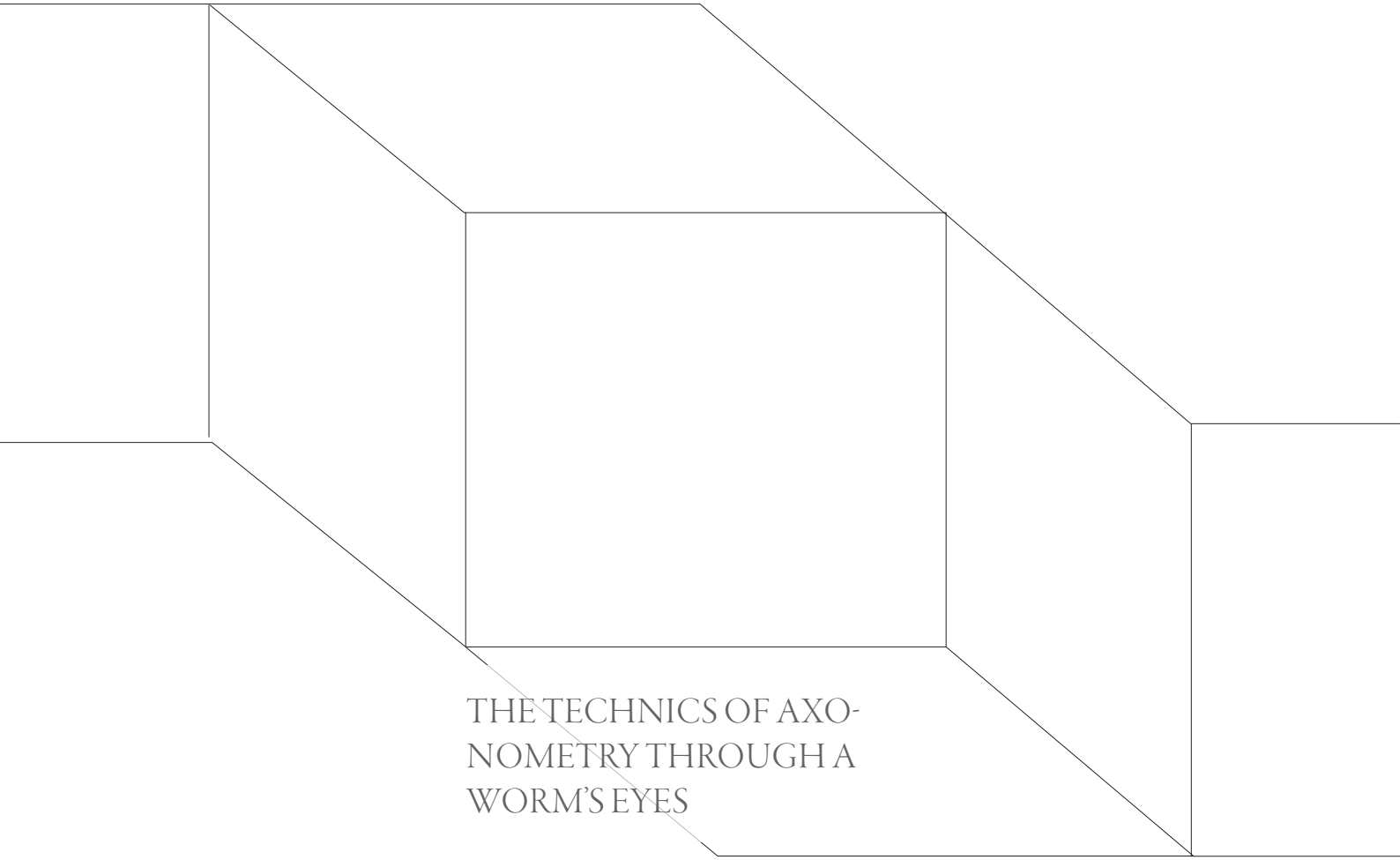

THE TECHNICS OF AXONOMETRY THROUGH A WORM'S EYES

An enquiry into the state and potential of architectural representation in the post-orthographic age

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Abstract

This paper is an investigation into the role axonometry holds in architectural representation. As Stan Allen describes, there is something pervasive in how axonometries can be filtered though literally any kind of reference – this essay is an attempt to trace them back in history to their origins. In order to reveal the ideas they stem from, worm's eye axonometric case studies are analysed, a projection which is said to be closest to architectural thought.

Working with the axiom that the technics of production are definitive of the cognitive framework of the architectural process, concepts such as orthography, post-orthography, pseudo-orthography, and the kind of time and space axonometries are being conceived in are of central importance. The aim of the paper is to raise awareness of the technological framework of contemporary architectural labour, and to suggest different modes of practice through the analysis of the effect of technics on the intervening mediums of architecture.

A closer look at the history of axonometry reveals how intertwined it is with our conception of space; in this regard, the virtual space of computers can be seen as the continuation of the space of descriptive geometry in the enlightement. A greater awareness and appropriation of digital technics, however, is indispensable for the success of the discipline: internally, adapting architecture's representational conventions could lead to less time wasted and thus better working conditions, while externally, a better engagement with the virtual is needed to regain its spatial-sociological agency.

CONTENTS

Introduction

– The surge of axonometric?
– Yeah, well, we use axonometric, but it has become somewhat cliché.[1]

Indeed, if someone starts paying attention, axonometries are everywhere in architectural circles, – from the Biennale (Fig.0.0.1) through magazine covers (Fig.0.0.2) to every second student project – and they cannot be escaped. If someone has a second look, they can also observe the great variance of references these axonometries operate with, including, but not limited to, abstract art, popular culture, or the history of the discipline. What ties them together is an awareness of image culture – axonometries are often the front pieces of a project, competeing for attention. Curiously, they stem from completely different attitudes towards virtual space and distribution: some embraces a digital aesthetic, while others evoke the pre-digital origins of the projection.

