volume, accentuating the individuality of the volume.
> Architects today are afraid of the geometric constituents of surfaces.
> The great problems of modern construction will be solved through geometry.
> Under strict obligation to an imperative program, engineers use the directing vectors and accentuators of forms. They create limpid and impressive plastic facts.[155]

It is clear that for Le Corbusier, "surface" did not mean merely the "elevation" of a building in the orthographic set, which corresponds to the outside appearance of the building. The conception of "surface" represents all the planes that define or differentiate the spaces, or as in the case of *Une Petite Maison*, sub-spaces of a single volume. Reading the "plan" of the house with an understanding of Le Corbusier's claims on "surface," it can be interpreted that, as can be derived from the generators and the vectors determined in the plan, he actually organizes both the internal and external surfaces so that they form a series of planes shaping a coherent whole. The series of planes can be considered as a chain in terms of their internal relations, as if all of the planes can be unfolded to form a single "surface". This effect of continuity in the configuration of surfaces is thus reflected on the totality of the space. When the internal

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[154] Ibid. 57.

[155] Le Corbusier. Toward an Architecture, 2007: 86.

surfaces are considered in the plan, it is observable that the effect of a single volume is not broken as the result of the continuous arrangement of surfaces.

The reading of external surfaces, or rather “elevations,” is important if one is to understand how these surfaces define and actually become the “critical boundary” of the building for Le Corbusier. An analysis of the north and the south elevations reflects the irony in Le Corbusier’s treatment of the “façade”. Le Corbusier oscillates between the assumption of the non-existence of a façade in Modern Architecture, by which the outside of the building is a reflection of the interior, which is functionally and internally organized, and the recognition of the façade as the “critical boundary” between the interior and the exterior. The traces of the first tendency are observable on the north elevation of *Une Petite Maison*. The internal organization of the house, which is determined by the plan, is exposed in the elevation; and the functional, or in other words, practically required, elements of the house, such as the entrance door, the wash basin and the chimney, are expressed in the façade with determinations in the plan for these elements to protrude from the surface.

Figure 3.15 North Façade of *Une Petite Maison*.
Source: “LE CORBUSIER, La petite maison, Corseaux, Suisse, 1923-1924.” 9 Sep.2011. <http://ltha.epfl.ch/enseignement_lth/theorie/exemples_th1/reg_irreg_1/M_01_Le_Corbusier_Petite_maison_du_Lac/CORBU_TH1_Petite_Maison_Du_Lac_mise_en_page.pdf>.

Figure 3.16 North Façade of *Une Petite Maison*.
Source: Villa "Le Lac" Le Corbusier. 3 Sep. 2011. <http://www.villalelac.ch/>.

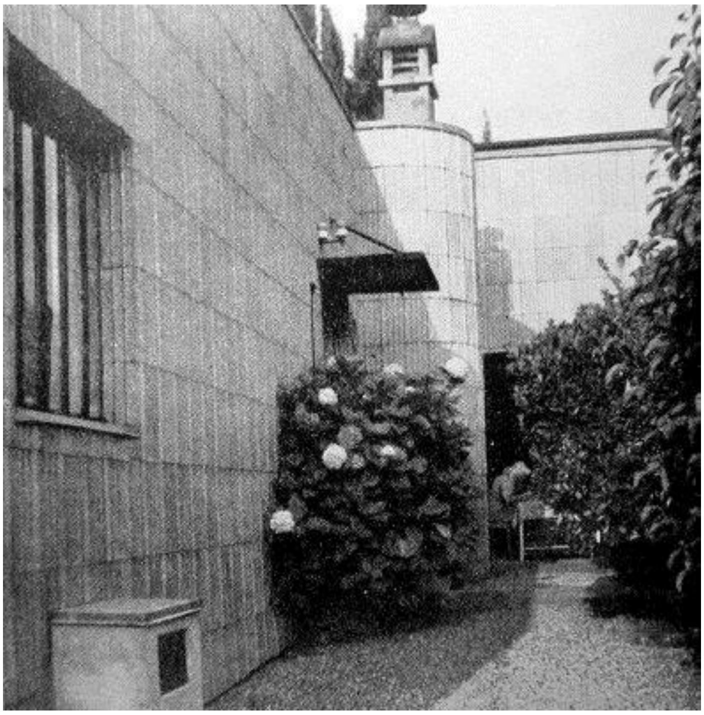

Figure 3.17 North Façade of *Une Petite Maison*.
Source: Le Corbusier, *Une Petite Maison*, 1954: 19.

The south elevation, in contrast to the north, reflects the second tendency, which is to see the elevation as the critical boundary between the inside and outside. The extravagant eleven-meter window has no strict relationship with the internal organization of the house or the particular divisions of the sub-spaces; however the south elevation for Le Corbusier is clearly the front façade of the building. Le Corbusier shifts from the convention of Classical Architecture, in which the front façade is the most significant elevation of the building, providing a welcome through the glorification of its architectural language. The south façade is not actually on the direction of approach to the building, yet it is the most important façade for Le Corbusier because it faces towards the "view".

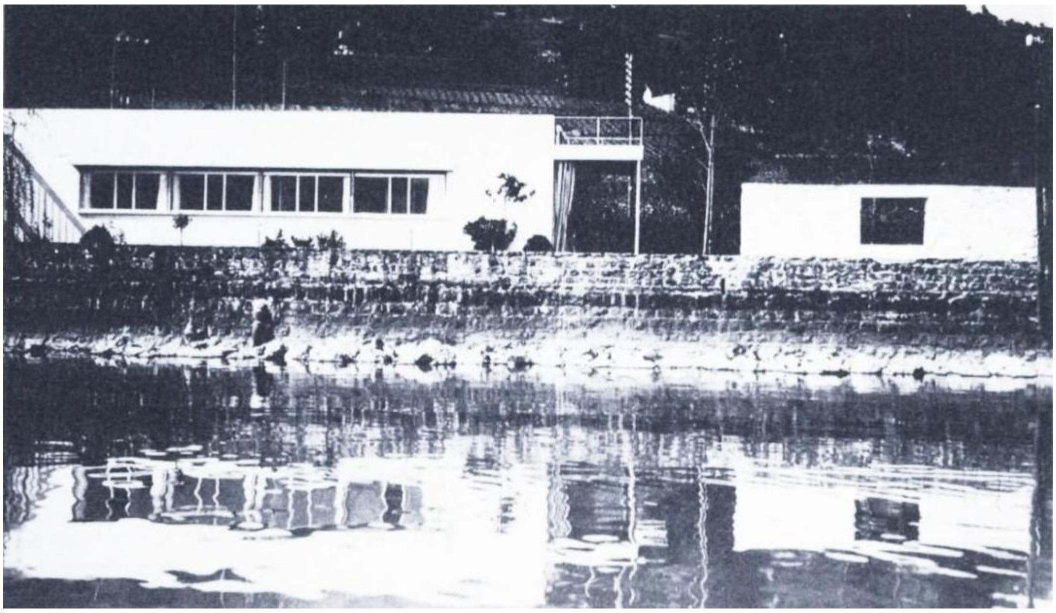

Figure 3.18 *Une Petite Maison* from south.
Source: Adolf Max Vogt; translated by Radka Donnell. Le Corbusier, The Noble Savage: Toward an Archeology of Modernism. Cambridge, Mass.: The MIT Press, 1998: 99.

The south elevation faces what is peculiar about the site, and is the "elevation" that constructs the building's relation with its context. Le Corbusier found it essential to concentrate on how the world would be seen from the house rather than how it will be seen. Still, the south elevation bears the hallmark of Le Corbusier – the *fenetre en* *longueur*. He claims that: "The window, eleven meters in length, gives it a style! The part played by the window is an innovation, for it becomes the main feature, the chief attraction in the house".[156]

The window is the most significant element of the elevation in the sense that it is actually the agent by which the building, and thus the observer, relates the self with the exterior, being actually its context. Rather than how building will look, Le Corbusier considers how one will see the outside from this interface, and attributes meaning to the window as an "eye" of the building. Colquhoun asserts that Le Corbusier's use of the window is "anthropomorphic".[157] As our eyes are what make us conscious of the world, the window in the buildings of Le Corbusier is the regulator of the critical boundary. This emulation of the "eye" is strengthened by the opening in the garden wall, which is designed to be a continuation of the surface of the south elevation. It is well known that Le Corbusier considered the window to be a device for "framing outside," and he extends the definition of the term by attributing the same purpose to the opening in the garden wall. The treatment of the "window" as the basic element of the elevation illustrates the fact that what is essential for Le Corbusier is the "sight" rather than the "site". By "framing outside," the window inhabits the "sight" within the house, thus Le Corbusier manages to make the house become a part of the "site". In this way, the exterior becomes an interior. In the case of *Une Petite Maison*, what connects the house with its site is its south elevation, and the eleven-meter window is the screen that inscribes the exterior and allows it to become a part of the house. This study claims that Le Corbusier was able to achieve an elaboration of the concept of "surface" through designing only by the "elevation".

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[156] Le Corbusier. *Une Petite Maison*. 1954: 30.

[157] Alan Colquhoun. "Displacement of Concepts in Le Corbusier." Essays in Architectural Criticism, 1981: 55.

Figure 3.19 View through eleven-meter window, contemporary photograph, *Une Petite Maison*, Le Corbusier.
Source: Bruno Reichlin. "For and Against the Long Window – The Perret - Le Corbusier Controversy." Constructing Architecture : Materials, Processes, Structures A Handbook. Edited by Andrea Deplazes, Basel; Boston: Birkhäuser - Publishers for Architecture, 2005: 181.

Figure 3.20 Garden wall with an opening "framing outside," *Une Petite Maison*, Le Corbusier.
Source: Villa "Le Lac" Le Corbusier. 3 Sep. 2011. <http://www.villalelac.ch/>.

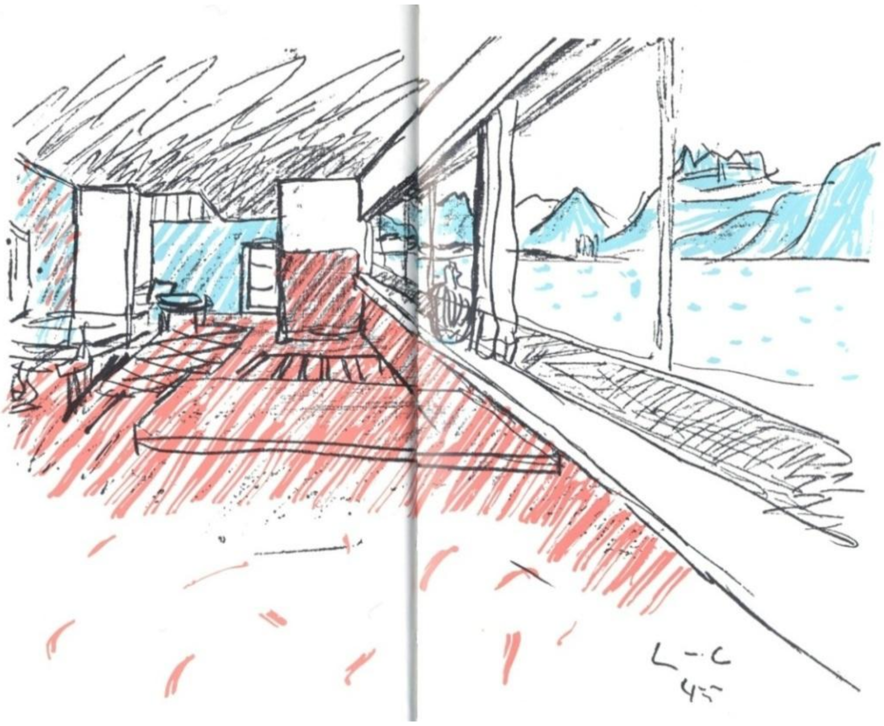

Figure 3.21 Sketch of the interior with the view through eleven-meter window, *Une Petite Maison*, Le Corbusier.
Source: Le Corbusier, _Une Petite Maison_. 1954: 72-73.

Figure 3.22 Sketch of the view through eleven-meter window*, Une Petite Maison*, Le Corbusier.
Source: Le Corbusier, _Une Petite Maison_. 1954: 70-71.

Figure 3.23 Eleven-meter window, *Une Petite Maison*, Le Corbusier.
Source: Jose Baltanas. Walking through Le Corbusier: A Tour of His Masterworks. London: Thames & Hudson, 2006: 43.

Figure 3.24 View through eleven-meter window, *Une Petite Maison*, Le Corbusier.
Source: Ibid. 42.

Robin Evans defines the “section” drawn using the technique of orthographic projection as being the result of synthesizing two kinds of drawing into one: “a profile of a cut, which need not involve projection; and an elevation of what lies beyond, which only involves projection but tends to open up a deeper space for it to survey”.[158] In this way, the section frames the “invisible”.[159] Considering the fact that a plan is actually a horizontal section, and that the specificity of the “plan” is only possible in a world with gravity,[160] a “section” is able to show the formation and relation of the space with all its constituents. In other words, by virtue of being at the same time “a profile of a cut” and “an elevation,” a “section” is able to display the relation of the visible with the invisible.

The third step in analyzing Le Corbusier’s relationship with the orthographic set is the comparison of Le Corbusier’s conception of “volume” with the orthographic set’s “section”:

> Our eyes are made for seeing forms in light.
> Primary forms are beautiful forms because they are clearly legible.
> The architects of today no longer make simple forms.
> Relying on calculations, engineers use geometric forms, satisfying our eyes through geometry and our minds through mathematics; their works are on the way to great art.[161]

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[158] Robin Evans. The Projective Cast. 1995: 118.

[159] Alper Semih Alkan. “Framing the “Invisible”: Section as a Spatial Frame for a Reconsideration of Architectural Representation.” Master’s Thesis, METU, 2004. Though the title of the thesis speaks for itself, Alkan’s study is a critical redefinition of section as a spatial act of “framing”. By redefining the “section” as the operation of a spatial framing, which rather “hides” than “displays,” architectural representation is revealed in respect to its hidden dimension.

[160] Jennifer Bloomer. “Vertex and Vortex: A Tectonics of Section.” Perspecta vol. 23, 1987:40. This reading benefits from the statement of Bloomer on the dialectic between the “plan” and the “section”: “A section is an assemblage of dark spots on a plane. It maps the residual of a surgery on an object by a plane of incision. Each spot marks an instant of convergence of an axis of inscription with an axis of incision. The sectioned object undergoes permutations in a logical system of representation – a system of coordinates. The logic of the representation resembles the logic imposed upon the physical world: the logic of gravity. ... On the plane of inscription, the scratchings which represent the object sliced by a plane perpendicular to the line connecting ‘top’ and ‘bottom’ are called ‘plan’. A plan is a section which demands the presence of gravity. ‘Plan’ has distinct meaning, therefore, only in a world in which the concepts of ‘heaviness’ and ‘lightness’ are distinct and unambiguous.”

[161] Le Corbusier. Toward an Architecture, 2007: 85.

The longitudinal section of *Une Petite Maison* can be regarded as an elaborate version of Le Corbusier's sketch of the very same section during the design process of the house. The "contour" does not change, meaning that the "contour" of the sketch has become the "profile cut" of the house in the orthographic section. This articulation of the contours of the sketches through orthographic drawings is valid also for his plans. Recognizing that for Le Corbusier "contour modulation is a pure creation of the mind,"[162] his insistence on the defined outlines of the house is legible when the development of the design through drawings is analyzed. His remark on the section shows that the "volume" of the house is determined in the section, with the size of the "space" determined in the "plan" by applying the minimum of standards for varying functions. The "space," or rather projection of the space in plan is evolved into a "volume" by the section with a compactness in the dimensioning of the form, as in the plan. Finally, the house acquires a "box" form.

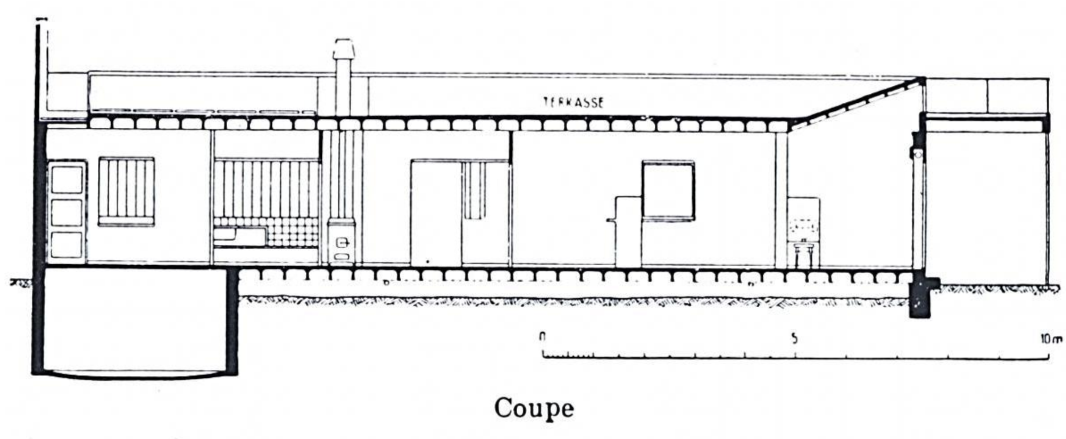

Figure 3.25 The longitudinal section of *Une Petite Maison*.

Source: Willy Boesiger, Oscar G. Storonov, Le Corbusier [pseud.] et Pierre Jeanneret, *Œuvre complète de* 1910-1929. Zurich: Girsberger, 1960: 74.

[162] Ibid. 232.

Recalling that a "section" is the synthesis of a profile cut and the elevation beyond this cut, the "visible" in the orthographic section of *Une Petite Maison* is the internal face of the north elevation, and at the same time, the surface that envelopes the space within. However, the profile cut of the building differentiates from its figure in the elevations – the predetermined "contour" of the section being distinct from the "contour" of the building's appearance. The "box" is somehow deconstructed, with the perfect flatness of its surfaces destroyed by the partial inclination of the flat roof towards east. The design of this skylight is only possible through the section. Without intervening into the perfect geometrical "appearance" of the house, the form is articulated.[163] Le Corbusier's selection of the longitudinal section for this articulation is no coincidence. The plan defines a main axis for the development of sub-spaces. The clarity and singularity of the "box" volume is preserved through the continuous interrelation of sub-spaces along the axis of development; and the skylight is directed towards this axis by its inclination. It catches the sun and leads it to circulate through and around the axis, enhancing the perception of the "volume". The skylight can be accepted as a representation of "seeing forms in light".

Besides its symbolic value in the process of design, the "section," with the "plan" included in this definition, is the medium for solving problems related to the relationships of parts. "Part," in this context, is meant to cover both the spaces and the volumes that enable a conception of space. The relationships of spaces in the internal organization are determined by the plan, which is accepted as a horizontal section, and the relationships within the remaining third dimension are worked out by the section. In contrast to the exposed visibility of the elevation, a "section" provides the architect with the opportunity to visualize the invisible with the visible by composing the profile cut with the internal elevation. By virtue of transforming the invisible into the visible, the practical problems in the interconnection of physical elements to make a definition of

[163] It is the "rationale" of the section that enables Mies to shift the preconceived bilateral symmetry of Classical Architecture in the Barcelona Pavilion. See, Robin Evans "Mies van der Rohe's Paradoxical Symmetries." Translations from Drawing to Building and Other Essays. Cambridge, Mass.: The MIT Press, 1997: 233-276.

the "space" possible are immersed within the designing of the space(s). It is the miracle of the "invisible" that connects the "section" to reality.

3.3. Architectures of Negation: "Breaking the Box"*

Robin Evans identifies the perfect accord between Classical Architecture and the orthographic set as "a good bargain". He observes that the three drawings, the plan, elevation and section, are, respectively, the significant displayers of the building's footprint; the front façade, which represents the magnificence of the building; and the axial section, which underlies the symmetrical internal organization. In Evans' words, "Maximum descriptive power is obtained at minimum price," in that the lines of projection are not only perpendicular to the projection planes of the respective drawings, but also to the major surfaces of the building to be drawn.[164]

"What happens when it is not frontal, symmetrical, axial, and orthogonal?" asks Evans, and offers a measurement of the distance between Raphael and Hans Scharoun to provide an understanding of the impact of drawing in the production of architecture. Evans states that, "To the extent that modern architecture relinquished the underlying order of frontality, symmetry, planarity, rectangularity and axiality, it was no longer in easy accord with its drawing techniques".[165] However, if one looks at the designs that make Modern Architecture "modern," the severance from frontality, symmetry and axiality may be grasped at first glance, while planarity and rectangularity appears to be the unifying feature among most of the examples. A simple, yet obvious, impression could be stated, as it is actually in easy accord with its drawing techniques as long as "orthogonality" is preserved. Evans states that "the internal logic of parallel projection" actually pushed the form to become rectangular. Though not referring directly to Modern Architecture, he states that:

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* Assoc. Prof. Dr. Ayşen Savaş conducts the course "ARCH 524 Architecture and Different Modes of Representation". The expression of "breaking the box" is the main objective of the course.

164 Robin Evans. "Architectural Projection" 1989: 25.

165 Robin Evans. The Projective Cast. 1995: 121.

> It is easiest to deal with the three types of drawing [plan, section, elevation] if they are perpendicular to each other, and it is easiest to align the principal surfaces of an object with the surfaces on which it is drawn; in consequence, a building will be a box in a box of pictures. So planar, rectangular form is economical too, within the confines of the technique.[166]

Although the underlying order of frontality, symmetry and axiality has been the subject of much criticism, and have indeed been abandoned, planarity and orthogonality have been preserved. Modern Architecture accepted the orthographic set as the "rationale" behind the conceptualization and production of "space," and distinct from Classical Architecture, applied a kind of "adaptation" of the orthographic set. The influence of the major principle of orthographic projection, which dictates that projection lines remain parallel and thus intersect with the projection plane at an angle of 90 degrees, dominated Modern Architecture's desire for "orthogonality". The orthographic set dictated only that the projection lines should be perpendicular to the projection planes. In the technique of projection there is no rule that the projection planes of plan, section and elevation must be perpendicular to each other; however the term "orthographic" has come to be recognized as "orthogonal." Modern Architecture utilized the projection planes of the plan, section and elevation as perpendicular to one another and the form has become "orthogonal".

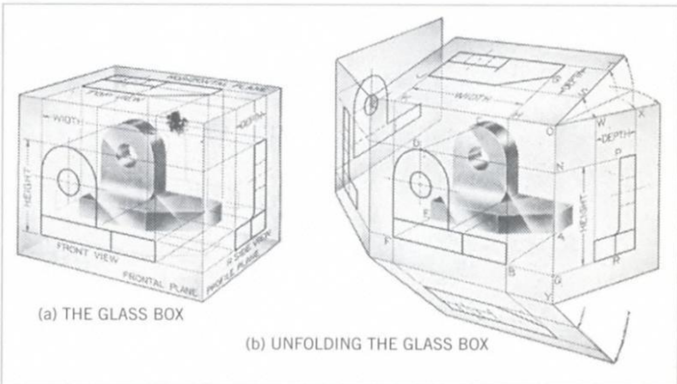

Figure 3.26 The Glass Box, from Technical Drawing by Giesecke, Mitchell, and Spencer, 1958.
Source: Stan Allen. "Terminal Velocities: The Computer in the Design Studio." The Virtual Dimension: Architecture, Representation, and Crach Culture. Edited by John Beckman, New York: Princeton Architectural Press, 1998: 247.

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[166] Ibid. 118-119.

"Orthogonality" led the form to become a "box," with one of the most common illustrations of the technique of orthographic projection being to assume the object to be represented in a transparent box that, in principle, absorbs the views of the object from various sides onto its surfaces. Modern Architecture's obsession with the "box" led to the emergence of the "white box" metaphor – the white box actually being defined as a "glass," and thus "transparent" box, and so conceivable from the outside. Modern Architecture embodied the premise behind the metaphor. The purification of form and the clearance of traces of the past led to the symbolic use of "white," and since the "white box" meant what is inside is legible from the outside, it is adopted with the inception of a principle that manifests the external form as being the result of a functionally organized interior.

Colquhoun claims that it is not possible to grasp the meaning of the Modern Movement without understanding the role of "symbolic expression". [167] He identifies the distinction of the logical, technical and utilitarian aspects from the concerns of aesthetics, referring to the first criteria as the "real," and the second as the "representational". Colquhoun asserts that this distinction is false for architecture since it is necessary to embrace both the "real" and the "representational," which means that a work of architecture is a part of the real, "usable" world, as well as being a representation of that world. He says:

> [The] Modern Movement radically confused these two aspects, attributing to the need for practical buildings a representational function or, conversely, burdening the representational function with the responsibility for solving practical building problems. But if it did this, the reason must lie in the fact that these two aspects of architecture, which are independent from a logical point of view, are never independent experientially, and that the search for the "essence" of the building has an aesthetic motivation, embracing a certain idea of utility and its representation – one in which the transparency of the form was symbolic of a reality which could be totally described and manifested.[168]

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[167] Alan Colquhoun. "Symbolic and Literal Aspects of Technology." Essays in Architectural Criticism, 1981: 28.

[168] Alan Colquhoun. "Rules, Realism, and History." Essays in Architectural Criticism, 1981: 68.

Colqhuoun illustrates the significance of “symbolic expression” by commenting on the difference between the works of Buckminster Fuller and Le Corbusier:

> The difference between Fuller and Le Corbusier lies not in the ideal importance which they attach to mathematics but in the symbolic role it plays. In Fuller’s domes the forms are identified by their lines of force, resembling those High Gothic structures where a framework alone defines the volumes which it encloses and seeming to exemplify Fuller’s philosophy of the forms of art being absorbed back into the technical process. In Le Corbusier, the plastic act is hypostatized. His forms are, as it were, congealed in space, as in a solid graph. In both, Phileban solids play an essential part; in both, the aesthetic and the discipline are identified. But whereas in the case of Fuller the formulation and the identification take place on a supersensuous level and the aesthetic is transmuted into the act, in the case of Le Corbusier the act becomes solidified in the sensuous object. With Fuller the idea explains the form; with Le Corbusier the form explains the idea.[169]

When Modern Architecture started to criticize the primacy of the pure form dominated by the rationale of its representation techniques and became “orthogonal,” the reciprocal relationship between the “drawing” and “building,” thus, the “representational” and the “real,” collapsed. The question raised by Evans as to “what happens when it is not frontal, symmetrical, axial, and orthogonal” is illustrated in Scharoun’s Philharmonie in Berlin. Scharoun, inspired by the work and writings of Hugo Häring, developed the form of Philharmonie neither by geometry nor by drawing influence from nature, its form being rather a result of the “function”.[170] The building is a criticism of Modern Architecture that emerged from within. “Architecture is still a composition of intersecting planes with the occasional curve; it is just that fewer of the intersections are rectangular”.[171] The building is unrepresentable using conventional techniques of orthographic projection, with the problem evolving from the formal qualities of the building, which are stated by Evans as:

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[169] Alan Colquhoun. “The Modern Movement in Architecture.” Essays in Architectural Criticism, 1981: 24.

[170] Robin Evans. The Projective Cast. 1995: 94.

[171] Ibid. 98.

> Scharoun's Philharmonie has none of the properties that are bolstered by classical projective representation; it had no front face, it is not rectangular. There is a residual axis at the length of the auditorium, but it does not divide space into exactly mirrored halves, nor does it correspond to a processional route.[172]

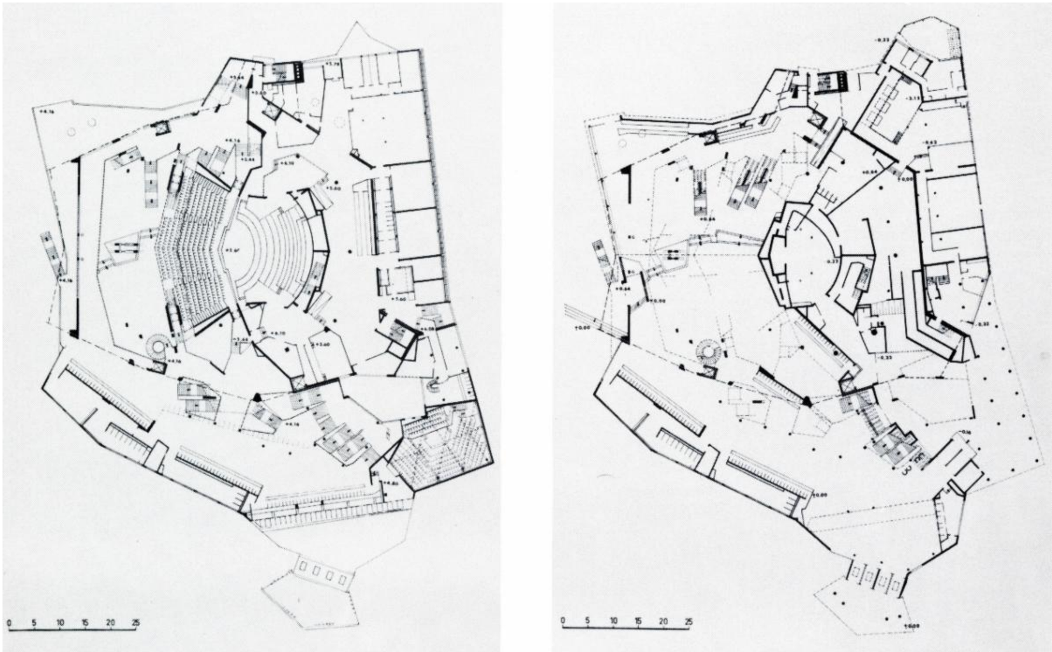

Figure 3.27 Plans of Berlin Philharmonie, Hans Scharoun, 1956-1963.
Source: Robin Evans. The Projective Cast: Architecture and Its Three Geometries, Cambridge, Mass.: The MIT Press, 1995: 96.

In the case of Scharoun's Philharmonie, the orthographic projection technique does not provide the maximum information with the minimum drawings. To understand the building, many plans and sections drawn at close intervals are necessary, meaning that a vast number of drawings are required not only for the comprehension of the building, but also for its construction. Orthographic projection geared towards making things rather than for depiction, but for the Philharmonie it fell short of easing the construction project, being neither economical nor describing the building's metric

[172] Robin Evans. The Projective Cast. 1995: 119.

proportions. Surprisingly, it worked well in depicting the space. When the two published sections of the building are observed, it can be seen that the projection lines, or in other words “references” of the building, are composed in such a way that the section not only stands as a cut through the building, as the geometry of canted and curved surfaces also enabled the occupation of a perspective view within the section. It is impossible to draw the section without perspective, thus, without representing the depth within.

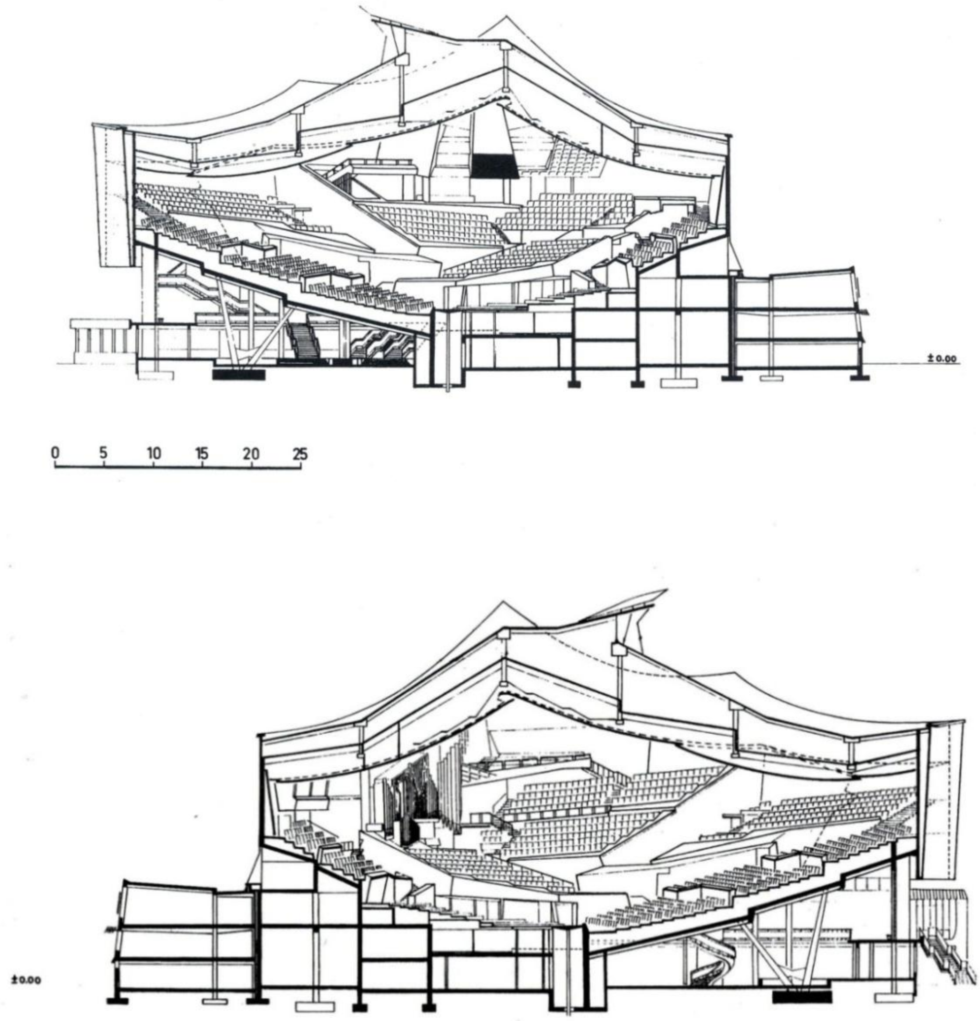

Figure 3.28 Published sections of Philharmonie, from *Akademie der Künste*, Hans Scharoun.
Source: Ibid. 120-121.

CHAPTER 4

BEYOND SURFACES:
DISCOVERING THE "NON" AND "N" DIMENSIONS

4.1. Reconciliations

4.1.1. Representation of the "Objective Space": Axonometric Projection

For Robin Evans, there has been no radical alteration of the practice of drawing, however he suggests that two distinct shifts of emphasis have occurred during the twentieth century. First, the sketch has obtained greater prominence as "a source of originality" and as "a means of investigation"; and second, axonometric drawings have found a place between the perspective and orthographic projections as an "expeditious way of representing the third dimension without sacrificing the scale measure of the plan, elevation and section".[173] The sketch and the axonometric are at the opposite extremes of expression – the former being "indefinite," "often amorphous," "synthetic" and "without obvious geometry"; while the latter is "exact," "often rectilinear," "analytic" and "full of geometry".[174] Between these two extremes of expression, axonometric projection is worthy of analysis as a radical shift in the mode of representation. It represents descriptive geometry within a Cartesian context and exhibits a rehearsal for the confrontation between architectural design and computation by preserving the "precision" in three dimensions. In this sense it has come to represent a "new objectivity" in visual communication and a new form of "orthography".

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[173] Robin Evans. The Projective Cast. 1995: 337.

[174] Ibid.

Evans claimed that he was unable to find a modern architect or critic that expressed a serious opposition to architectural projection as an evolution that took place in tandem with classical architecture. The triumvirate of the plan, elevation and section has never been scrutinized as a problem of architectural production and remained fundamental in the discipline of architecture. On the other hand, says Evans, modern painters have condemned perspective with vigor, claiming that the vision itself is not perspectival, and exclude the "convention" of perspective from their paintings. Evans claims that for modern painters the dominant means of representation was an issue, but not, apparently, for modern architects.[175]

Yves-Alain Bois states that it is no coincidence that the axonometric revival was actually begun by two painters. He dates the modern revival of axonometry quite precisely: "It began during the De Stijl exhibition in the gallery *L'Effort Moderne* in Paris from October to November of 1923, in which the drawings of van Doesburg and van Eesteren caused a general sensation".[176] Architecture, once again, followed the lead of painting, and it is interesting to note, states Bois, that axonometric projection began to be used extensively by modern architects. The origins and the history of this drawing technique, or rather, the "projection" technique, have never been questioned. Even the masters and pioneers of axonometry, such as Theo van Doesburg, Alberto Sartoris and Hannes Meyer, presented very few accounts of their reasons for adopting this method, or have declined even to mention it. Bois cites only one exception to this – Claude Bragdon's discussion of the "isometric perspective" in The Frozen Fountain in 1932. Bois begins his seminal article, entitled "Metamorphosis of Axonometry," with a quote from Bragdon that is essential for this study in identifying the peculiarity of axonometric projection as a "way of seeing" and as a "representation of the object and objectness":

> [The] isometric perspective, less faithful to appearance, is more faithful to fact; it shows things more nearly as they are known to the mind:

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[175] Ibid. 119.