Such ambivalency can be seen as a symtom of the profession's struggles to come to terms with "a transformation in the nature of visuality probably more profound than the break that separates medieval imagery from Renaissance perspective."[2] This paper investigates the reorganisation of the architectural process by "post-orthographic" mediums, which have displaced architecture's historically embedded forms of representation. As such, it operates with technical definitions of labour, with the underlying premise that architects, never directly working on the subject of their thought, are producers of negotiating artifacts, not buildings.[3]

In order to be able to prioritise technics over the mode of representation and the ideas conveyed (without completely neglecting them), a single type of mediator, the worm's eye axonometry will be analysed throughout the paper. Widely attributed to Auguste Choisy, the worm's eye is a returning trope since its inception to the present (Fig.0.0.3); often described as a hermetic drawing ("from architects, to architects"[4]), I believe it is revelatory of architectural thinking, especially with regard to different conceptions of the space in which the design process takes place. Through an analyis of different worm's eyes, this thesis aims to raise awareness of the role of technics, with special attention to the shift of architectural production to virtual models and simulated mediators; to untangle the logic of such operations, revealing their potentials and idiosyncracies, and to examine the effect of different technical approaches on the design process.

1 Conversation between Fabrizio Gallanti (interviewer) and Michael Meredith of MOS Architects, 2021. Drawing Matter, https://drawingmatter.org/pan-scroll-zoom-mos/

Fig.0.0.1 MOS, *House, No. 4, A Situation Aggregated from Loose and Overlapping Social and Architectural Aggregates,* 2016, screenshot, presented in the US pavilion at the 15th Venice Architecture Biennale. https://assets.mosnyc/sites/default/files/styles/optimize/public/2016-08/Detroit_Axon08_Summer_LowRes.jpg

2 Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*, (Cambridge, MA.: MIT Press, 1992), 1

3 Robin Evans, *Translations from Drawing to Building and Other Essays* (London: Architectural Association, 1997), 156

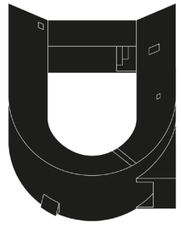


Fig.0.0.2 Michele Marchetti, *Front Cover, San Rocco 0, 'Innocence'*, printed digital axonometry, 2010. https://snrcc.s3.amazonaws.com/new_website/shop_item/image/26/SR0.jpg

4 Bruno Reichlin, "Reflections – Interrelations between Concept, Representation, and Built Architecture", *Daidalos* 1 (Berlin: Bertelsmann, 1981), 72

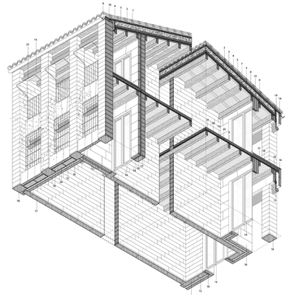


Fig.0.0.3 IBAVI Arquitectes *Social Housing in Mallorca, Spain,* construction axonometric view, in *El Croquis* no. 219, 2023, 86

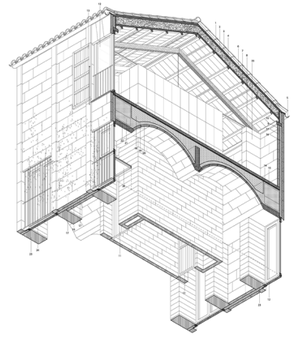


Fig.0.0.4 IBAVI Arquitectes *Social Housing in Mallorca, Spain,* construction axonometric view, in *El Croquis* no. 219, 2023 129

Methodology and research questions

The method of analysis is underpinned by two main secondary sources, *Signal. Image. Architecture* by John May, and *Translations from Drawing to Building* by Robin Evans; these works will be introduced in greater detail in order to define a solid theoretical framework for later investigations, followed by an overview of architectural representation in the age of orthography.

The primary sources of research are various types of worm's eye axonometries, – drawings, paintings, vector images, screenshots, etc. – treated as autonomous objects for analysis: what values do they have as translational devices? What technical processes shaped them, and how labour-intensive were they?

The first chapter establishes the origins of the worm's eye view, and outlines how axonometry became part of the modern architect's toolkit, following its path to the Bauhaus. What created the demand for axonometry, and what were the mathematical-philosophical advancements that enabled its emergence in western architecture? Why is the work of Auguste Choisy seen as the culmination of this process?

From this point onwards, the linearity of historic time is broken, echoing the rupture of modernism; later chapters are thematically arranged instead, as a quasi-simulation of different post-orthographic technics.

Chapter two is concerned with Stan Allen, whose working methods are well-documented, and reflected on by himself. How has he reproduced Choisy mechanically, and what is the process in current practice, using CAD? Here, pre-digital examples of Eisenman and El Lissitzky will be used to visualise the transformations ocurring in virtual space now.

The paintings in chapter three are worm's eyes inspired more so by abstract art than the need for rational objectiviy: what are the aesthetic qualities of the worm's eye, what are its origins in art, and how are these references enhancing the capacities of axonometry?

Chapter four touches on education, and the different attitudes towards representation and technics. How are worm's eyes used to explain projects, and what is their relationship with the models they stem from? What is the place of Choisy in the training of future architects?

By answeing these questions, the paper does not argue neither for or against any particular technics or form of representation; rather, it aims to highlight the potential of each approach, helping professionals, including myself, decide on what path to embark on.

Theoretical Framework

The technics of architecture

It is May 2022, and I find myself burning the midnight oil in studio, accompanied by a set of fineliners and an A1 roll of tracing paper, working on the final set of drawings for my bachelor's graduation project. The decision to execute the project by hand worked wonderfully during the design process, as I drew up a new iteration week by week, with ever-increasing detail and resolution. Admittedly, I burned out using the computer during a previous group assignment, where I took on the role of "CAD-monkey"; yet, as the deadline was approaching, I realised pressing ctrl+P in a continuously progressed file is not an option – the final set needs to be drawn from scratch (Fig.0.1.1).

This little anecdote may sound banal, but for me it highlighted the issue with the general attitude towards the shift of architectural production to the computer: "It was not that the art of drawing by hand with pencil and brush had been replaced, but rather that it was supplemented by another eye-to-hand dextrous drawing skill using keyboard and mouse"[5] – or, in short "the architect simply had a new drawing tool". Sure, it is faster – but when the quantitative time difference is a full working need to five minutes, it raises the question whether the time spent on the process is qualitatively different.