[176] Yves-Alain Bois. "Metamorphosis of Axonometry." Daidalos, 1981: 42.

> Parallel lines are really parallel; there is no far and no near, the size of everything remains constant because all things are represented as being the same distance away and the eye of the spectator everywhere at once.
> When we imagine a thing, or strive to visualize it in the mind or memory, we do it in this way, without distortions of ordinary perspective.
> [The] isometric perspective is therefore more intellectual, archetypical, it more truly renders the mental image – the thing seen by the mind's eye.[177]

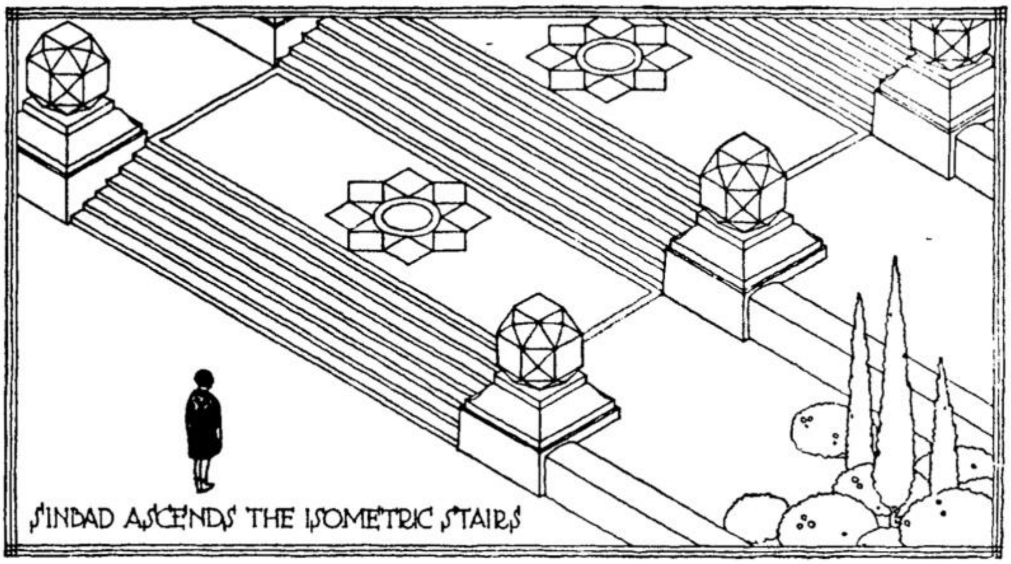

Figure 4.1 The Frozen Fountain, 1932, Claude Bragdon.
Source: Yves-Alain Bois. "Metamorphosis of Axonometry," Daidalos, 1981: 40.

This spectacular opinion of Bragdon displays perfectly how axonometric projection deals with the "real," or the "objectness" of the "object," within an "ideal" space of "representation". Axonometric projection achieves an indispensable schizophrenia by dealing with the "fact of seeing," which is defined as "seeing by the mind's eye," rather than concerning the "act of seeing" as "perspective" does.

Perspective is concerned with the act of seeing, with concentration set on the "subject" rather than the "object"; and, as claimed by Bois, the existence of perspective space is

[177] Ibid. 40.

dependent solely on the existence of the subject. Moreover, perspective actually demands "the petrification of the spectator"[178] If the spectator leaves the standpoint demanded and determined for each and every case of perspective construction, the space of representation collapses. "The petrification of spectator" is possible only in theory, however perspective demands more than that, actually requiring a petrification of the world and time. This means that practically everything that penetrates the spectator's cone of vision should be petrified with the spectator. Based on this assumption, this study claims that orthographic projection has released the subject, and thus questions the very notion of "vision" as the field resulting from the "act of seeing," and rather focused on the "object". Although orthographic projection liberated vision by severing the object from the subject, what happens in this case can be summarized as "the petrification of the object".

According to Bois, orthographic projection, in capturing the "analytical views" of the object, aims at the geometrical representation of the object on a two-dimensional medium, while the objective of axonometric projection is the geometrical representation of the "space" in which the object exists. Axonometric projection extends beyond the limitations of perspectives and orthographic projections, abolishing the fixed viewpoint of the first, and the flatness of the second, and leads to only one possible outcome of the interlocked two-dimensional representation. Axonometric projection has become "a space in between the real and the ideal," negating neither the depth nor the geometry. Axonometric projection is the geometrical representation of the "ideal" infinite space in which a "real" object could be objectively rendered. Bois states that:

> For in all variations of axonometry - isometric, dimetric, or trimetric (identical standard measurement in all three, in two, or in none of the three axes: height/width/depth); rectangular or oblique (geometrical projection of one of the sides of the object or not) - the center of projection is in infinity, and the rays of projection run parallel, so that there is no diminuation in depth and no limit or stopping point of space.[179]

[178] Ibid. 46.

[179] Ibid. 44.

Axonometric projection is the composition of two-dimensional orthographic projections in three dimensions, and is practically a representation of three-dimensional Cartesian space. Keeping in mind that the Cartesian coordinate system is based on the X, Y and Z axes, in axonometric projection the plan, or rather a view that is projected onto a horizontal projection plane, is placed on the XY plane, while views that are projected upon vertical planes are located on the XZ or YZ planes. Occupying a position between perspective and orthographic projection, axonometric projection exhibits a rationalization of the object of representation. It "objectifies" the representation with the elimination of the viewpoint, and therefore the observer, as in orthographic projection, and occupies an ideal infinite space which has no visual references within the real world. The objective space represents the absolute object with precise measurements preserved in three dimensions.

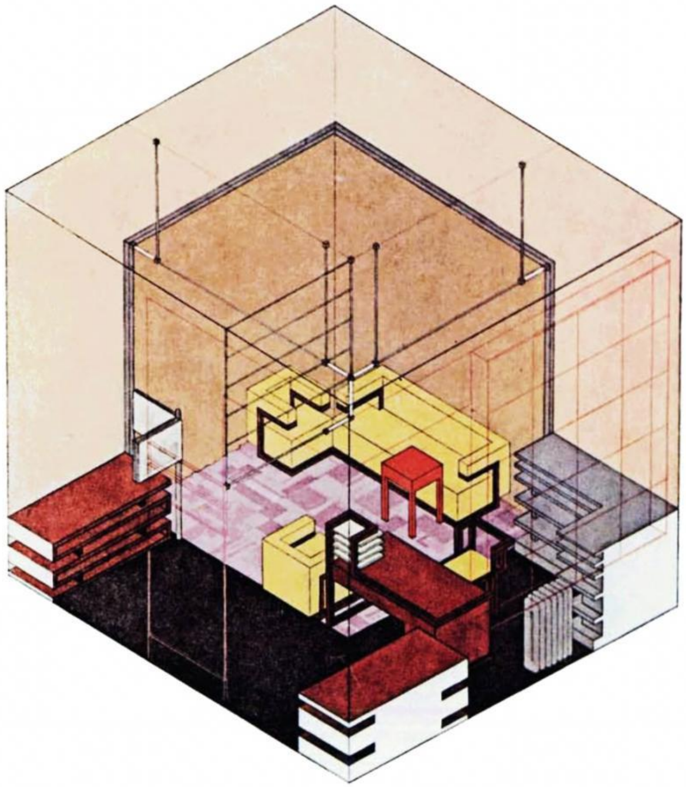

Figure 4.2 The office of Walter Gropius at the Bauhaus in Weimar, Herbert Bayer, 1923.
Source: Yves-Alain Bois. "Metamorphosis of Axonometry." Daidalos, 1981: 41.

The Cartesian coordinate system processes information through the positions of "points". A point on a two- or three-dimensional geometry is defined by its distance from the zero point of the X, Y and Z axes – known as the origin. There are no projection lines to define a geometry, these being replaced by numbers. Gaspard Monge systematized the algebra in projective space. The Cartesian coordinate system is regarded as a three-dimensional unified space, defined by infinitely large planes of XY, YZ and XZ, which means that the system is actually a "cube" defined by an infinite number of points located at infinitely close distances along the X, Y and Z axes. If axonometric projection is a representation of three-dimensional Cartesian space constructed by projections rather than points in space, then the "cube" turns into a form defined by lines projecting from the surfaces of the cube that extend to the opposite surface. The "cube" is actually a "three-dimensional grid," or rather, a "lattice"[180] in Rosalind Krauss's definition.

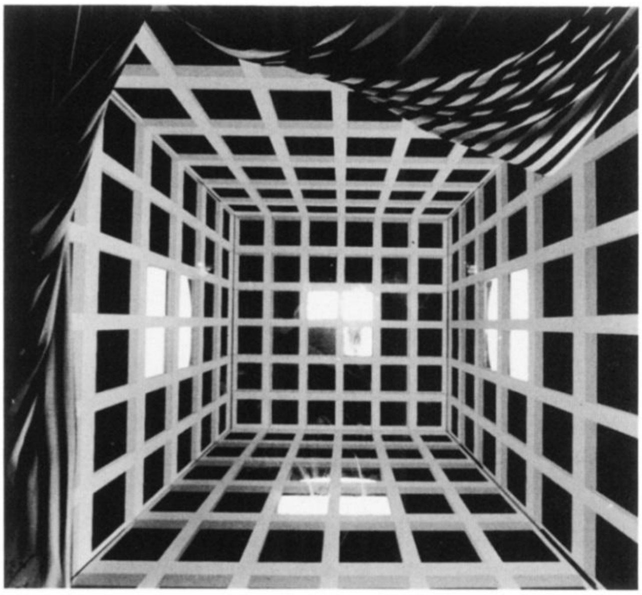

Figure 4.3 "The Room of the Four Elements" an example from series of installations entitled as "Architecture of Images" by Daniela Bertol, 1988 (in collaboration with David Foell).
Source: Daniela Bertol. "Architecture of Images: An Investigation of Architectural Representation and the Visual Perception of Three-Dimensional Space." Leonardo Vol.29, No.2, 1996: 87.

[180] Rosalind Krauss. "Grids" October 9, Summer 1979. Reprinted in The Originality of the Avant-Garde and Other Modernist Myths. Cambridge, MA: The MIT Press, 1985: 21.

Understanding the term “grid” is important if one is to comprehend the homogenous space created in three-dimensions by the projection lines. According to Daniela Bertol, the “grid” is “a means of measure and therefore of appropriation of space”.[181] It becomes a constructive tool that provides the illusion in her series of installations entitled “Architecture of Images”. On the other hand, Rosalind Krauss conceptualizes the “grid” as a structure within the visual arts of the twentieth century, and dwells on the bivalent structure, namely centrifugal and centripetal, of the grid over the work of art:

> Logically speaking, the grid extends, in all directions, to infinity. Any boundaries imposed upon it by a given painting or sculpture can only be seen – according to this logic – as arbitrary. By virtue of the grid, the given work of art is presented as a mere fragment, a tiny piece arbitrarily cropped from an infinitely larger fabric. Thus the grid operates from the work of art outward, compelling our acknowledgement of a world beyond the frame. This is the centrifugal reading. The centripetal one works, naturally enough, from the outer limits of the aesthetic object inward. The grid is, in relation to *this* reading a *re*-presentation of everything that separates the work of art from the world, from ambient space and from other objects. The grid is an introjection of the boundaries of the world into the interior of the work; it is a mapping of the space inside the frame onto itself. It is a mode of repetition, the content of which is the conventional nature of art itself.[182]

If an axonometric projection is constructed over the idea of a three-dimensional grid or lattice, it can be interpreted as a “theoretical model of architectural space”.[183] The space of translation is formed visually and yet virtually on a three-dimensional projection within the flatness of a drawing. The orthographic set is used in an “inter-projective” manner in three dimensions. The projection lines become the reco(r)ders of information in three dimensions, or in other words, the representation of the object is translated and preserved in three dimensions through axonometric projection. This study affirms that axonometric projection is a “reconciliation of orthographic and perspective projections”.

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181 Daniela Bertol. “Architecture of Images: An Investigation of Architectural Representation and the Visual Perception of Three-Dimensional Space.” Leonardo Vol.29, No.2, 1996: 90.

182 Rosalind Krauss. “Grids.” 1985: 18-19.

183 Ibid. 21.

4.1.2. Deconstructing Projection: Mapping into Points

Robin Evans claims that perspective projection has subordinated orthographic projection, claiming that while a vast number of treatises have been published on perspective projections, almost none deal with orthographic projection. Yet, in the 1470s Piero della Francesa presented a crucial work that included a series of studies using plans, elevations and sections to describe geometrical figures. Although the treatise, entitled *De Prospectiva Pingendi*, utilized orthographic projections, its main focus was perspective, and Evans cites this as the earliest recorded account of orthographic projection. Francesca presented an "Other Method" in the third book of his treatise for the drawing of perspective, in which Evans says that "the result is achieved entirely by orthographic means – just like architecture".[184] Evans, recognizing the irony of this, says: "Many are aware that perspective was first described by architects; few are aware that architectural drawing was first described by a painter".[185]

The Other Method is actually a straightforward procedure based on two fundamental abstractions: "orthographic projection and the dissolution of surfaces into constellations of dots".[186] Francesca starts the procedure by preparing a plan and side elevation of what is to be drawn in perspective. His selection of the "object" to be drawn in perspective is a "head," which is a complicated subject for depiction with two orthographic projections. The overall irregularity of the head makes the construction of plan and elevation drawings impossible, but Francesca's approach was to begin by taking a number of horizontal sections of the head, and then drawing the plan and the elevation according to these horizontal sections, while also displaying the contours of the eight horizontal sections. To avoid confusion, rather than drawing a single plan, he creates two diagrammatic plans, each composed of the superimpositions of four sections. The eight cross-sections have 16 lines radiating from a central point determined by Francesca to their circumference. Although the contours of the sections

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[184] Robin Evans. The Projective Cast, 1995: 151. The sub-chapter in the book is first published as "When the Vanishing Point Disappears," AA Files 23, 1992: 6.

[185] Ibid.

[186] Ibid.

reflect the irregularity of the head, if the contours would have been perfect circles, then the angle between each line slicing the section would be 22.5 degrees. Francesca then gives numbers or "codes" to the 128 points that he gained through the intersection of the 16 lines with the contours of the eight sections. The side elevation is also drawn with reference to the sections, and the points taken from the plan are projected onto the respective locations. After this preparation phase, the "mapping" of the front elevation can easily by achieved by projecting the points from the plan and the side elevation.[187]

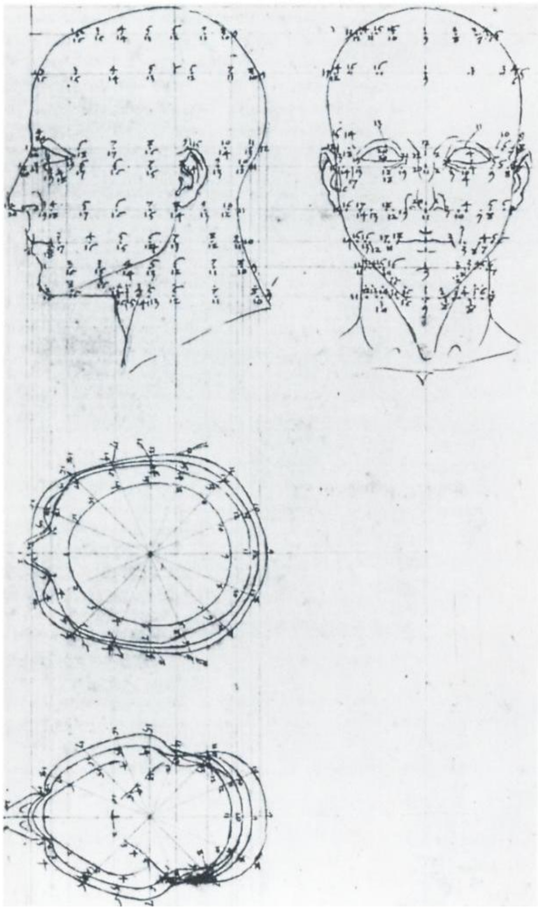

Figure 4.4 Orthographic projections [plans, front and side elevations] of a head, *De Prospective Pingendi*, Piero della Francesca.
Source: Robin Evans. The Projective Cast, 1995: 153.

[187] The descriptions on the "Other Method" are based on the explanations of Robin Evans and Kristi Andersen. See, Robin Evans, The Projective Cast, 1995: 154-156; Kristi Andersen. The Geometry of an Art: The History of the Mathematical Theory of Perspective from Alberti to Monge. New York and London: Springer, 2007: 71-73.

The whole system of the "other method" is formulated by three orthographic projections: the plan, side elevation and front elevation. Diverging from these three orthographic projections, Francesca could draw auxiliary projections of the head, thus depicting the head as tilted, and was able to "map" the perspective drawing of the head. As seen in his perspective drawing, additional lines of measurement exist on both sides and below the drawing, carrying information about the sectional rings of the head from the plan and elevation drawings.

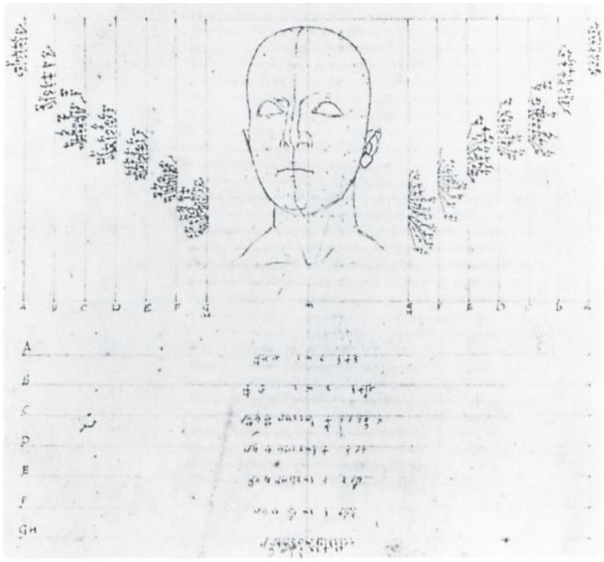

Figure 4.5 Perspective of a head, *De Prospectiva Pingendi*, Piero della Francesca.
Source: Ibid.

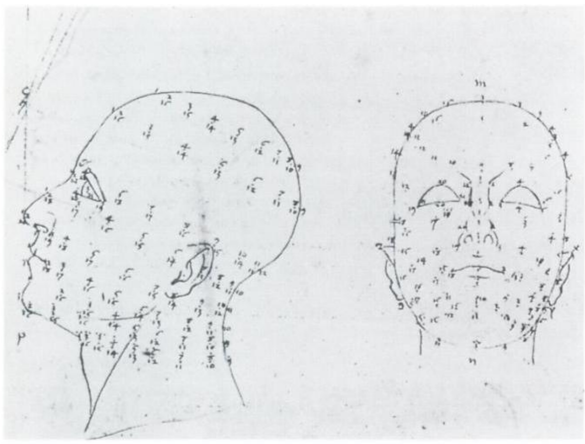

Figure 4.6 Orthographic projections of a tilted head [elevations], *De Prospective Pingendi*, Piero della Francesca.
Source: Ibid. 157.

For Evans, Francesca's "achievement was to separate the form of the object from the form of its projection".[188] Although the means of projections leaves its traces, "a certain zone of liberty was found". [189] Through orthographic projection, the "object" has been liberated from the viewpoint, and therefore from the subject. Through his use of the "Other Method," Francesca achieved a "reconciliation" of perspective and orthographic projection by virtue of separating the object from projection. In other words, the "object" is liberated even from the "projection". The separation of the object from "the form of its projection" demonstrated that the vanishing point, which is actually the "symbolization of the subject's eye," does not necessarily have to be the constructor of the perspective space.[190] Francesca, through the "Other Method," abolished the "petrification of the spectator" that the perspective construction had previously demanded.

The severance of the object from the contingencies of the method of projection means that, in theory, the object is disposed from any conception of space. The "mapping" of the object by, or rather, into points brings a degree of independent existence to the object and its drawing. However, the points are subjected to the "surface" that envelopes the object, and it is the contour of that "surface" that is actually drawn. Whether regular or irregular, the points exist only with the existence of the "surface" that defines the "object". They are practically attached to the surface and delineate the contour that "represents" the surface and can only redefine a space or an object if their enveloper is transformed. The points alone do not offer a system for the conceptualization of an object; in that they actually "reproduce" the "surface" of the object in the absence of the ability to produce images of something that is yet to exist. Right from the start, the existence of the object is demanded. If an object exists, then the procedure of "theoretical surgery"[191] can be applied to the object, and the

[188] Ibid.

[189] Ibid.

[190] Ibid. 156-158.

[191] Ibid. 154. Evans defines the act as a "conceptual surgery".

necessary orthographic projections of the object for the construction of its perspective image can be produced.[192]

Thus, “reconciliation” is achieved by separating the object “from the form of its projection,” as while the projection lines remain parallel between the object and the projection plane in orthographic projection, they converge in perspective, and are mastered with “points”. Not only the object to be represented abstracted and left under the control of points, but also the drawing of the object. To a certain degree, the drawing is also separated from the projection, however the “indefiniteness” of the points without the drawing led the process again to be executed by means of projection. “Point,” being the prime condition for defining a location, is used symbolically in Francesca’s “Other Method”. The painstaking procedure in the determination and the translation of the “points” or “coordinates” on and among the picture planes reflects “a passion for accuracy”.[193]

Mario Carpo claims that “long-established staples of architectural craft,” such as orthographic projection, perspectival drawing and three-dimensional models, “acquired their modern form and mode of use” during the Renaissance, and can all be traced back to Leon Battista Alberti.[194]

> At the end of the Middle Ages, Leon Battista Alberti, the universal man of the early Renaissance, aimed at identical reproductions of almost everything: of text and images, of letters and numbers, of drawings and designs, of paintings and sculptures and other three-dimensional objects, of architectural parts and occasionally of entire buildings; in

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[192] The break between the “Other Method” and the “object” can also be expressed by considering to make practical changes in the procedures. More than eight horizontal sections could have been taken from the head, or the angle that determined the polar distribution of the points on the contours of the sections could have been less than 22.5 degrees. These applications are not determined according to the form of the object. This situation resulted into the dependence of the points to the object since the applications of sectioning and slicing that construct them are totally independent from the object.

[193] Kristi Andersen. The Geometry of an Art. 2007: 71.

[194] Perspective, Projections and Design: Technologies of Architectural Representation. Edited by Mario Carpo and Frédérique Lemerle. New York: Routledge, 2007: 2.

short, of almost every manifestation of art and nature. Unfortunately, identical reproduction was technically, almost, impossible – and often culturally irrelevant – at the end of the Middle Ages.[195]

In the absence of suitable existing technologies, Alberti had to invent new techniques and his own mechanizations which later become the most important turning points in the history of art, science and media. Carpo says that in *Descriptio urbis Romae*[196], Alberti wanted to record and transmit the manuscript drawing and the measurements of the city of Rome as precisely as possible. He did not provide any drawing or any map of the plan of Rome. Alberti just described a simple technical device which is to be used as an instrument to produce the "drawing." The instrument can easily be constructed by the user. It was composed of two graduated parts: the first component was the "horizon," which was simply a circle, and the second was the "radius," which was actually a straight spoke that corresponds literally to the radius of the circle and revolved around the center of the circle. The method for users to produce their own copies of the map of was as followed:

> Alberti provides a list of polar coordinates for 175 chosen points, either within the ancient city of Rome or along its wall; each point is identified by two numbers: an angle, to be read on the circle, and a distance from the centre, to be read on the spoke. Alberti explains how to use his tool, the circle and spoke, to locate each point of the drawing, and how to join some of these dots with continuous lines so as to draw an approximate contour of the city walls and the course of the Tiber within the city; other isolated points mark sites and buildings in the city. Alberti insists that every user is free to choose the scale of each new rendering, and so each time create a new diagram of the map of the city.[197]

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[195] Mario Carpo. "Alberti's Media Lab" in Perspective, Projections and Design: Technologies of Architectural Representation, 2007: 47.

[196] See Leon Battista Alberti, Delineation of the City of Rome / *Descriptio urbis Romae*, Medieval and Renaissance Texts and Studies, vol 335, Edited by Mario Carpo and Francesco Furlan, critical edition by Jean-Yves Boriaud and Francesco Furlan, English translation by Peter Hicks. Tempe, Arizona: Arizona Center for Medieval and Renaissance Studies, 2007.

[197] Ibid. vii.

Figure 4.7 (left) Reconstruction of the map and drawing device following the methods and coordinates in *Descriptio urbis Romae*, Leon Battista Alberti.
Source: Mario Carpo. "Alberti's Media Lab," Perspective, Projections and Design: Technologies of Architectural Representation, Edited by Mario Carpo and Frédérique Lemerle. New York: Routledge 2007: 51.

Figure 4.8 (right) An example from the matrix of coordinates in *Descriptio urbis Romae*, Leon Battista Alberti.
Source: Ibid.

Alberti intentionally refers to the produced drawing as a "diagram," since each drawing would be built upon a limited number of points and would actually be sketchy and incomplete. That said, all copies of the map of Rome would be proportionally precise and identical to the original. Alberti reduced the drawing into "points" that could be relocated by the agency of a specific instrument, which can also be easily produced, and a matrix of these points, which are indicated in numbers actually correspond to "coordinates". While Francesca provided a "method" for perspective drawing that altered the conception of projection, he could only "record" the points because he was dependent on the "drawing". It is a mystery how he was able to slice the head into horizontal layers and begin the process of preparing plan drawings; but a simple solution would have been to cut physically a three-dimensional solid model of a head and then use the slices as templates for the production of sectional rings that would constitute the plan drawings. The problem is that still there is a dependence on the existence of the "object" and then the "drawing" to attain points for the creation of the perspective drawing. To overcome this, Alberti constructed a system that not only "records," but also "reproduces," the drawing by points, and then released the points from the drawing. In this way, the “point” actually becomes the “producer” of the drawing. What enabled the existence of points without the drawing is their transformation into “coordinates”. Thus, it is the coordinates that record the information, not the drawing, making it becomes possible to produce and reproduce it by “mapping”. Alberti produced a system to “produce the drawing,” rather than only “recording” it, which can be referred to as a process of “digitization”. In terms of computation, he “wrote” the drawing “program,” defined its constituents and scripted the procedure of production.

4.2. Computing the Object: Reco(r)ding

4.2.1. Processing the “New”: Scripts and Algorithms

The definition of “orthography” as a standardized way of using a specific writing system may lead the term to be recognized as a “script”. “Script” means literally “a system of writing”; and though it commonly refers to the written text of coding lines composed of words, numbers, symbols and equations that generates a computer program or its processes, more generally it corresponds to “a plan of action”. On the other hand, “algorithm” means “a process or set of rules, usually one expressed in algebraic notation, and is now used especially in computing, machine translation and linguistics”.[198] An algorithm can be interpreted as a defined step-by-step procedure for calculating, processing information or solving problems. The core of an algorithm is to be deterministic, precisely defining the set of rules that will lead the sequence of operations; yet there is no specific way of expressing an algorithm. As indicated in previous chapters, “orthography” is defined as “correct writing,” meaning that a language has elements with assigned meanings and missions by which a text can be spelled properly and read without misunderstanding. In this respect, orthography is actually a system for production, however algorithms are more about processing information or solving problems, which may mean that they already deal with something in hand.

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[198] The Oxford English Dictionary. Oxford: Clarendon Press, 1989.

Orthography inherits the logic of the algorithm. In the action of drawing an orthographic projection of an object, the subject has a set of rules for the execution of the drawing. The system of drawing itself is algorithmic, and in being transferred to the act of design, it has actually become a process of production with the discovery of digital media. The processes of design, representation and production are controlled simultaneously by equations and algebraic functions based on numerical information without the need of a visualization process, as is the case with drawings produced by means of projection. Rather than the composition of geometrical figures reduced to lines, the process is triggered by means of computation through the processing of numerical and relational information. The designer, or rather the user, "codes" the model of the object. In other words, a replication of the "ideal" object is constituted through the writing of scripts based on algorithms derived from algebraic equations of numbers.

The analogy of drawing as a "visual language" is easily comprehensible, as the use of lines by architects to communicate their intentions is neither new nor a discovery. This study claims that the orthographic set is the "Esperanto" of this visual language, in that its constituents are "lines" that work as elements and are assigned meanings by a system of codification to describe the different characters of the object or the objects represented in the drawing.[199] In the case of computers and machines, understanding the language of coding is not so easy. Architects are not trained to write scripts, but they are trained to think parametrically. With the use of computers, thinking processes are directed by a different language, and the "visual orthography" of the orthographic set shifts to an "invisible script" of symbols and numbers. Indeed, the use of digital media has to be visual for an architect, and solutions have been developed that allow architects to work in "visualized" versions of algorithms and scripts. Reminding that algorithms do not have to be expressed in a specific manner, and that scripts are actually the coded abstractions of algorithms, Grasshopper, a generative algorithm plug-

[199] In orthographic projections, there are standards to differentiate the use of lines according to the purpose and visibility of the contours depicted such as, thick solid line for visible outlines, dashed line for the objects or parts hidden, dotted lines for the objects behind the projection plane, chain line for the indication of the section plane. See, Peter Jeffrey Booker. "Conventions and Standards in Drawings," A History of Engineering Drawing, 1963: 171-184.

in for the three-dimensional modeling program Rhino, is one of the most notable examples, with the ability to convert algorithms into visual arrangements of components and relations within by a flowchart-type system.

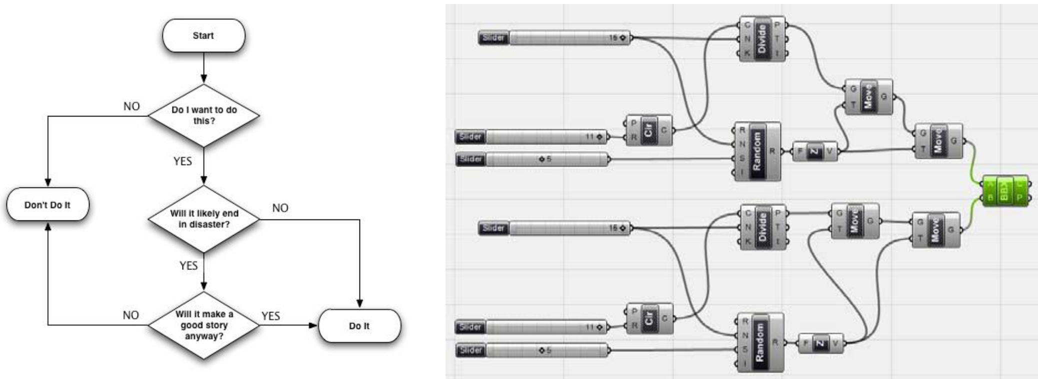

Figure 4.9 The comparison of a flowchart with the visual algorithms of Grasshopper.
Source: Zubin Khabazi. Generative Algortihms using Grasshopper, digital publication, 2001: 9.

With the shift of the "language" of design from "visual orthography" to a "numerical script," the process of design, representation and production becomes inevitably "coded". This codification has actually deciphered the processes and blurred the definitions that identify them. The whole process, previously considered as stages of architectural production, can now be controlled by a single "thinking" process, with results achieved simultaneously. The deciphering of the thinking processes into numbers under the control of algebraic functions has enabled designers to think and design in an algorithmic manner. The design of the relations has gained in importance, as have the parameters; and thus, the determinism of the system does not necessarily dictate the relations or values to be deterministic. The generation process has become flexible in the sense that once a rule is defined, it does not necessarily have to result in the same form because the user can always change the parameters to be processed in the script. Additionally, if the whole system of rules is delicately "designed," a rule can be responsive to the changes in the other rules in the way that it responds to differentiations in the parameters. In better terms, the "relations" can also be designed and changed. The real achievement of computational thinking can be understood in the way that the "deterministic" and "strict" nature of equations and functions cleared the way for the discovery of the "unpredictable" and "infinitely many" possibilities of generations. Branko Kolarevic defines the shift of concern from the result to the relations and parameters that generate the result as a "digital morphogenesis," and states that:

> Parametrics can provide for a powerful conception of architectural form by describing a range of possibilities, replacing in the process stable with variable, singularity with multiplicity, using parametrics, designers could create an infinite number of similar objects, geometric manifestations of a previously articulated schema of variable dimensional, relational or operative dependencies. When those variables are assigned specific values, particular instances are created from a potentially infinite range of possibilities.[200]

4.2.2. Accommodating the "New": Space of Reference

The revolutionary Cartesian coordinate system, named after its 17th century inventor René Descartes, allows any geometrical shape to be described with the aid of algebraic equations in reference to the coordinates of the points of a shape. Rather than the system, what is essential in this case is the conception of Cartesian space. The coordinate system can be regarded as the arrangement of projection planes, as in the orthographic set, lying perpendicular to each other, which would later become known as "orthogonality" in Modern Architecture. The perpendicular arrangement of straight axes defines the "planes" of projection in reference to one another, thus, defining a "space" within the boundaries of the planes. In theory, there exists no boundary because the "space" expands to infinity. The three-dimensional Cartesian space can be illustrated in three diagrams as follows: The three axes of X, Y, and Z are attached to each other at a point known as the "origin" in such a way that the angle between two pairs of axes will

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[200] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age: Design and Manufacturing. ed. by Branko Kolarevic. London and New York: Spon Press, 2003: 17.

be 90 degrees. The result of this composition will be the definition of the XY, XZ and YZ planes, which define a cubical, and ideally infinite, space within.

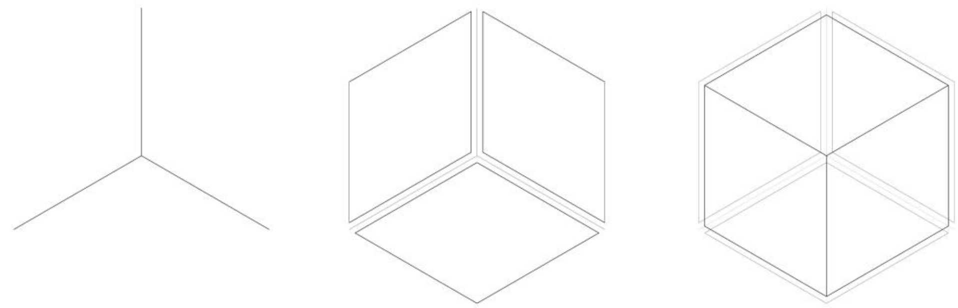

Figure 4.10 X,Y,Z directions / XY, XZ, YZ planes / XYZ – cubical space of Cartesian system.
Drawn by the author.

Yet Cartesian space is not composed of three continuous axes, empty planes or a homogenous cubical space. The basis of the Cartesian space is the coordinate system, which allows the location of a point inside it. The division of the three axes into smaller units of lines affects the planes, and as a result, the planes become "grids". Thus, the space becomes a cube with gridded surfaces. In turn, the transformation of the planes into grids also affects the cubical space and transforms it into a "lattice" rather than a cube, of which only the surfaces are gridded.

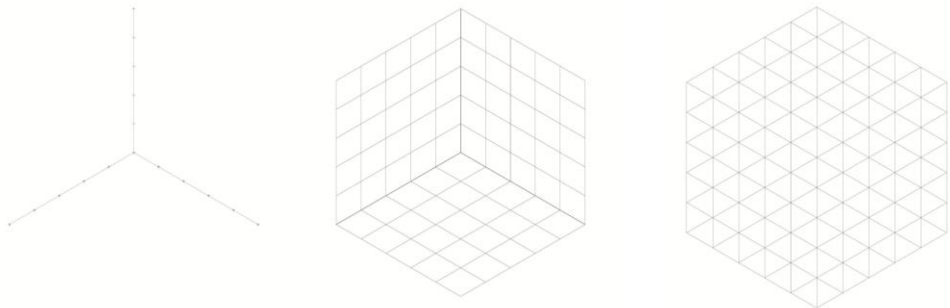

Figure 4.11 Cartesian Space as a "lattice".
Drawn by the author.