In *Signal. Image. Architecture.,* John May distinguishes between the historic time and real time of (architectural) production, which for him constitutes this difference. Underpinning these notions of time are axioms derived from Bernard Stiegler's *Technics and Time* volumes, and its central thesis which claims that "Technics, far from being merely in time, properly constitutes time."[6] Presuming that life is lived through means other than life, by the means of technical organs (objects), and that these are tied to the deepest region of our consciousness, John May argues that thinking is inseparable from the technical means of its production,[7] and that the use of such technical organs constitutes the time spent externalising thought – which is qualitatively different between distinct technical ages.[8]

For a long time, architecture's workings consisted of hand-mechanical gestures; and although new tools gradually made the process more efficient (think of the ruler or the compass), architectural labour took place in historic time – that being the linear conception of a present, which stems from a past, and precedes a future,[9] where a newer drawing supersedes its previous iteration, retracing it over and over. In this notion is embedded the concept of *precedent*, (prior work that is built upon), which has historically always been paramount to the operations of the profession. The time spent re-drawing existing projects is also the time of analysis, of understanding, establishing architecture intimate relationship with its own history.[10]

Walter Benjamin in the seminal essay *The Work of Art in the Age of Mechanical Reproduction* highligths the effects that the speed of labour means for artistic production; however, the advancements he witnessed come nowhere near that of computation, which allows for instantaneous (or at least faster than human perception) simulations of postorhthographic outputs, and I can only wonder how he would have reflected on it. John May calls this condition *real time*, which "continuously relates the present to all possible futures at once"[11]. A CAD file is not a digital drawing board, but a running analyis of all possibilities: perspective views, plan diagrams, the backdrop of augmented reality – the list is endless. These potential future states are experienced as being simultaneously present; it seems that we have traded our historical consciousness for the ability to simulate thinking itself in cyberspace.[12]

Architectural translations

The most illustrative example of how computational technics changed not only the production, but also the reasoning of architecture may be building information modelling. BIM objects are data-infused entities which, on top of the geometry of the object, also contain non-spatial properties of the design; data of performance, of efficiency, which is then used to justify architectural form.[13] These so-called "digital twins" also facilitate the technological-managerial mind's wish for absolute control, and by assuming a 1-to-1 correspondance between themselves and the final building, they aim to eliminate any ambiguity.[14]

As Robin Evans observes in *Translations from Drawing to Building,* architects, unlike artist, never work directly on the subject of their thoughts – they are producers of mediating artifacts instead.[15] Discussing the potential in the hinge between representation and building, he emphasies the communicative, translative properties of the intervening mediums of architecture. He believes that their real power lies in their difference to what is being represented, rather than their likeness; that their disembodied properties of abstraction and mediation are enabling the imagination of the architectural mind, and thus are the birthplace of unexpected results, of innovation.[16] On the other hand, simulations in virtual space – such as BIM – are giving birth to the illusion that architects are now directly working on the subject of their thoughts, eliminating the need for any translation.

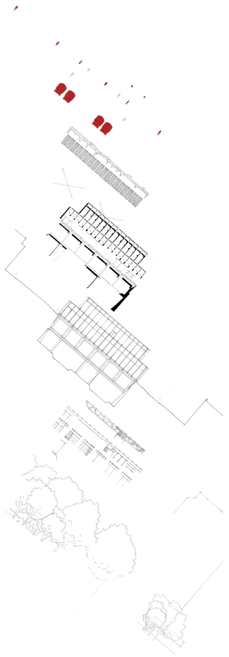


Fig.0.1.1 Bálint Kerekes, *Deconstructed elevation*, pen drawings scanned and edited in Photoshop, 2022

5 Neil Bingham, *100 Years of Architectural Drawing: 1900-2000.* (London: Laurence King Publishing, 2013), 238.

6 Brian Stiegler, *Technics and Time 1* (Stanford, CA: Stanford University Press, 1998), *27*

7 John May, *Signal. Image. Architecture.* (New York, NY: Columbia Books on Architecture and the City, 2019), 38

8 Ibid, 39

9 Ibid, 69

10 Ibid, 69

11 Ibid, 83

12 Ibid, 97

13 Ibid, 85

14 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 3

15 Robin Evans, *Translations from Drawing to Building and Other Essays* (London: Architectural Association, 1997), 156

16 Ibid, 160

We now see the danger the real time of cyberspace presents to architecture: Imported tools and technics are displacing architecture's own, historically embedded methods and conventions, suspending the profession in this state of breathless amateurism,[17] losing agency over their processes and work: if the imported tools reflective of a managerial-technical approach are taken for granted, the profession gives up on the creative potential that lies in the difference, the translation, the approximation.[18]

If we accept that architecture is brought into existence by its representation, it is the production of the mediating artefacts, not the buildings, which needs to be analysed in order to reflect on architectural thinking. And in order to investigate the translational properties of architectural representation, an awareness of the underlying technics is indispensable – it does not only establish the cognitive framework of design operations, but the creative interpretation and use of available tools presents the very opportunity to explore the generative potential of representation.

Yet, the technics of representation are concealed by discussions on its visual qualities. Evans talks about architectural drawings as a general term for three-dimensional objects (buildings) projected onto two-dimensional surfaces through conventions of the discipline (plan, perspective, axonometry)[19]. Writing in 1986, at the verge of the digital revolution (the first version of AutoCAD was released in 1982)[20], he did not feel the need to distinguish between different mediums, as long as the conventions of translation are the same. However, disregarding the technics of representation is dismissive of the fact that the conventions of drawing are rooted in the original technics of their production, mechanical delineation – or architectural orthography.[21]

A brief history of architectural orthography

Although drawings are certainly the devices most often associated with architectural representation, it has not always been the case; in fact, architectural drawings were very rare before the renaissance.[22] In medieval times, architecture was more of a constructive practice, where the 'design' and 'execution' phases were not separated the same way we think of them now. Instead, design issues were solved during construction, as the problems arised, and in many case through (structural) mock-ups.[23] The rich layering of different styles, characteristic of most gothic churches, also highlights the lack of a comprehensive representation of the building before construction.

17 John May, "Field Notes From 'The Instruments Project,'" *Journal of Architectural Education* 69, no. 1 (2015): 59

18 Robin Evans, *Translations from Drawing to Building and Other Essays* (London: Architectural Association, 1997), 160

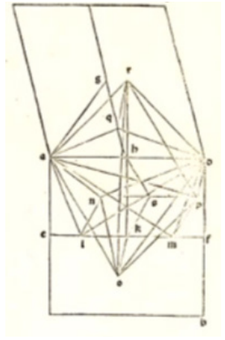


Fig.0.1.2 Erhardus Ratdolt, *illustration of Preclarissimus liber elementorum Euclidis perspicassimi: in artem geometrie incipit ...*, in Erhardus Ratdolt, *World of book* (Venice, 1482)

19 Ibid, 157

20 John May, *Signal. Image. Architecture.* (New York, NY: Columbia Books on Architecture and the City, 2019), 81

21 Ibid, 33

22 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 8

23 Ibid, 9

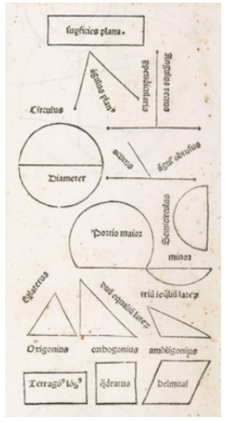


Fig.0.1.3 Erhardus Ratdolt, *illustration of Preclarissimus liber elementorum Euclidis perspicassimi: in artem geometrie incipit ...*, in Erhardus Ratdolt, *World of book* (Venice, 1482)

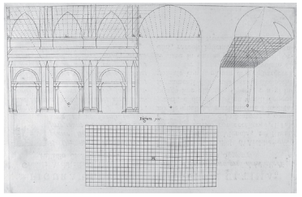


Fig.0.1.4 Andrea Pozzo, *Diagram explaining the quadratura method*, in Andrea Pozzo, *Perspectiva pictorum et architectorum* (Rome: Typis Joannes Jacobi Komarek Bohemi, 1693-1700)

24 Ibid, 3

25 Noam Andrews, "From Delineation to Drawing" (Berlage Sessions, Delft, November 25, 2022).

26 John May, *Signal. Image. Architecture.* (New York, NY: Columbia Books on Architecture and the City, 2019), 61

27 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 148

28 Ibid, 149

29 Ibid, 149

30 Ibid, 150

31 Ibid, 148

It is not until the Renaissance, when architecture started to be considered a liberal art, that drawings were considered autonomous devices for communication, and that ideas were conveyed though geometric shapes on paper.[24] The re-discovery of seminal ancient texts, Euclid's *Optics*, and (famously) Vitruvius' *De Architectura* provided the mathematical and architectural backgrounds, respectively. The original texts, however, were not illustrated themselves – it was the renaissance masters who, after studying the text, illustrated them according to their interpretation of the content, making them a lot easier to understand (Fig.0.1.2)[25]. This highlights the role of the architect as an *orthographer* - that is, someone who arranges linear marks both into writing (through the conventions of language), and into drawings (following established disciplinary conventions)(Fig.0.1.3) [26].It is important to note that the latter category transcends the much more narrow concept of *orthographic projection* in architecture, and refers to the wider set of rules encompassing scales, line types, symbols, and many other aspects alongside projections.

Vitruvius' treatise stressed the analytical function of of architectural drawing: the proportions of the various temple layouts and different column orders were communicated with plans and elevations – two-dimensional drawings, which preserve ratios. Vitruvius distinguished a third type of drawing as well: the perspective, which became quintessential in the renaissance (Fig.0.1.4). Its single viewpoint, which emphasises the role of the observer, aiming to replicate human perception, was in line with the humanist philosophy of the age and dominated spatial representation both in art and in architecture.[27]

As established earlier, the operations of orthography take place in historic time, and thus adhere to tradition; indeed, the theoretical works of Renaissance masters built upon Vitruvius, gradually establishing the conventions for the graphic devices of architecture. The *Letter to Leo X*, written in 1519 and generally ascribed to Raphael, introduced the section,[28] while Alberti prescribed in *De Re Aedificatoria* that the orthogonal views shall be drawn and presented on separate sheets.[29] Although Palladio's *Four Books on Architecture*, published in 1570, reinforced the idea of autonomous projections, their interrelations in geometric terms were apparent to architects, which sparked the ambition to synthesise the different views.[30] However, architects did not succeed in theorising the relationship between plan, section and elevation, for they were unable to conceive infinity due to the contradiction inherent in perspective: "the vanishing point was supposed to represent infinity; but infinity cannot be represented, for only god is infinite".[31] The tradition of history was simply too strong, and could only be broken by the scientific mindset of enlightement.

I The Emergence of Axonometry

Geometry and architecture in the enlightenment

Some contemporary accounts define axonometry as a special case of perspective, where the converging points are postulated at infinity[32] – a way of thinking which reveals how quasi-axonometries were produced pre-enlightenment, either by drawing a small object, or an object from afar. The first case opens up a connection between model and axonometry, a view explored by Massimo Scolari in Oblique Drawing: A History of Anti-perspective, for which the quest for drawing platonic solids, often via precise measurements of scale models may be the best example of.[33] Meanwhile, the bird's eye sketches of Leonardo, or the details in Codex Coner are fine instances of the latter (Fig.1.0.1); yet, it is a drawing of St Peter's by Baldassare Peruzzi, which, according to Yve-Alain Bois, "...expresses a desire for synthetic representation of architectural space which would not be seen again in the history of architectural drawing until Choisy" (Fig.1.0.2).[34] These drawings, which exist outside the realm of clearly defined projections, already suggests the ability of axonometry to provide an image of the whole building in one drawing, showing the interrelations of various spaces and structures. Nonetheless, other Italian architects were not keen on adopting the style, due to a belief that perspective is inherently artistic, and should never be used to provide measurements.

The demand for a drawing which explains complex geometries in space while providing measurements as well came from military architecture; with the advancements of ballistics, the design of fortifications became a rather scientific discipline, and the architects and engineers working in the fields realised the advantages of parallel projection.[36] Several publications from the field suggest an intent for sharing the method with 'civil' architects as well; still, the general breakthrough had to wait until the mathematical background was established, enabling architects to break away from the perceptual accuracy of perspective for the objectivity of axonometry.

The establishment of descriptive geometry is generally attributed to Gaspard Monge, who essentially functionalised Eucledian geometry by reducing it to algebraic functions (Fig.1.0.3).[37] His *Géométrie Descriptive,* published in 1789, is considered to be the first synthetic and systematized methodology for the execution of geometric projections – meaning that it could be applied regardless of the specifities of the represented object.[38] The importance of descriptive geometry on architectural representation cannot be understated; it did not simply provide a handbook for

32 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 8

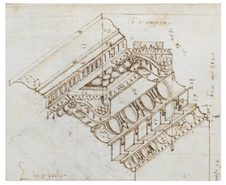


Fig.1.0.1 Unknown Florentine carpenter, *detailed drawing of the Arch of Constantine*, in Codex Coner, 16th century. https://www.facebook.com/SirJohnSoanesMuseum/photos/a.101507842049 89512/10157390355544512/?type=3

33 Noam Andrews, "From Delineation to Drawing" (Berlage Sessions, Delft, November 25, 2022).

34 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 150

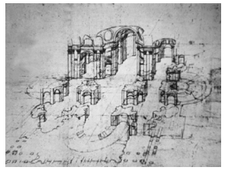


Fig.1.0.2 Baldassare Peruzzi, *Perspectival "section" of St. Peter's in Rome*, (1520-35), in Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 311.