Although the consequents of developments in the digital medium call for a change in the technique of representation, the basis is still on “geometry” in digital design, as well as representation. While computational design and representation tools such as parametric design, associative geometry, diagrammatic abstraction, and parametric and numerical representation are all highly complex, Bernard Cache expresses that software programs still depend on the Cartesian coordinate system and Euclidian geometry.[201] Three-dimensional modeling programs such as 3DsMax, Rhinoceros, AutoCAD, MAYA and CATIA all make use of virtual computational grids that are dependent on the “Cartesian grid,” with virtual space again expanded along the X, Y and Z axes. The information is kept and processed according to the coordinates defined with reference to the origin – the ultimate 0, 0, 0 point at the intersection of the three axes, with the Cartesian grid also “visible” in the interfaces of the programs.

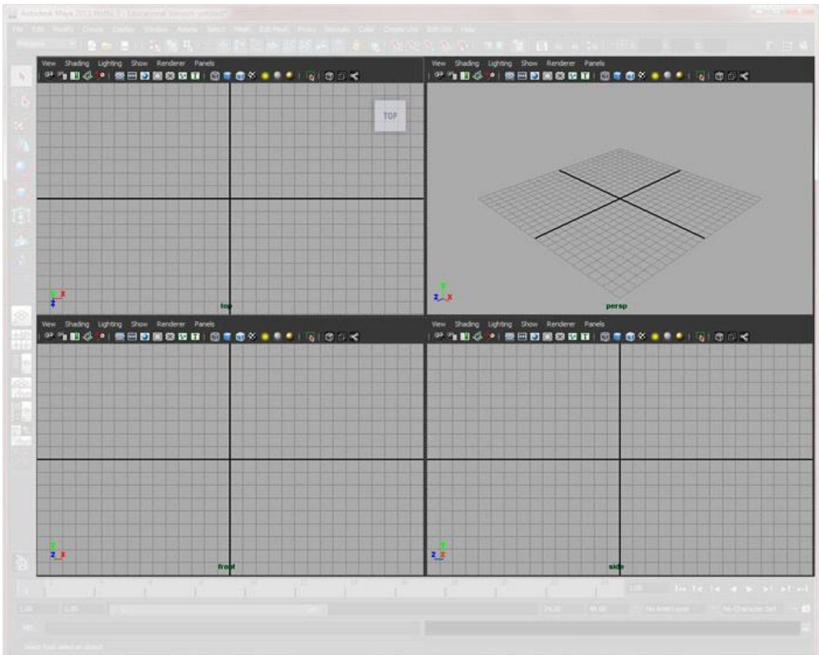

Figure 4.12 Screenshot from Maya.

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201 Bernard Cache. “A Plea for Euclid.” Objectile, 27 Aug. 2011 <http://www.objectile.net>. Cache denotes the dependence of software programs on the Euclidean geometry and the Cartesian system as follows: “Suffice it to say that the twin brother of CATIA was called EUCLID.”

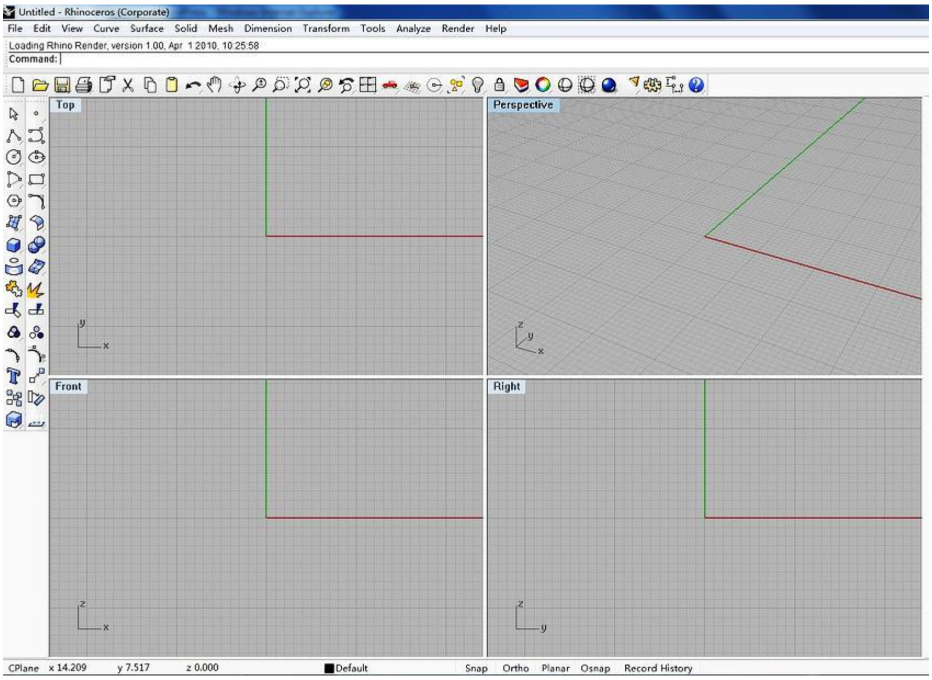


Figure 4.13 Screenshot from Rhino.

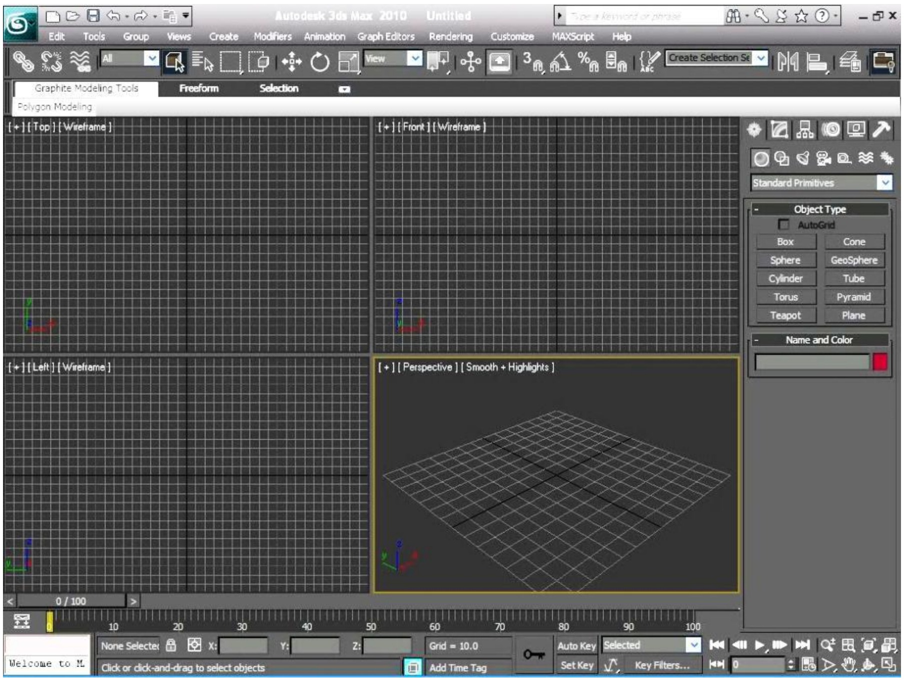


Figure 4.14 Screenshot from 3ds Max.

It is observed that the “grid” is infinite in two-dimensional views; however in “perspective” views the display of the grid encounters a problem, in that it only displays the grid on the XY plane, which works as a base for construction. Actually, if the perspective view is to show and process the model in three dimensions, then it should represent a “lattice” as the result of the intricate reflection of the infinite grids of interdependent views. Paradoxically, the ultimate two-dimensional grid acts as the unifier in an “n” dimensional space. The absence of projection lines alienates the designer, or in digital terms the “user,” from the translation process of references since the instructions are executed by the program automatically through unobservable numerical data processing.

4.2.3. Displaying the “New”: Representing (by) the Surface

The conventional approach to the basic conception of three-dimensional space is also reflected in the way of representation. In many of the three dimensional modeling programs, which are extensively used not only for modeling but also for algorithmic design, animation, and rendering, the conventional organization of orthographic set exists with only slight differences. They provide a top view, a front view and a side view, with the addition of a perspective view, compared to classical architecture’s ground plan, front elevation and axial section. The “projection planes” of the orthographic set are translated into the “interfaces” of digital modeling programs, raising the question of whether it shifts the perception of orthographic projection or strengthens it.

The proposed views depend on a system of orthographic projection as a “way of seeing”. The issue of “facing” is still crucial, since the true position of a point is only observable by looking at it “orthographically”. The fragmented views act as projection planes that are adhered to the surfaces of the object. Although this is not the case, the objects or the parts of an object can be confused because modeling programs do not consider a hierarchy in the representation of lines in respect to their distance from the projection plane. Additionally, since the space is actually, or at least should be, a lattice, meaning that there is an intricate composition of an infinite number of gridded planes expanded in the X, Y and Z directions, the "views" offered complicate rather than simplify the image due to the insistence on the use of the two dimensional grid as the unifier and the referential system of the virtual space. The viewer has to use the viewports interchangeably in such a way that after deciding on the location of a point in three dimensions, to locate it precisely the user may determine the coordinates on the XY plane, and then switch the viewport to one of the side views to specify the missing value in the Z direction.

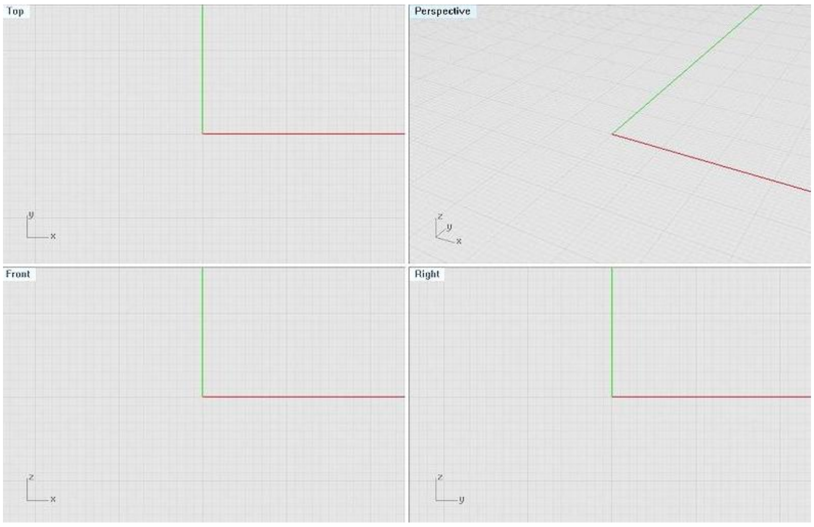


Figure 4.15 Top (XY plane), front (XZ plane), right (YZ plane), and perspective views in Rhino.

The display in the "surface" formation is no mere coincidence, in that most of the 3D modeling programs prefer to models in terms of "surfaces". Although there exists solid modeling opportunities, "surface" modeling is common for a number of different reasons. Working in solid modeling is like sculpting, while surface-based modeling is similar to working with planar materials such as paper, cardboard or wooden plate, with the modeling method selected based on the type of "geometry". For surface modeling, there are two types of geometry used in modeling programs to create three dimensional objects: polygons and NURBS. The users select the appropriate geometry based on what it is they want to model. Both polygon and NURBS surfaces are composed of smaller “faces,” which are triangular in polygons and rectangular in NURBS. While polygons have straight formations, NURBS surfaces eliminates the edge conditions, thus, the notion of straightness becomes irrelevant. Since architecture is about “volume,” designers have remained fascinated by the possibilities of the “surface”. With the NURBS surfaces, the modernist idea of “volume of surface,” which necessitates the volume to be unbroken, is completely utilized in the new system.

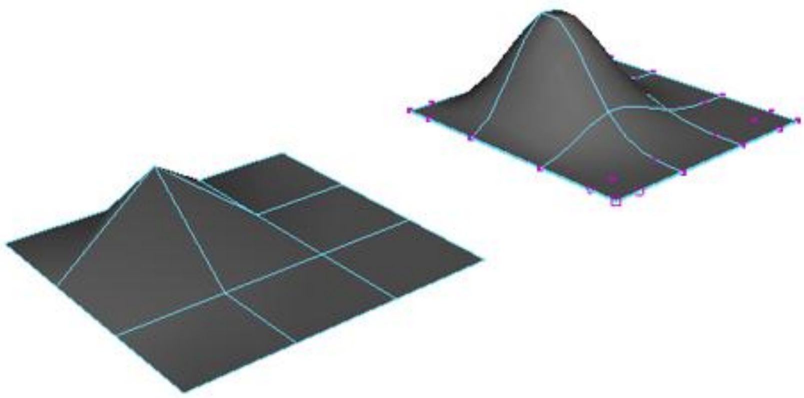


Figure 4.16 Comparison of polygon and NURBS surfaces.
Source: TOI-Pedia. TU Delft. 7 Sep. 2001.
<http://wiki.bk.tudelft.nl/toipedia/Geometry_types#Comparison_between_nurbs_and_polygons>

The definition and behavior of these two surface geometries differ in the “character of points” that actually construct or control them. The definition of “surface” to envelope a volume, thus, the process of defining and creating an object, has been shifted. There are different methods of modeling with surfaces that depend on the selection of different surface geometries; however, the change actually occurs in the treatment of points. Surfaces are either controlled or constructed by points, and the characters of the surface geometries vary as the definition of the “point” varies.

4.2.4. Reco(r)ding the “New”: Points

The process of constructing a soft model in computer-aided design programs differs from the process of obtaining a drawing through projection. Conventionally, an orthographic drawing, or set of drawings, is an outcome of a projective process and implies an “end” in itself. It alludes to a space, but the space is not real since it has yet to be built. If the object to be drawn is required to been seen from another angle, the process has to start all over again, with the “recorded” information “recoded” in the new views via projection lines. In the digital medium, the “user” does not simply draw the views of the object of representation, rather a “soft-model” is constructed in the three-dimensional virtual, yet still Cartesian, space. Information on the forms is “recorded” numerically in a database; and each time an addition or a change is made to the numeric model, the program automatically “recodes” the data retained in the memory and re-visualizes the model by mapping the numerical data onto the screen.

Mapping is possible by locating points in the Cartesian coordinate system, in which any point in space, whether on a three-dimensional form, a plane or a line, can be specified using numerical Cartesian coordinates, with each value indicating the distance of the point to the origin in three dimensions. The distances are actually measured by the “projection line” drawn from the point to the XY, XZ and YZ planes. Simply, while the projection of the point onto the XY plane locates the point on the plane to determine its X and Y coordinates, the length of the “projection line,” which is the distance of the point from the XY plane, actually determines the value of the Z coordinate. The system, while not visualized or expressed by projection, is thus constructed. The system is based on units which are indicated by numbers. The position of a point is not kept or defined by projection, but by “coordinates”. In other words, the programs “record” the information of the “coordinates” of the object, whether generated by a script or modeled by the user, by reducing it into points; and each time the object is translated and transformed it “recodes” the coordinates. The processing, or the system of information, is not only dependent on “points” as the definers of the coordinates for locating and mapping the object, as the “points” are also the “generators” of forms. As stated previously, there are two types of surface geometries that are differentiated by the definitions of “point”.

Polygons are defined by points, which are actually a set of coordinates compiled to define and differentiate objects known as “vertices” that are attached to the surface that envelopes and define a volume or an object. The computer actually works with a point cloud when processing the object. To make the form visible, the program renders a triangular surface between each of the three points, known as "faces." The edges of the faces, in other words the lines that connect the three points and define the faces, are always straight. This does not mean that polygon modeling only allows for orthogonal geometries, as it is also possible to create round geometries, such as a sphere. The defects of straightness do not disappear, as straight lines always remain straight, but the density of vertices enables the surface to become smoother, though never achieving a perfect curvature.

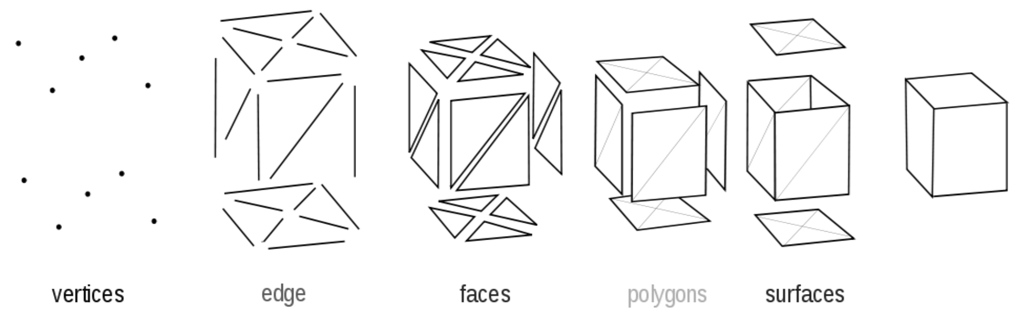


Figure 4.17 Elements of polygonal modeling.
Source: Wikipedia. 10 Sep. 2011 <http://en.wikipedia.org/wiki/File:Mesh_overview.svg>.

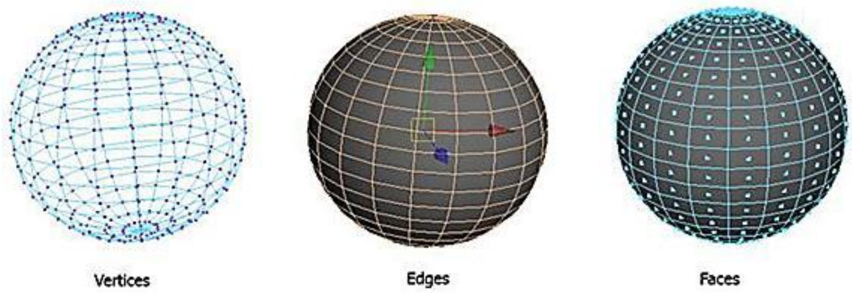
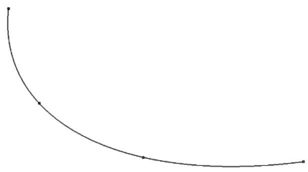


Figure 4.18 Components of a polygon sphere.
Source: TOI-Pedia. TU Delft. 7 Sep. 2011.
<http://wiki.bk.tudelft.nl/mw_toi-pedia/images/8/88/Polygon_components_overview.jpg>.