35 Ibid, 151

36 Ibid, 152

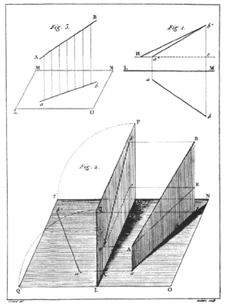


Fig.1.0.3 Gaspard Monge, *Diagram of projection*, 1811, in Gaspard Monge, *Géométrie Descriptive* (Paris, 1811), 13.

37 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 305

38 Ibid, 304

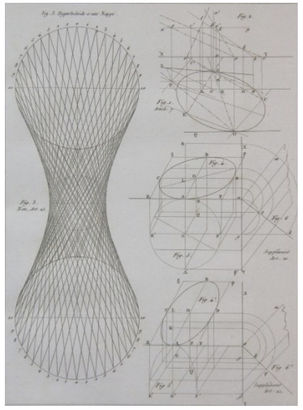


Fig.1.0.4 Gaspard Monge, *Diagram of projection*, 1811, in Gaspard Monge, *Géométrie Descriptive* (Paris, 1811), 17.

39 Ibid, 298

40 Ibid, 4

41 Ibid, 3

42 Ibid, 3

43 Ibid, 4

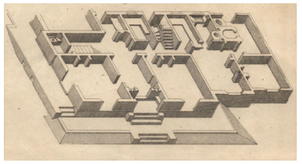


Fig.1.0.5 Joseph Jopling, *Isometry of a plan*, 1835, in Joseph Jopling, *The Practice of Isometrical Perspective* (London: M. Taylor, 1835)

44 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 152

45 Ibid, 152

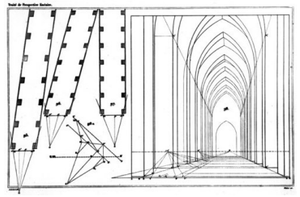


Fig.1.0.6 Jules de la Gournerie, *One-point perspective distortion analysis*, 1859, in Christopher Tyler, "A Horopter for Two-Point Perspective" (Proceedings of SPIE - The International Society for Optical Engineering 5666, 2005), 5

execution, but essentially moved the entire operation to a qualitatively different space. Infinite, homogenous and unitised, Mongue's objectified matrix is where axonometry historically resides (Fig.1.0.4) – but first, it had to be introduced to architectural thinking.

It was Jacques-Nicolas-Louis Durand who first used descriptive geometry as a *modus operandi*; sharing Monge's drive for the aquisition of objective truth, he fully relied on the mathematical principles of projection.[40] These projections operate through "reductive syntactic connections":[41] edges and contours are obtained by projecting the intersections of parallel rays with the object onto a plane. Mongue's geometricised space allowed him to aim for an objective representation of the whole, which is not without challenges – as each projection conveys the represented object only in part, it is their combination which is expected to form an unambiguous, complete transcription.[42] His *Mechanisme de la Composition*, which involved the precise analysis and characterisation of building elements, indicates a shift from the representation of appearance to the representation of the objective, measurable qualities of artifacts; this reductive approach forms the basis of modern architectural representation.[43]

Durand became Professor of Architecture at Ecole Polytechnique in 1795, introducing the technological worldview of the 19th century to architecture; indeed, over the next decades, architects became a lot more susceptible to publications challenging the primacy of perspective than before. *On Isometrical Perspective* by William Farish (1820), and *The Practice of Isometrical Perspective* by Joseph Jopling (1835) (Fig.1.0.5) were the first treatises dedicated entirely to axonometry;[44] Jopling was an architect himself, which indicated that the profession started adopting the projection. In the second half of the century, more than 50 texts dealing with axonometry were published in German territory alone,[45] proving that by this time, both the conceptual and technical knowledge to employ axonometry were known by architects: it just took one of them to fully embrace the method for it to become widely spread and accepted.

Auguste Choisy: objectivity in Eucledian space

Throughout the history of architecture, there are types of drawings that became simultaneous with a certain architect. Auguste Choisy and the worm's eye axonometry is a prime example of this phenomenon; architects keep referring to his oeuvre when using a similar projection – sometimes even using his name to define the *Choisy-style* axonometry, as we will see. He was definitely a pioneer of axonometry in the 19th

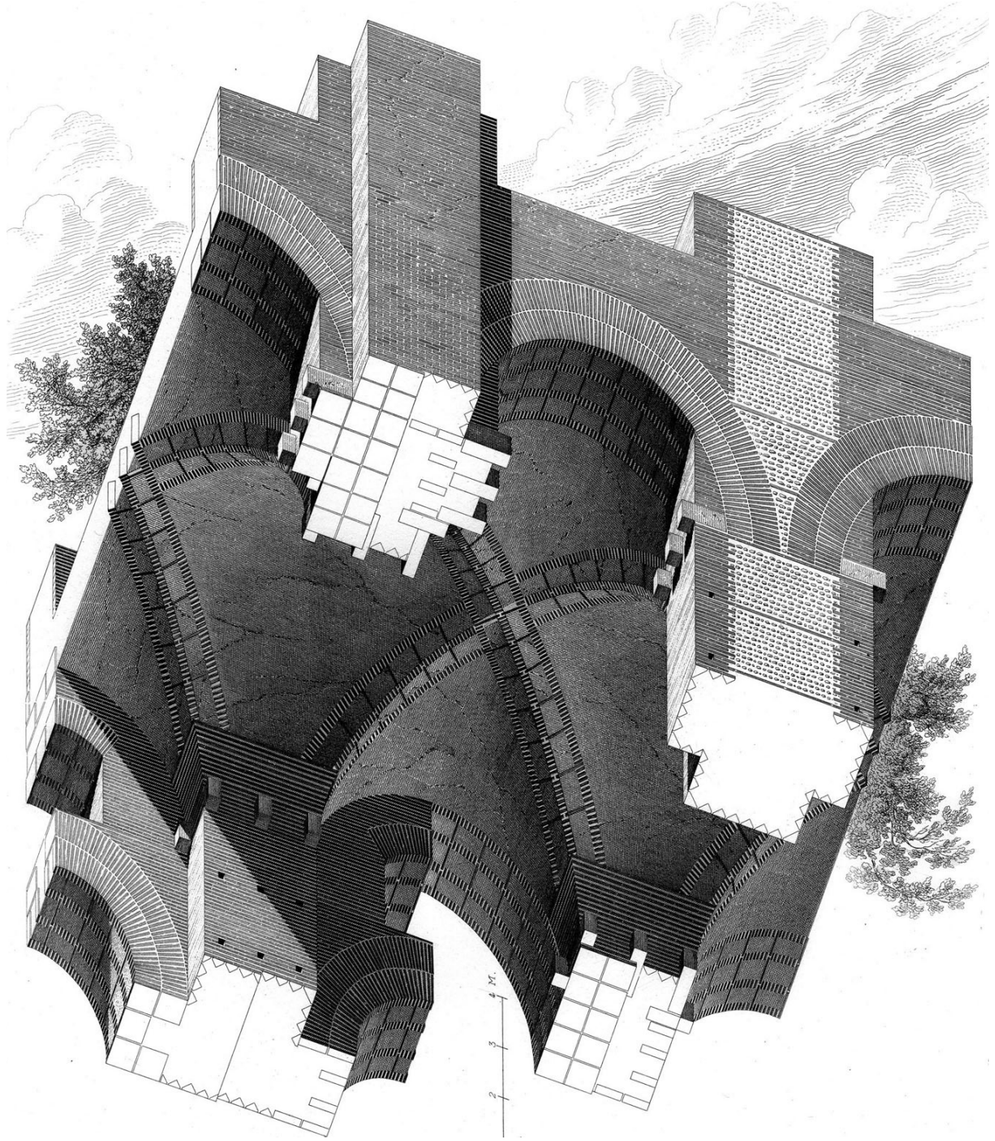
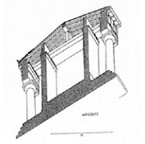
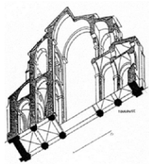


Fig.1.1.1 Auguste Choisy, *The bay as a constituent element,* 1899, in Auguste Choisy, *Histoire de l'Architecture*, vols. I and II (Paris: Gautier-Villars, 1899)





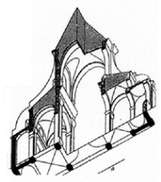


Fig.1.1 Auguste Choisy, *Worm's eye axonometry of the structures on the Palantine*, 1873, in *L'Art de batir chez les Romains* (Paris: Ducher, 1873), plate VIII.

46 Ibid, 4

47 Thierry Mandoul, "From Rationality to Utopia", in *Perspective, Projections and Design* (London: Taylor & Francis, 2007), 154

48 Ibid, 155

49 Ibid, 155

50 Stan Allen, "Drawing with Raphael Moneo, Madrid 1984", 2019. Drawing Matter, https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

51 Thierry Mandoul, "From Rationality to Utopia", in *Perspective, Projections and Design* (London: Taylor & Francis, 2007), 157

52 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 152

53 Thierry Mandoul, "From Rationality to Utopia", in *Perspective, Projections and Design* (London: Taylor & Francis, 2007), 158

century; although the method was established, and known by architects at the time, it was his first publication, L'Art de batir chez les Romains (1873) that really introduced axonometry to the architectural canon.[46]

Choisy studied at the Ecole Polytechnique under Jules de la Gourneire, whose influence is not to be underestimated.[47] Gourniere was a vocal critic of the perspective, who argued for the relativistic nature of perspective as opposed to it being a "way of seeking the truth" when constructed by descriptive geometry, as advocated by Mongue (Fig.1.0.6). Gourneire's work raised questions about representation, inciting students to conceptualise alternatives of the standard norm.[48]

It is important to note that Choisy was an art historian; therefore, the main objective of his illustrations is to analyse existing structures, revealing the principles that shaped them, rather than the effective representation of a design. And in the era of Villoet-le-Duc, who considered the vault the "rational architecture feature par excellence",[49] the roof structure had great importance, which highlights the rationale behind Choisy's drawings. The worm's eye view intrinsically puts the emphasis on the ceiling,[50] which replaces the ground as the horizontal bound to space. But while le-Duc embraced the complexity of the represented objects, Choisy followed Durand's combinatory approach instead – by drawing a single bay (and never the complete building), he aimed for the classification through the basic constructive structures – further exemplified by axonometric projection –, which allowed for the measurement and comparison of the different systems.[51]

As a result of the low viewpoint and the fragmental representation, the structures are depicted independent of their context, suspended in space as autonomous objects, floating free from gravity. Their detachment and objectivity can be seen as the culmination of the rationalist architectural philosophy of Durand, showcasing the technical ability of the architect to synthesise all aspects of a project. Moreover, Choisy, following the advice of la Gourniere, employed shadows,[52] and included a great level of detail to avoid the spatial ambiguity inherent to axonometry, which would have hindered his aim for absolute objectivity (Fig.1.1).

The later works of Choisy are especially descriptive of his all-encompassing technical mindset – compared to the 27 plates in L'Art de batir chez les Romains, the 1899 Histoire de l'Architecture contained an astounding 1780 drawings, which came at the expense of resolution and detail.[53] Through the simplification of lines, the drawings became increasingly more diagrammatic (Fig.1.1.1), which is especially important to consider given the popularity of the book.