In NURBS surfaces, on the other hand, points gain another character. They do not act like "vertices" in defining the start and end point of a line, as the points are also assumed to have "weights" that affect the form of the lines and turn them into "curves" by destroying their straightness. The effect is the same for surfaces. This time a grid or net of points controls the form of the surface; with the locations and the weights of the points transforming the end product. The points that generate NURBS surfaces are also referred to as "weights," or more commonly as "control vertices". Aside from where the start and end points of a curve are defined, the control vertices are not necessarily located on the line or the curve itself. In this respect, by drawing a curve with control vertices, one can control the curvature by adjusting the distances between the control vertices and the line, and defining their degree of weight. There also exist points on the curve itself, known as "edit points".



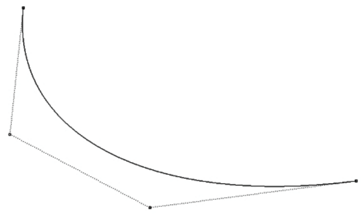


Figure 4.19 (left) Edit points on a NURBS curve.
Source: TOI-Pedia. TU Delft. 7 Sep. 2011 <http://wiki.bk.tudelft.nl/toi-pedia/File:EditPoints_gr.jpg>.
Figure 4.20 (right) Control Points on a NURBS curve.
Source: TOI-Pedia. TU Delft. 7 Sep. 2011 <http://wiki.bk.tudelft.nl/toi-pedia/File:Vertices_gr.jpg>.

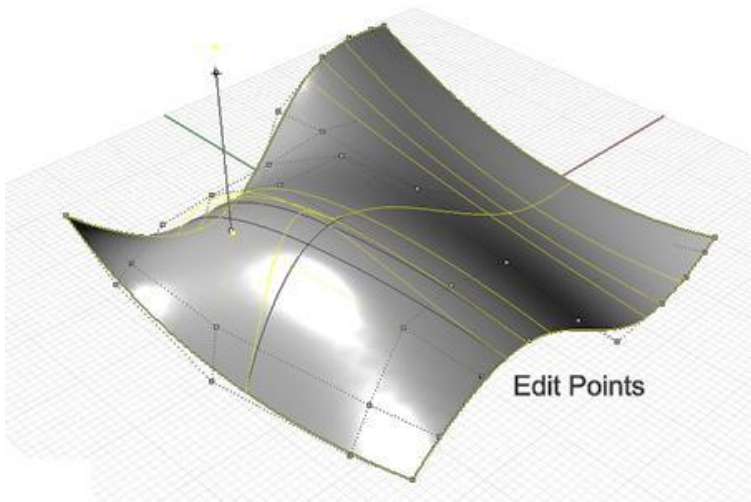


Figure 4.21 The illustration of a NURBS surface – the control vertices are connected by dotted lines and forms the grid of control
Source: TOI-Pedia. TU Delft. 7 Sep. 2011 <http://wiki.bk.tudelft.nl/toi-pedia/File:Editpoints_gr.jpg>

4.3. Digital Form and Production: The Issues of "Topology" and "Non-Standard" in Architecture

Although the advent of digital media has brought a computational approach to processes of design, thus representation (defined in this study as a process of "reco(r)ding, still the use of digital architecture is built upon the notion of "form". Regarding Colquhoun's assessment of architecture as a "private will to form," [202] it is no surprise that the realm of architecture has begun to be influenced by the possibilities of form discovered through computational design processes. Kolarevic claims that through the generative processes of computation, emphasis has shifted from the "making of form" to the "finding of form,"[203] implying that forms are actually "found" as the result of the computational processes. However, computational generation concentrates neither on the subject, as is the case with perspective construction, nor on the object, as with the orthographic set, but on the "process" that will not only represent but also produce the "form". It aims at finding "new ways of thinking," thus "new" ways of designing, representing, seeing and producing rather than merely finding "new forms". Forms are a result of the computational design process, and thus Kolarevic's statement can be revised as the digital age shifts the objective of design from the "making of form" not to the "finding of form" but to the "finding of rationale". Thus, the glorification of complex forms, "found" through the generative processes of computation, can be regarded as a "deception," and what creates this deception is the interest developed around the studies of "topology".

The idealization and realization of architecture had been based on Euclidean geometry, constructed through a definition of five postulates. Bernard Cache, referring to these studies in geometry, states that while the first four postulates defined by Euclid could be recognized as the basis of "absolute geometry," the fifth postulate, dealing with the

[202] Alan Colquhoun. "Symbolic and Literal Aspects of Technology." Essays in Architectural Criticism, 1981: 28.

[203] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age, 2003: 13.

problem of “parallelism,” has been called to question.[204] Cache claims that the “absolute geometry” started to bifurcate, continuing:

> Once this absolute geometry is assumed, you have three options: you can stay within Euclidean geometry and assume that the number of parallels is only one; you can state that there are no parallels which lead to the " elliptic geometry " of Riemann; or, finally, you can postulate that there is more than one parallel, which opens the doors to Lobachevsky's "hyperbolic geometry".[205]

While it was a problem in the definition of the “Parallel Postulate” which differentiated the Euclidean and non-Euclidean geometries, the difference between Euclidean geometry and topology is more than just a matter of the number of postulates that define and differentiate a geometry. Topology deals with properties that do not change under the application of transformations to the object, which not only includes Euclidean transformations such as translation, rotation and reflection, but also modifications such as deformation and stretching. Cache says, the “topology”:

> … enables one to focus on fundamental properties from which our Euclidean intuition is distracted by the metric appearances. Because topology doesn’t register a difference between a cube and a sphere, it focuses on what is left, order and continuity, and makes the difference between the sphere and the torus. But, of course, order and continuity are essential to Euclidean geometry. Euclidean geometry includes topology. Topology is less than Euclidean geometry. Common misunderstandings result from the fact that topology focuses on properties which typically lead to complex interlaced figures, or we would say, which appear all the more difficult to draw since perspective is no longer taught to the general public.[206]

Although digital architecture popularized the term “topology” by appreciating it as the generator of complex forms, it is inferred from Cache’s statements that “topology” not only concerns the “form,” but focuses on the properties of a form and the relations within. It is the abstraction of the “visible” character of form that enables topology to concentrate on the inherent properties. Thus, topology observes the inherent properties of form and searches for possible alterations in the relations of these properties. By

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[204] See, Bernard Cache, “A Plea for Euclid.” Cache states the five postulates of Euclidean geometry and then refers to the studies of Carl Friedrich Gauss, Nikolai Lobachevsky, and János Bolyai which the “Parallel Postulate” has been criticized and proved to be independent from the first four postulates.

[205] Ibid.

[206] Bernard Cache. “A Plea for Euclid.”

abstracting itself from the "visibility," topology manages to discover and create different "visible" outcomes of a system based on the properties and their relations. Although topology, by definition, has no connotations of form, digital architecture caused a "clash" of Euclidean geometry and topology in the generation of complex curvatures. Cache unfolds the misconception of "topology," as a system of generating complex curviliear forms, as follows:

> One single topological structure has an infinity of Euclidean*incarnations*, the variations of which are not relevant for topology, about which topology has nothing to say. New topological structures can be incarnated in Euclidean space as squared figures as well as curved figures. Topology cannot be said to be curved because it precedes any assignment of metrical curvature. Because topological structures are often represented with in some ways indefinite curved surfaces, one might think that topology brings free curvature to architecture, but this is a misunderstanding. When mathematicians draw those kind of free surfaces, they mean to indicate that they do not care about the actual shape in which topology can be incarnated. In so doing, they should open the mind of architects and allow them to think of spatial structures before styling them as either curved or squared. And, of course, as soon as it comes to actually making a geometrical figure out of a topological structure, we enter into Euclidean geometry; that is, the design of complex curvature is essentially Euclidean. One should not think of Euclidean geometry as cubes opposed to the free interlacing of topology.[207]

Regarding Cache's statements, topology can be assessed as being a realm of discovery and creation that focuses on the definition and alteration of the "invisible" properties and relations of a system, which can acquire different "visible" forms. Yet, the visible variations of this system, which would be identified as different forms in Euclidean geometry, remain in the same topological field. Kolarevic underlines the possibilities discovered by topology, explaining that they depend upon topology's severance from the conception of "visibility":

> Instead of modeling an external form, designers articulate an internal generative logic, which then produces, in an automatic fashion, a range of possibilities from which the designer could choose an appropriate formal proposition for further development. The emphasis shifts away from particular forms of expression (*geometry*) to relations (*topology*) that exist between and within the proposed program and an existing site. These interdependences then become the structuring, organizing principle for the generation and transformation of form.[208]

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[207] Bernard Cache. "A Plea for Euclid"

[208] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age, 2003: 13.

From the above explanations it can be deduced that the great achievement of topology has not been in the discovery of form, but in its consideration as a system for the configuration of new compositions of properties and relations that generate visible variations of form that are not considered in Euclidean geometry. Since topology deals with fundamental properties and does not register a difference between a cube, a sphere or even a blob, the form is expanded into "invisibility". As the context of form expanded and redefined it, an infinite number of visibilities of form have been discovered in the realm of invisibility. Yet, what is essential in the utilization of computational generative processes of digital programs is more than just the realization of an infinite number of possibilities of complex and unpredictable forms. In attaining the form, both the processes of design and production gained a "topological" character. Forms discovered through the consideration of topology and generated by computational processes have become producible and reproducible by the same means. This resulted in a "shift" in the definition of the term "standardization".

Bernard Cache, one of the key figures in the development of the contemporary theory of architecture, investigated the use of digital tools and computational techniques for architectural conception and production, introducing the term "non-standard architecture". He explains the meaning of the term as follows: "The architectural project consists of a 'model' with its primary elements varying on the basis of invariant relations between them".[209] In the use of digital software programs, while the form is thought to be "found" as the result of a computation process, Cache says that the "objects are no longer designed but calculated".[210] Since computational processes generate many variations of form, when the designer decides on the final form from among these possibilities, the process of generation comes to an end. Therefore, in such a system the object is, Cache says, "a particular instance on a continuum".[211] In other words, the object is selected from among variations of form generated by the computation. The

[209] Patrick Beaucé and Bernard Cache. Objectile, 2007.

[210] Bernard Cache. Earth Moves: The Furnishing of Territories, 1995: 88.

[211] Bernard Cache. "Towards a Non-Standard Mode of Production." Objectile, 2007: 28.

processes of idealization and representation, defined as imagination and drawing by Evans, have been transformed into processes of generation and selection, and the shift continues to include the means of production. By means of computation, the process of realization, actually building, has been replaced by the processes of manufacturing and assembly, and the concept of “construction” has undergone a shift of meaning into “fabrication”.

As the processes of conception, design and representation has been integrated and controlled by computation, production has become a part of the system. The architectural project becomes “associative” as a result of the interdependent processes, starting from the conception of a design idea and proceeding to the fabrication of the parts of an object or a structure that will be assembled, all of which are entirely controlled by computation. Production becomes numerically controlled, along with the algorithmic generation of form. As the link between conception and production becomes direct, the translational processes, as defined by Evans, between imagination, drawing and building is lost; and the dependence on the modes of representation, as the articulation between the ideal and the real, is challenged. Yet, regarding Damisch, the relationship between architectural conception and its material realization still depends on the modes of production. As the “conception and production are integrated”[212] and controlled by computation, Kolarevic states that “constructability becomes a direct function of computability”.[213]

In this way, the “standard” mode of production becomes “non-standard,” as the necessary process of representation to make the conceptualization of architecture “visible” and “producible” has been abandoned. Architecture has become a continuous process of computation in which the conception, representation and production are in a discontinuous relation. Cache underlines this change in the means of production, and states that, “The image-machine organization is reversed: the design of the object is no

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[212] Ibid. 38.

[213] Branko Kolarevic. “Digital Production.” Architecture in the Digital Age, 2003: 31.

longer subordinated to mechanical geometry; it is the machine that is directly integrated into the technology of a synthesized image".[214]

There are various fabrication techniques that can be driven digitally. Although it is possible to form or transform solids with systems using additive, subtractive and formative fabrication, the production strategies used in architectural projects have been more commonly developed around the fabrication of surfaces, since architecture is about the "volume" and its definers are "surfaces". It can be claimed that architecture's material realization, in this way, is once again reduced to "surfaces," thus, to "two-dimensionality". Kolarevic states that the "rules of constructability" demand the "rationalization of geometry" and explains the different strategies of fabrication according to their way of rationalizing the surfaces in irregular forms:

> The production strategies used for two-dimensional fabrication often include *contouring, triangulation* (or *polygonal tessellation*), use of *ruled, developable surfaces* and *unfolding*. They all involve the extraction of two-dimensional, planar components from geometrically complex surfaces or solids comprising the building's form. The challenge in the two-dimensional interpretation, of course, is to choose an appropriate geometric approximation that will preserve the essential qualities of the initial three-dimensional form.[215]

Among the strategies highlighted by Kolarevic, "contouring" is based on the principle of "sectioning" in orthographic projection. However, the critical positioning of the section loses its importance because the strategy of contouring necessitates a "sequence" of sections positioned at close intervals in order to complete the structural skeleton of the building. Generally, these sections are parallel to each other, yet in some cases the sections do not follow a straight line, remaining parallel but aligned to a curvilinear axis of development. Additionally, in both ways of arrangement, the sequence does not have to follow one direction, as the sections positioned in different directions of alignment may intersect according to the structural system of the building. While the components that are fabricated through contouring can be the main elements configuring the form

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[214] Bernard Cache. Earth Moves: The Furnishing of Territories, 1995: 96-97.

[215] Branko Kolarevic. "Digital Production." Architecture in the Digital Age, 2003: 43.

of the final design in small-scale structures, such as pavilions or installations, they can also be the structural elements of a large-scale architectural design works in which the fabricated elements are covered with surfaces to envelope the volume inside the building. The following examples illustrate two cases in which contouring has been used in the fabrication of structural elements in projects of different scales, where the arrangements of the sequence of sections vary.

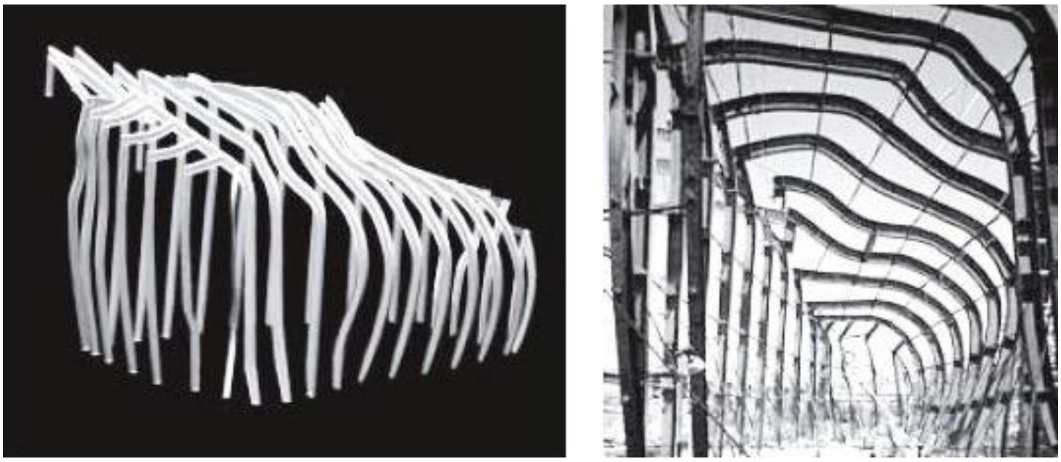

Figure 4.22 a - b Structural frames in Frank Gehry's Experience Music Project (2000) in Seattle
Source: Branko Kolarevic. "Digital Production." Architecture in the Digital Age. Edited by Branko Kolarevic. London and New York: Spon Press, 2003: 42.

Figure 4.23 [C] Space – 'AADRLTen' Pavilion
Source: CORE.FORM-ULA. 12 Sep. 2011 <http://www.core.form-ula.com/2008/04/16/c-space-adrlten-pavilion/>.

Figure 4.24 (top-left) Structural frames of Burnham Pavilion, Chicago, USA, by Zaha Hadid Architects, 2009.
Source: Time Out Chicago. 13 Sep. 2011. <http://timeoutchicago.com/things-to-do/out-about-blog/133452/burnham-pavilions-opensort-of>.

Figure 4.25 (top-right) Membrane-like skin covered upon the structural frames, Burnham Pavilion, Chicago, USA, by Zaha Hadid Architects, 2009.
Source: The Burnham Plan Centennial. 13 Sep. 2011.
<http://burnhamplan100.lib.uchicago.edu/history_future/burnham_pavilions/>

Figure 4.26 (bottom) Burnham Pavilion, Chicago, USA, by Zaha Hadid Architects, 2009.
Source: Zaha Hadid Architects. 13 Sep. 2011.
<http://www.zaha-hadid.com/architecture/burnham-pavillion/>.

After the structural members of the building have been fabricated and the skeleton is erected, the complex curvilinear surfaces that will envelope these elements are either triangulated or transformed into ruled surfaces. The procedure of triangulation, or other tessellations in which the units can be also in the form of different polygons, is simply a division of the surface into triangular units so that the surface turns into a network. This triangulated or tessellated surface in an irregular form is then unfolded and turned into a flat plane. The linear elements dividing the network and the triangular or polygonal areas remaining within these elements are fabricated from flat sheets of preferred materials according to their structural condition in the system.

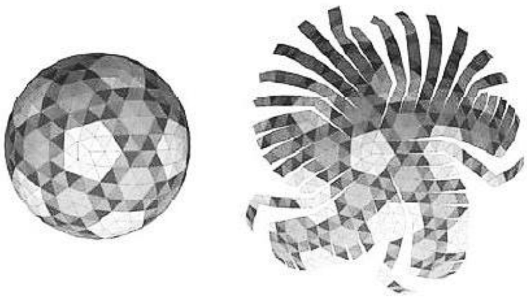

Figure 4.27 The unfolding of a triangulated sphere
Source: Peter Szalapaj. Contemporary Architecture and the Digital Design Process. Amsterdam; Boston: Architectural Press, 2005.

Figure 4.28 The triangulated surface of the British Museum Great Court
Photographed by the author.

The transformation of complex curvilinear surfaces into ruled surfaces is a process that suggests the surface is composed of curves, repeated regularly in one direction, and straight lines that extend in this direction to combine each pair of curves. Afterwards, while the curves can become primary structural elements, the lines that connect these curved elements become secondary structural elements. The above-mentioned strategy of contouring can be used in the fabrication of these elements. When it comes to the production of the ruled-surface, the surface is unfolded into a flat sheet, as in the method of triangulation. The “developed” surface is then fabricated, which is the same system used in the production of “development” drawings of cones or cylinders by means of orthographic projection.