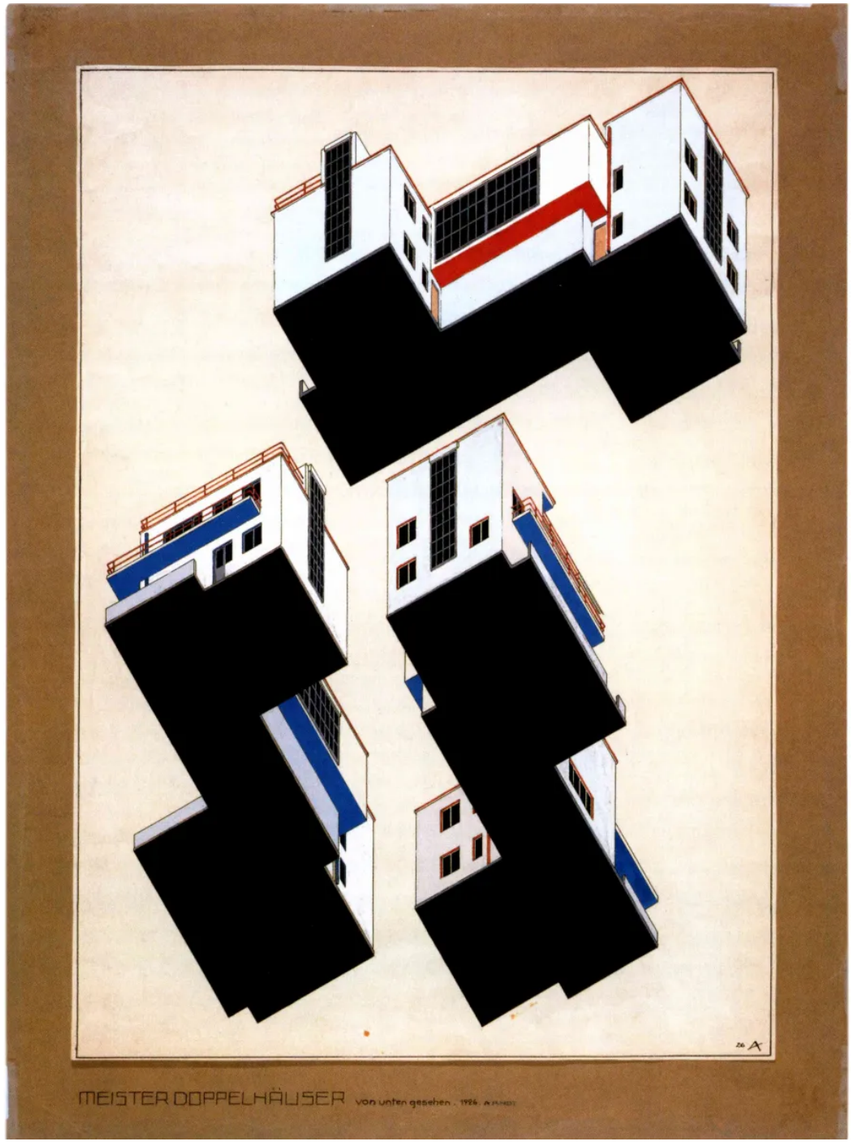


Fig.1.2.1 Theo van Doesburg, *Colour Construction in the Fourth Dimension of Space-time*, 1923, Stedelijk Museum, Amsterdam. https://s3-eu-west-1.amazonaws.com/production-static-stedelijk/images/adlib/a-6675-1647316837470.jpg

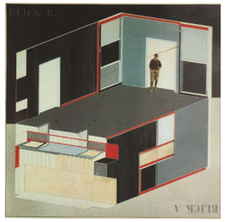


Fig.1.2.2 El Lissitzky *Cabinet of Abstraction*, 1926, graphite, gouache, metallic paint, ink and typewritten labels. https://socks-studio.com/2015/08/29/el-lissitzkys-cabinet-of-abstraction/

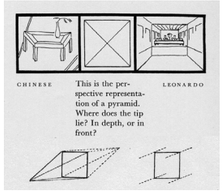


Fig.1.2.3 El Lissitzky, *Illustrations of K. und Pangeometrie*, in Carl Einstein and Paul Westheim (eds.), *Europa-Almanach* (Potsdam: Kiepenheuer Verlag, 1925), 105

Fig.1.2 Alfred Arndt, *Meister Doppelhauser*, 1926, ink and gouache in paper mounted on brown paper, in Neil Bingham, *100 Years of Architectural Drawing: 1900-2000* (London: Laurence King Publishing, 2013), 79.

54 Ibid, 162

55 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 316

56 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 147

57 Cees Boekraad, "Style and Anti-style", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 72

58 Ibid, 72

59 Yve-Alain Bois, "Metamorphosis of Axonometry", in *Neoplasticism in Architecture*, ed. Cees Boekraad et. al. (Delft: Delft University Press, 1983), 147

60 Ibid, 147

61 El Lissitzky, "K. und Pangeometrie", in *Europa-Almanach*, eds. Carl Einstein and Paul Westheim (Potsdam: Kiepenheuer Verlag, 1925), 107

62 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 321

63 Neil Bingham, *100 Years of Architectural Drawing: 1900-2000*. (London: Laurence King Publishing, 2013), 79.

From Choisy to the Bauhaus

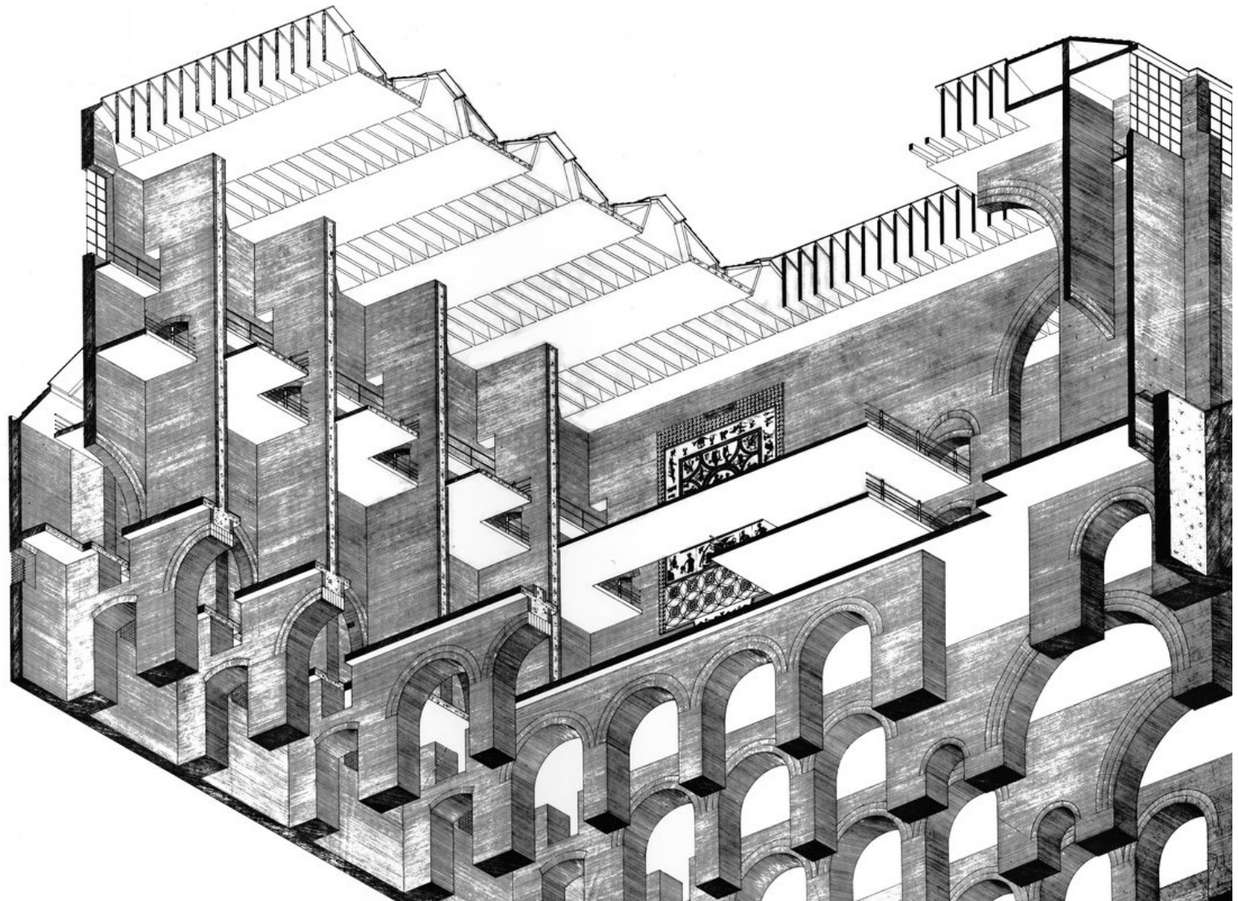
Axonometric drawings sketched a new, imaginative realm for conceiving architecture, and an aesthetic which would be invariably linked to the technist utopia of the modern movement.[54] However, the early 20th century avant-garde was largely dismissive of the history of the drawing method; and although the work of Choisy anticipated the technical mindset of modernism,[55] it did not find followers referring to him explicitly in the following decades. As Yve-Alain Bois explains, while architects still preferred perspective views and sketches, it was two painters – Theo Van Doesburg, and El Lissitzky – who were at the "heart of the axonometric landslide that engulfed architectural offices in the 1920s".[56]