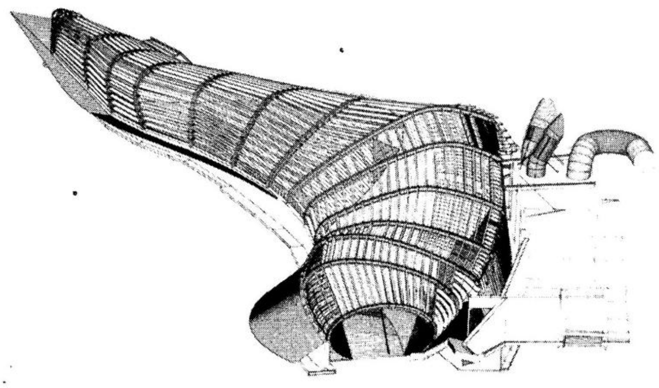

Figure 4.29 The use of ruled surfaces in HtwoOexpo, Lars Spuybroek / NOX Architects
Source: Branko Kolarevic. “Digital Production.” Architecture in the Digital Age, 2003: 47.

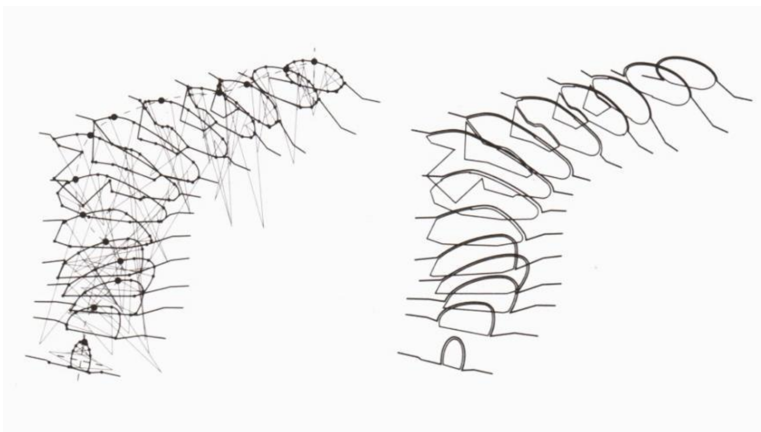

Figure 4.30 Sequence of structural frames in HtwoOexpo, Lars Spuybroek / NOX Architects
Source: Lars Spuybroek. NOX: Machining Architecture. New York: Thames&Hudson, 2004:22.

Figure 4.31 Structural frame of HtwoOexpo, primary curved frames and secondary straight beams, Lars Spuybroek/NOX Architects
Source: Ibid. 23.

Figure 4.32 HtwoOexpo by Lars Spuybroek/NOX Architects
Source: Branko Kolarevic. "Digital Production." Architecture in the Digital Age, 2003: 47.

The production strategies used in the fabrication of elements that form the “digital architecture” is based on the reduction of these elements into two-dimensional entities; while the “rationalization of geometry” is still enabled by means of orthographic projection. Although the plan as the “generator” and the elevation as the “face” of architecture is questioned in the processes of design and production, the section gained importance and became both the generator and the structure of the form. Yet, the plan has not been totally lost. Since the irregular and deformed surfaces of the envelope are fabricated after the production of the “development” of these surfaces, the digital data that is sent to the fabrication machine is actually the development drawings, or rather, the “unfolded plan drawings” of these surfaces. The “rationalization of geometry” still depends on the “surfaces” and “two-dimensionality.” Although the conventional orthographic set is deconstructed, the means of orthographic projection is still the basis of architectural production.

CHAPTER 5

CONCLUSION:
THE DECEPTION OF THE DIGITAL MEDIA

Although the intrusion of computers into the studios of architectural schools is generally described as being due to the increase in the "complexity of form," besides the visible outcomes, the result has actually been a change in the thinking processes of design. The origins of this change can be found in the concerns that emerged from the relationship between design and the discipline of science. Nigel Cross states that the emerging concerns in the discipline of design started with "a search for scientific products" in the 1920s, and re-emerged in the 1960s with "a concern of scientific design process".[216] He claims that the "desire to scientise design" originated from the ideas of the twentieth century Modern Movement in design. The new spirit of the age evolved around the concept of *Sachlichkeit*. The famous expression of the house by Le Corbusier as "a machine for living" reflects his conception, being "objectively designed" according to the functional requirements. Not only architects, but even modern painters have expressed the need for a new spirit. For Theo van Doesburg:

> Our epoch is hostile to every subjective speculation in art, science, technology, etc. The new spirit, which already governs almost all modern life, is opposed to animal spontaneity, to nature's domination, to artistic flummery. In order to construct a new object we need a method, that is to say, an objective system.[217]

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[216] Nigel Cross. "Designerly Ways of Knowing: Design Discipline versus Design Science." Design Issues, vol.17, no. 3, Summer 2001: 49-55.

[217] Theo van Doesburg, "Towards a Collective Construction" De Stijl 1923 as quoted by Gillian Naylor, The Bauhaus reassessed: sources and design theory, London: Studio Vista, 1968.

The desire to produce a new architecture is based on the premises of “objectivity and rationality,” which for Cross is “on the values of science”.[218] The demands of Modern Architecture influenced not only the products of design, but also the “act of design” itself. The search for objectively designed products has turned into a search for the objectification of the design process, which came to be recognized as the “design methods movement”[219] in the 1960s. Various structured approaches to “scientise” design process have been suggested by studies in design methodology.[220] There are stated definitions and elaborations of the design process, with a number of methods and techniques offered for utilization in the process that have a common characteristic of prescribing a set of tasks to be performed by the designer. Studies are directed to configure and identify design methodologies that are based on reasoning. Within the formalized representation of design, these descriptive models principally avoid becoming prescriptions used for the execution of design activities, rather aiming to provide a ground for creativity. Over the years, many systems for the analysis and description of design processes and certain generation methods have been developed, however criticisms of these models have raised interest in the fundamentals of design theory, logical form and the status of design. The discipline of design has shifted into the conception of the “science of design”.[221]

The more the discipline of architecture has become aware of the potentials of the computer, the more attention has focused on the “design of the process”. Architects are actively involved in the processes of scripting, thus production as well as the system of

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[218] Nigel Cross. “Designerly Ways of Knowing: Design Discipline versus Design Science.” 2001: 49.

[219] Ibid.

[220] See, John Chris Jones. Design Methods. London: Wiley Interscience. 1970; Design Methods in Architecture. Ed. by Geoffrey Broadbent and AnthonyWard, New York: Wittenborn Inc.. 1969; Developments in Design Methodology. Ed by Nigel Cross, Wiley, Chichester. 1984; Christopher Alexander. Notes on the Synthesis of Form. Cambridge, Mass.: Harvard University Press. 1964; Donald Schön. The Reflective Practitioner. London: Temple-Smith, 1983; Herbert A. Simon. The Sciences of the Artificial. Cambridge, Mass.: The MIT Press. 1969.

[221] Nigel Cross. “Designerly Ways of Knowing: Design Discipline versus Design Science.” 2001.

production, and go beyond the theoretical configuration of design methodologies. Design processes abandoned theoretical models and came under the control of scripts, algorithms, algebraic equations and functions. The desire to achieve "objective" products through an "objective" system of design has been fully realized with the advent of digital media.

As the emerging conception of design has shifted emphasis from the production of the object to the design of the process, new approaches have expanded the design thinking processes and formal conceptions of space, surface and point in design, introducing a new environment for creativity. The more the thinking processes have been elaborated, the more the boundaries between architecture and its representation have become blurred. Kolarevic states that "designers articulate an internal logic" with the aid of digital media, as a "generative tool for the derivation of form and its transformation,"[222] identifying this "shift" in the processes of thinking as a "digital morphogenesis". The demarcation between design, representation and production is erased by the destruction of "projection," which is no longer necessary for "translation" because there remains no "distanciation" between processes. In other words, the representation and the product have been imposed to a process of "morphosis" as a result of "fusion". Thus, the hierarchical procedures of representation have been displaced by the inevitable occurrence of "non-linearity," and while the form has been assumed to be about "geometry," its inherent "topology" has gained importance.[223] Contemporary architectural design is labeled as an "integrated design process" that challenges the "conventions such as stable design conceptualization and monotonic reasoning". [224] The "determinism" of conventional practice has shifted to a new creativity, one that is controlled by algorithmic thinking processes and associative models. This new realm of

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[222] Branko Kolarevic. "Digital Morphogenesis," Architecture in the Digital Age, 2003: 13.

[223] Branko Kolarevic. "Digital Morphogenesis and Computational Architectures." Cumulative Index of Computer Aided Architectural Design. 22 Aug. 2011. <http://cumincades.scix.net/data/works/att/fbc9.content.pdf>: 23-25.

[224] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age, 2003: 27.

creativity is based on the infinitely many possibilities that are generated by computation. Since the process of generation does not necessarily have to follow a determinate process, the new realm of creativity is also enhanced by the possibilities of "randomness"[225] and "indeterminacy".[226] Therefore, Kolarevic says, the designer has become an "editor"[227] of "emergence". The emphasis on the creation of an internal generative logic, which is computed by algorithmic procedures, parameters and relations, has enabled the production of a "flexible" and "functional" system.

It is possible to claim that what triggered architecture and the emerging methods of representation and production was the everlasting desire for the "new" and the ultimate search for "objectivity," both of which have periodically redefined the tendencies and products of architecture and affected its "visibility". Representation has become the realm of the practice itself – recording the desires for the "new" and the searches for "objectivity". By projecting these ideals into reality, representation has given architecture its visibility, and thus, recalling Evans, architecture has become reliant on its images to be built. The advent of the orthographic set can thus be interpreted as the very moment at which architecture and its representation began to construct direct links to achieve a "visibility".

The orthographic set aimed to provide a space for "objective representation," because it was to be used for making things, and is used in architecture to lead the process of building. To make representation objective, this started with the elimination of the consideration of an observing "subject". In the absence of a subject or the act of seeing, the object becomes abstracted from vision; so to reconstruct its relations with "visibility" the "projection lines," Evans says, are employed to relate the representation

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[225] Kristina Shea. "Directed Randomness." Digital Tectonics, 2004: 89-101.

[226] Branko Kolarevic. "Towards Non-Linearity and Indeterminacy in Design." Cognition and Computation in Digital Design. The University of Sydney Faculty of Architecture, Design Computing Cognition'04. 19 Aug. 2011 <http://www.arch.usyd.edu.au/kcdc/conferences/dcc04/workshops/workshopnotes6.pdf>

[227] Branko Kolarevic. "Digital Morphogenesis." Architecture in the Digital Age, 2003: 26.

to its material reality. These "invisible lines" are responsible for preserving and transmitting the information of the object to be produced. Since the technique of orthographic projection is utilized in two dimensions, it reduces the object to be conceived into a composition of "surfaces," and thus the object is abstracted into two-dimensionality. The orthographic set brought together the "surfaces" of this dissected object to provide a collective image. By definition, technique was about two dimensions in which the "invisible lines" could relate the two-dimensional drawings on the surface of the drawing. However, these invisible lines of orthographic projection have constructed "virtual surfaces," as defined by Evans, to achieve a "knowledge" of the object to be produced in three dimensions. These "virtual surfaces" enabled Dürer to understand the shape of the inclined arch of the fortification wall before he built it, and Francesca to derive the plan of the human head and draw its elevations and perspective views. The "surface" was not only a tool for preserving the shape and size of the object to be produced, but also a medium for rationalizing the geometry.

This relation between representation and production has become powerful in affecting the "form" of architecture. The orthographic set, and orthographic projection as a technique, has been re-interpreted not only as a means of producing the architectural object, but also designing it. Modern Architecture has become the paradigm of the orthographic set and materialized its visibility; and the "objectivity" inherent in the technique of representation has evolved into the "style" of the "new". By abstracting the object from its context, Modern Architecture desired to achieve the "new" by adapting the "objective representation" as its way of designing. The relationship between architecture and its representation has been challenged as representation has become more than a mere intermediary process in its construction, and turned into its generator. The two-dimensionality of orthographic projection has influenced Modern Architecture, leading it to be constructed by "surfaces". By adapting the "surface," as the definer of the "volume," Modern Architecture has redefined the architectural form as a rationalization of geometry. Inevitably, Modern Architecture has materialized according to its "surfaces," and the "representation of visibility" has turned into a "stylization of materiality".

With the use of digital media in architecture, the processes of design, the conception of space, the representation and production by "surface" and the definer of the object have started to change, while the level of abstraction has also increased. The process of translation was visible in orthographic projection through the visualization of the "invisible projection lines," however this process has been reduced entirely to "invisibility". The "invisible" process of computing has become the thinking process, modeling process, representation process, and even the production process – there remains no distinction, since the spaces of translation have disappeared with the elimination of projection. Thinking, design, representation and production have all been reduced into an "invisible orthography," i.e. have been derived by a "script," actually a programming language which is numerically controlled. The "virtual surfaces" constructed in orthographic projection have been totally transferred to a "virtual dimension"[228]. As the conception of "dimension" has blurred, the "surface" has expanded beyond two dimensions, yet the modernist idea of the surface as the definer of "form" and "volume" still remains. Considerations of "topology" have stripped the object from its form and enabled the designer to focus on the "invisible" relations and rules that will generate the form. As the form is abstracted into the relations and rules that will define them by topology, the "conventional" boundaries of form have disappeared. The "orthogonality," or in other words, the necessity of the 90 degree angle between the projection lines and the projection plane to preserve the "true shape" of the object, has been questioned. The notions of front, back, top, bottom and side have disappeared, and the "90 degrees" that influenced Modern Architecture in becoming a style through the rationalization of geometry and enabled it to produce "objective products," has been destructed. Although it remains as the definer of the "volume" and "form," the "surface" is no longer the medium that represents the "objectness" of the object to be produced.

[228] The Virtual Dimension: Architecture, Representation, and Crash Culture. Ed. by John Beckman, New York: Princeton Architectural Press, 1998.

Yet, software programs construct their interfaces upon the “conventional” fragmentation of the frames of the orthographic set, and replace “projection lines” with a homogenous infinite “grid” to create “references” in the “virtual dimension”. Consequently, the referential surfaces defined by the “grid” lost prominence, while the “point” gained importance and became the generator and controller of the “surface” that defines the object. The object has been abstracted to “non-dimensionality” through being mapped into points that are numerically controlled and represented; while the “grid” has become the representation of the Cartesian space that inhabits and determines the positions of these points in an “objective space”. However, the ultimate representation of the “objective space” in axonometric projection has become dynamic and literally infinite, and the geometry of the object does not have to be described by two planes that are perpendicular to each other, as claimed by Monge. The object is mapped into the space and becomes “visible” through its points and the rendering of the areas within these points by surfaces. As opposed to “Piero’s heads,” the points do not have to follow the shape of the object, as the object rather has to be shaped according to the points. The reduction into “non-dimensionality,” thus “invisibility” enables digital media to separate the process of “creation” from the contingencies of the technique of projection, the form of representation and the three-dimensionality of the space, expanding beyond mere dimensions. This non-dimensionality has projected the digital media into the “n-dimensionality”.

However, when the process of production starts, the “surface” is still required. Since the modernist idea of “architecture as volume” is never surpassed and the “surface” is still its definer, the fabrication strategies used in architectural production have been developed around the fabrication of “surfaces”. Although the whole process of fabrication is controlled numerically, these fabrication techniques can produce planar elements to be assembled to construct the whole building, and the means of orthographic projection are used to transform the complex curvilinear surfaces generated by computation into planar surfaces. In other words, architecture is still reduced to two-dimensionality and is thus reduced to its “surfaces”; and orthographic projection is still the means of rationalizing the geometry in two-dimensions. From this perspective it can be claimed that the production of architecture is still based on orthographic projection.

The relationship between representation and production has been firmly defined in Modern Architecture because to achieve "standardization," the object, its representation technique and its means of production have to be in perfect accord. Modern Architecture achieved this by adapting the means of representation as its means of design and production. However, in the digital media, the technique of representation, the form of the object and the means of production are not dependent on each other, but all are controlled by computation. This means that representation techniques and the means of production are not reciprocal, but are rather entirely committed to the processes of computation. By breaking the link between the form, representation and production, and controlling them through an "invisible script," the processes of production has been re-defined; the "producibility" and "reproducibility" has become indifferent; and the term "standard" has shifted. Attempts at so-called standardization in Modern Architecture to produce "objectively designed end products" have moved on from "stereotyping" and evolved into "standardization," as defined by Cache, and into a "non-standard mode of production" that allows variety in the generation of forms and relations. Although Kolarevic stated that "constructability becomes a direct function of computability" and the necessity of "representation" for the translation of an idea into a material reality is abandoned, the material realization of architecture is still produced by translating it into a composition of its "surfaces"; and the "producibility" of the "surfaces" is still dependent on the rationalization of their geometry in two-dimensions by means of orthographic projection.

This study challenges the prejudices against the "orthographic set" that suggest it is an ineffective or insufficient tool for representation in contemporary architectural practice that as a result of the advent of "digitization". It claims that the "orthographic set" is actually a methodology in architectural production that is still powerful in the representation of the "rational" thinking processes of design; and remains as a highly relevant technique, a "convention," that contains "objectivity" right from its constitution. The term "convention" is understood here in its most basic definition, without the mystification of the visual traditions of architecture. The deception of the digital media can be overcome by looking into its essence, which lies in the "invisible orthography" that generates the "new visible" rather than the "visible" outcomes, which are, arguably, accorded superiority over the products of the "conventions". Although it no longer seems to be what makes architecture visible, the orthographic set, labeled critically as a "convention," is still inherent in the representation and production of architecture in the digital age.

Therefore, is it possible to say that the ultimate "objectivity" has been achieved? Has the desire for an "international architecture" in its total abstraction finally been acquired? Has the everlasting attempt to create the "new" become irrelevant, since it is not the "conventions" of representation that produce architecture any longer, but rather the infinite number of possibilities that are achieved through computing already provide "unique instances" of a process of creation? Has the modernist idea of the "volume of surfaces" been produced exactly according to the principle of "architecture as volume"? Is it no longer necessary to be "concerned with the regularity," since the form is entirely controlled and generated by points that are determined through the execution of scripts? Does the form no longer need to be stripped from the ornament, as the form itself has actually become an "ornament" that is merely a rendering of the areas between generated points? Is it the "invisibility" that now makes architecture visible?

REFERENCES

Ackerman, James. Origins, Imitation, Conventions: Representation in the Visual Arts. Cambridge, Mass., and London: The MIT Press, 2002.

_______. "Style." Distance Points: Essays in Theory and Renaissance Art and Architecture. Cambridge Mass.: The MIT Press, 1991: 3-22.

_______. "Architectural Practice in the Italian Renaissance." Distance Points: Essays in Theory and Renaissance Art and Architecture. Cambridge Mass.: The MIT Press, 1991: 361-384. Firs published in JSAH vol. 13, no.3, October 1954: 3-11.

Agrest, Diana. "Representation as Articulation Between Theory and Practice." Practice: Architecture, Technique, and Representation / essays by Stan Allen; commentary by Diana Agrest. Australia : G+B Arts International, 2000: 163-177.

Akın, Ömer. Psychology of Architectural Design. London: Pion Limited, 1986.

Alberti, Leon Battista. Delineation of the City of Rome / *Descriptio urbis Romae*, Medieval and Renaissance Texts and Studies, vol 335, Edited by Mario Carpo and Francesco Furlan, critical edition by Jean-Yves Boriaud and Francesco Furlan, English translation by Peter Hicks. Tempe, Arizona: Arizona Center for Medieval and Renaissance Studies, 2007.

Alexander, Christopher. Notes on the Synthesis of Form. Cambridge, Mass.: Harvard University Press. 1964.

Alkan, Alper Semih. "Framing the "Invisible": Section as a Spatial Frame for a Reconsideration of Architectural Representation." Master's Thesis, METU, 2004.

Allen, Stan. Practice: Architecture, Technique, and Representation. Commentary by Diana Agrest. Australia: G+B Arts International, 2000.

Andersen, Kristi. The Geometry of an Art: The History of the Mathematical Theory of Perspective from Alberti to Monge. New York and London: Springer, 2007.

Anderson, Stanford. “Architecture and Tradition that isn’t ‘Trad, Dad’.” Marcus Whiffen ed., The History, Theory and Criticism of Architecture. Cambridge Mass, 1965: 71-89.

A+U, Special Issue “Visions of the Real: Modern Houses in the 20th Century: I,” March 2000.

Baltanas, Jose. Walking through Le Corbusier: A Tour of His Masterworks. London: Thames & Hudson, 2006.

Banham, Reyner. “Conclusion: Functionalism and Technology.” Theory and Design in the First Machine Age. Cambridge, Mass.: The MIT Press, 1992: 320-330.

Beaucé, Patrick, and Cache, Bernard. Objectile : Fast-Wood: A Brouillon Project, Wien: Springer Wien, 2007.

Beckman, John, ed. The Virtual Dimension: Architecture, Representation, and Crash Culture. New York: Princeton Architectural Press, 1998.

Behne, Adolf. *Der Moderne Zweckbau* / The Modern Functional Building. Introduction by Rosemarie Haag Bletter, trans. Michael Robinson. Santa Monica, CA: Getty Research Institute for the History of Art and the Humanities, 1996.

Benevolo, Leonardo. History of Modern Architecture. 2 vols. Cambridge, Mass.: The MIT Press, 1971.

Bertol, Daniela. “Architecture of Images: An Investigation of Architectural Representation and the Visual Perception of Three-Dimensional Space.” Leonardo Vol.29 No.2, 1996: 87-94.

Bletter, Rosemarie Haag. “Introduction” to *Der Moderne Zweckbau* / The Modern Functional Building. Adolf Behne, trans. Michael Robinson. Santa Monica, CA: Getty Research Institute for the History of Art and the Humanities, 1996: 1-83.

Bloomer, Jennifer. “Vertex and Vortex: A Tectonics of Section.” Perspecta vol. 23, 1987: 38-53.

Boesiger, Willy, Storonov, Oscar G., Le Corbusier [pseud.] *et* Pierre Jeanneret, *Œuvre complète de* 1910-1929. Zurich: Girsberger, 1960.

Broadbent, Geoffrey and Ward, Anthony, ed. Design Methods in Architecture. New York: Wittenborn Inc.. 1969.

Bois, Yves-Alain. “Metamorphosis of Axonometry.” Daidalos, 1981: 40-58.

Booker, Peter Jeffrey. A History of Engineering Drawing. London: Chatto & Windus, 1963.

Cache, Bernard. Earth Moves: The Furnishing of Territories. Trans. Anne Boyman, ed. Michael Speaks. Cambrdige, Mass.: The MIT Press, 1995.

_______. “A Plea for Euclid.” Objectile. <http://www.objectile.net>. Last accessed in August 2011.

Carpo, Mario and Lemerle, Frédérique, ed. Perspective, Projections and Design: Technologies of Architectural Representation. New York: Routledge, 2007.

Carpo, Mario and Lemerle, Frédérique. “Introduction” Perspective, Projections, and Design: Technologies of Architectural Representation. Ed. Mario Carpo and Frédrique Lemerle. New York: Routledge. 2007: 1-17.

Carpo, Mario. “Alberti’s Media Lab.” Perspective, Projections and Design: Technologies of Architectural Representation, 2007: 47-63.

Colquhoun, Alan. “Introduction: Modern Architecture and Historicity.” Essays in Architectural Criticism: Modern Architecture and Historical Change. Preface by Kenneth Frampton. Cambridge, Mass.: The MIT Press, 1981: 11-19.

_______. “The Modern Movement in Architecture.” Essays in Architectural Criticism: Modern Architecture and Historical Change. Cambridge, Mass.: The MIT Press, 1981: 21-30.

_______. “Symbolic and Literal Aspects of Technology.” Essays in Architectural Criticism: Modern Architecture and Historical Change. Cambridge, Mass.: The MIT Press, 1981: 26-30.

_______. “Displacement of Concepts in Le Corbusier.” Essays in Architectural Criticism: Modern Architecture and Historical Change. Cambridge, Mass.: The MIT Press, 1981: 51-66.

_______. “Rules, Realism, and History.” Essays in Architectural Criticism: Modern Architecture and Historical Change. Cambridge, Mass.: The MIT Press, 1981: 67-74.

CORE.FORM-ULA: <http://www.core.form-ula.com/2008/04/16/c-space-adrlten-pavilion/>. Last accessed in September 2011.

Cross, Nigel. “Designerly Ways of Knowing: Design Discipline versus Design Science.” Design Issues, vol.17 no. 3 Summer, 2001: 49-55.

_______. ed. Developments in Design Methodology. Wiley, Chichester. 1984.

D’Amico, Robert. Historicism and Knowledge. New York: Routledge, Chapman and Hall Inc., 1989: ix-xiv.

Damisch, Hubert. “Anything But?” Anything. ed. Cynthia C. Davidson. New York: Anyone Corporation. 2001: 249-54.

Doesburg, Theo van. "Towards a Collective Construction" De Stijl 1923 as quoted by Gillian Naylor, The Bauhaus Reassessed: Sources and Design Theory, London: Studio Vista, 1968.

Dubbeldam, Winka, Snooks, Roland, and Kolatan, Ferda, comp. New Normal: Post-Professional @ Penn Design 2010-2011.

Duster, David. Key Buildings of the Twentieth Century. London: Architectural Press, 1985.

École Polytechnique Fédérale De Lausanne, Laboratoires de Théorie et D'Historie: a pdf publication entitled “LE CORBUSIER, La petite maison, Corseaux, Suisse, 1923-1924.” <http://ltha.epfl.ch/enseignement_lth/theorie/exemples_th1/reg_irreg_1/M_01_Le_Corbusier_Petite_maison_du_Lac/CORBU_TH1_Petite_Maison_Du_Lac_mise_en_page.pdf> Last accessed in September 2011.

Evans, Robin. “Translations from Drawing to Building.” Translations from Drawing to Building and Other Essays. Cambridge, Mass.: The MIT Press, 1997: 153-193. First published in AA Files 12, Summer 1986: 3-18.

_______. “Mies van der Rohe’s Paradoxical Symmetries” Translations from Drawing to Building and Other Essays. Cambridge, Mass.: The MIT Press, 1997: 233-276.

_______. The Projective Cast: Architecture and Its Three Geometries. Cambridge, Mass.: The MIT Press, 1995.

_______. “When the Vanishing Point Disappears,” AA Files 23, 1992: 3-18.

_______. “Architectural Projection,” Architecture and Its Image: Four Centuries of Architectural Representation: Works from the Collection of the Canadian Centre for Architecture. Eve Blau; Edward Kaufman; Robin Evans; *Centre Canadien d'architecture*.; et al. Montreal: *Centre Canadien d'Architecture*/Canadian Centre for Architecture ; Cambridge, Mass.: Distributed by the MIT Press, 1989: 19-35.

Ford, Edward R.. The Details of Modern Architecture. vol2 with the subtitle 1928-1988, Cambridge, Mass.: The MIT Press, 1990.

Gans, Deborah. Le Corbusier Guide. Princeton, NJ: Princeton Architectural Press, 1987.

Goldhagen, Sarah Williams. “Something to Talk About: Modernism, Discourse, Style.” JSAH vol. 64 June 2005: 144-167.

Goldhagen, Sarah Williams, and Legault, Réjean, eds. “Introduction: Critical Themes of Postwar Modernism.” Anxious Modernisms: Experimentation in Postwar Architectural Culture. Cambridge, Mass.: The MIT Press, 2000: 11-23.

Gombrich, E. H. “Norm and Form: The Stylistic Categories of Art History and Their Origins in Renaissance Ideals.” Norm and Form: Studies in Art of the Renessaince 1, Chicago: University of Chicago Press, 1966: 81-98.

_______. “Style.” The Art of Art History: A Critical Anthology. ed. Donald Preziosi. Oxford: Oxford University Press, 1998: 150-63.

Hays, K. Michael. “Critical Architecture: Between Culture and Form.” Perspecta, 11, 1981: 14-29.

Hewitt, Mark. “Representational Forms and Modes of Conception: An Approach to the History of Architectural Drawing,” Journal of Architectural Education vol. 39, no. 2, Winter 1995: 2-9.

Heynen, Hilde. Architecture and Modernity: A Critique. Cambridge, Mass.: The MIT Press, 1999.

Hitchcock, Henry Russell and Johnson, Philip. The International Style. New York: Norton, 1966.

Institut für Auslandsbeziehungen. <http://www.ifa.de/en/exhibitions/exhibitions-abroad/architecture/neues bauen-international-1927-2002/ detached -houses-and-villas/> Last accessed in September 2011.

Jameson, Frederic. "Postmodernism and Consumer Society." The Cultural Turn: Selected Writings on the Postmodern. 1983-1998. New York: Verso, 1998: 1-20.

Jenks, Charles. "The Death of Modern Architecture." The Language of Post-modern Architecture, 3rd enlarged and revised edition London: Academy Editions, 1978: 9-54.

Jones, John Chris. Design Methods. London: Wiley Interscience. 1970.

Jordy, William H.. "The Symbolic Essence of Modern European Architecture of the Twenties and Its Continuing Influence." JSAH vol. 22 October 1963: 177-187.

Kolarevic, Branko. "Digital Morphogenesis." Architecture in the Digital Age: Design and Manufacturing. Ed. Branko Kolarevic. London and New York: Spon Press, 2003: 11-28.

_______. "Digital Production." Architecture in the Digital Age: Design and Manufacturing. Ed. Branko Kolarevic. London and New York: Spon Press, 2003: 29-54.

_______. "Digital Morphogenesis and Computational Architectures," Cumulative Index of Computer Aided Architectural Design: <http://cumincades.scix.net/data/works/att/fbc9.content.pdf>. Last accessed in August 2011.

_______. "Towards Non-Linearity and Indeterminacy in Design." Cognition and Computation in Digital Design. The University of Sydney Faculty of Architecture, Design Computing Cognition'04: <http://www.arch.usyd.edu.au/kcdc/conferences/dcc04/workshops/workshopnotes6.pdf>. Last accessed in August 2011.

Krauss, Rosalind. "Grids." October 9, Summer 1979. Reprinted in Rosalind Krauss. The Originality of the Avant-Garde and Other Modernist Myths. Cambridge, MA: The MIT Press, 1985: 9-22.

Kuhn, Thomas S. The Structure of Scientific Revolutions. 2nd Ed., Chicago, 1970, originally published in 1962**.**

Leach, Neil, Turnbull, David, and Williams, Chris, eds. Digital Tectonics. Chichester, West Sussex, U.K.; Hoboken, NJ: Wiley-Academy, 2004.

Le Corbusier [pseud.]. *Une Petite Maison* 1923. Basel; Boston; Berlin: Birkhäuser - Publishers for Architecture, 1954.

_______. *Vers Une Architecture* / Toward An Architecture, Introduction by Jean-Louis Cohen, trans. John Goodman. Los Angeles, Calif.: Getty Research Institute, 2007.

Le Corbusier le grand. London: Phaidon, 2008.

Lotz, Wolfgang. “*Das Raumbild in der Architekturzeichnung der italienischen Renaissance*”, *Mitteilungen des Kunsthistorischen Instituts in Florenz*, 1956, 7, 193-226. Republished in Wolfgang Lotz. “The Rendering of the Interior in Architectural Drawings of the Renaissance.” Studies in Italian Renaissance Architecture. Cambridge Mass.: The MIT Press, 1977: 1-65.

McQuaid, Matilda. “Acquiring Architecture: Building a Modern Collection,” Envisioning Architecture: Drawings from The Museum of Modern Art. Ed. Matilda McQuaid, with an Introduction by Terrence Riley. New York : Museum of Modern Art ; London : Thames & Hudson, 2002: 18-37.

Online Etymology Dictionary. <http://www.etymonline.com/index.php?search=orthography&searchmode=none>. Last accessed in September 2011.

Panofsky, Erwin. Life and Art of Albrecht Dürer. Princeton, NJ: Princeton University Press. 1945 and subsequent editions.

Pieffer, Jeanne. “Constructing Perspective in Sixteenth-Century Nuremberg,” Perspective, Projections, and Design. Ed. Mario Carpo and Frédrique Lemerle. New York: Routledge. 2007: 65-75.

Pérez- Gómez, Alberto and Pelletier, Louise. Architectural Representation and the Perspective Hinge. Cambridge, Mass.: The MIT Press, 1997.

_______. "Architectural Representation Beyond Perspectivism." Perspecta vol.207, 1992: 20-39.

Pérez -Gómez, Alberto. Architecture and the Crisis of Modern Science. Cambridge, Mass.: The MIT Press, 1983.

Portoghesi, Paolo. Postmodern, the Architecture of the Post-Industrial Society. New York: Rizzoli, 1982: 7-13.

Riley, Terrence. "Drawn into a Collection: A Context of Practices" Envisioning Architecture: Drawings from The Museum of Modern Art. Ed. Matilda McQuaid, with an Introduction by Terrence Riley. New York : Museum of Modern Art ; London : Thames & Hudson, 2002: 10-17.

Rowe, Colin. "The Mathematics of the Ideal Villa" in *Mathematics of the Ideal Villa and Other Essays.* Cambridge, MA: MIT Press, 1976, 1–27. First published as "The Mathematics of the Ideal Villa: Palladio and Le Corbusier Compared." Architectural Review 101, March 1947.

Savaş, Ayşen. "Reconstructing the White Wall," METU Plastic Arts Exbition Catalogue, Ayşen Savaş (ed), November 2007, pp.11-23.

_______. "Architecture and Its Image*: Notes on Representation and the Autonomy of Architecture III" *(Mimarlık ve O'nun İmgesi*: Temsil ve Mimarinin Özerkliği Üzerine Notlar III),* Tol Mimarlık Kültürü Dergisi, 2004.

_______. "Notes on Depth and Architectural Representation." A presentation at the Hacettepe University, 14 January 2002.

_______. "Linea Mentis: Definition of the Term "Façade" in Architecture" *(Linea Mentis: Mimarlıkta Cephenin Tanımı)* Terminology Problems in Art History Symposium. Ankara: The British Culture Institute, November 2001, pp.143-152

_______. "Vanishing Point of Architecture," ArchiSchope, vol.2, October-November, 1998, pp. 52-54.

_______. "Shallow Spaces," ArchiScope, vol.1, September, 1998, pp 84-86.

Schapiro, Meyer. “Style.” The Art of Art History: A Critical Anthology, ed. Donald Preziosi. Oxford: Oxford University Press, 1998: 143-149.

Schön, Donald. The Reflective Practitioner. London: Temple-Smith, 1983.

Simon, Herbert A.. The Sciences of the Artificial. Cambridge, Mass.: The MIT Press. 1969.

Spuybroek, Lars. NOX: Machining Architecture. New York: Thames&Hudson, 2004.

Szalapaj, Peter. Contemporary Architecture and the Digital Design Process. Amsterdam; Boston: Architectural Press, 2005.

The Oxford English Dictionary. Oxford: Clarendon Press, 1989.

TOI-Pedia. TU Delft. <http://wiki.bk.tudelft.nl/toi-pedia/Main_Page> Last accessed in September 2011.

Uluslararası Yeni Yapı Sanatı 1927 | 2002. TMMOB Ankara, 2006.

Vidler, Anthony. “Diagrams of Diagrams: Architectural Abstraction and Modern Representation” Representations. University of California Press No.72, Autumn 2000: 1-20.

Villa “Le Lac” Le Corbusier. <http://www.villalelac.ch/>. Last accessed in September 2011.

Vogt Adolf, Max. Trans. Radka Donnell. Le Corbusier, The Noble Savage: Toward an Archeology of Modernism. Cambridge, Mass.: The MIT Press, 1998.

Wigley, Mark. White Walls, Designer Dresses: The Fashioning of Modern Architecture. Cambridge, Mass.: The MIT Press, 1995.

_______. “Paper, Scissors, Blur” in The Activist Drawing: Retracing Situationist Architectures from Constant's New Babylon to Beyond Ed. Catherine de Zegher and Mark Wigley, New York: Drawing Center and Cambridge, Mass.: The MIT Press, 2001: 27-56.

Wölfflin, Heinrich. “Principles of Art History.” The Art of Art History: A Critical Anthology, ed. Donald Preziosi. Oxford: Oxford University Press, 1998: 115-126.