The Russian artist El Lissitzky, inspired by the works of Malevich, was investigating the three-dimensionality of suprematism in his Proun series. He moved to Weimar, the home of the Bauhaus in 1921; the next year, he presented the aims of his Proun in De Stijl, triggering Van Doesburg's reflection in *Balance* on the relationship between Suprematism and De Stijl.[57] In September 1922, the Constructivist International Association of Artist was established in Weimar,[58] showing how intertwined the movements of the modern avan-garde really were.

If we were to set a precise date for the revival of axonometry, it would be the De Stijl exhibitions held in Paris late in 1923, which included Van Doesburg's Contre-Constructions (Fig.1.2.1).[59] For him, axonometry was a privileged vehicle for conceiving architecture which no longer adheres to types or differentiates between directions, hence losing form. The exhibition moved to the Weimar Landesmuseum a couple months later, introducing these concepts to the Bauhaus as well.[60]

The final, theoretical confirmation for the use of axonometry is attributed to El Lissitzky. In *A. and Pangeometry* (1925) (Fig.1.2.2), he claims that "Suprematism has advanced the ultimate tip of the visual pyramid of perspective space to infinity".[61] He does not mention axonometry by name, which indicates that (unlike Van Doesburg), he does not treat this technical tool as a generative device; instead, he articulated the potential of a new, non-eucledian space for art an architecture, while noting the difficulties of realising such "irrational" space in the world of embodied experience (Fig.1.2.3).[62]

Both the works of Van Doesburg and El Lissitzky had an immediate effect on architectural drawing in the Bauhaus, as exemplified by the famous worm's eye ("von unter gesehen") axonometry of the Dassau model housing (Fig.1.2).[63] Axonometric excercises became part of the curriculum, which, given the overwhelming influence the school had on architecture, cemented axonometry as an integral part of the architects representational arsenal.



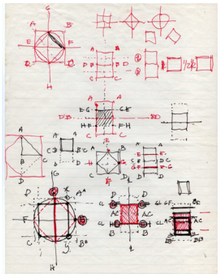


Fig.2.0.1 John Hejduk and Stan Allen, *Projection sketches*, 1981, ink on paper. *https://drawingmatter.org/john-hejduks-axonometric-degree-zero/*

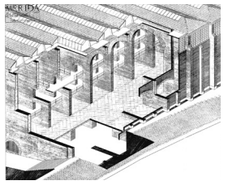


Fig.2.0.2 Enrique Teresa, drawn for the office of Raphael Moneo, *Museum in Merida, bird's eye axonometric*, 1984, 2H pencil on 20-gram Canson tracing paper. https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

Fig.2.0.3 Stan Allen, left edge of the worm's eye, as cut

Fig.2.0 Stan Allen, drawn for the office of Raphael Moneo, *Museum in Merida, worm's eye axonometric*, 1984, 2H pencil on 20-gram Canson tracing paper. https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

II Stan Allen: from Orthography to Post-orthography

In conversation with history

The extensive use of axonometry is present throughout the oeuvre of Stan Allen; moreover, he lived through the shift from orthography to post-orthography, and is vocal about what it meant for his architectural process. He was introduced to axonometry by John Hejduk in 1981, when studying at the Cooper Union. Hejduk considered axonometry as "cubist projection in architecture",[64] a reference which is clear in his famous diamond series. Some enigmatic projection sketches preserved the vibrancy of their conversations (Fig.2.0.1); and although Stan Allen avoided the method later in his studies, this knowledge came in handy when he started working at Rafael Moneo's office in 1984.

At the time, the construction of the National Museum of Roman Art in Merida was nearing completion, and Allen was tasked with drawing a worm's eye axonometry of the project for an exhibition Moneo scheduled at Harvard GSD.The drawing is a detailed study of the building's structure, with the aim to explain the solution on a single sheet – which was also an economic way for producing presentation material, given that this single drawing took 10 days to complete (Fig.2.0).[65]

Several irregular section cuts peel back the fabric of the building layer-by-layer, highlighting the vaults, the buttresses, and the roof structure. The former two give an additional hint why Choisy's drawing, which also depict intricate masonry structures, served as an inspiration. The worm's eye, necessarily cut at plan level and thus absent of context, accentuates the relationship between plan and section,[66] with the latter shown in full detail. The bird's eye axonometry shows ground and context, establishing the building as an urban fragment locked into a specific site condition (Fig.2.0.2); in the worm's eye, the focus is on the ceiling plane and its features, which condition the experience of space – especially in museums, where skylights are often used, and the large internal heights prompt the visitors to look up when they enter the building.[67]

The absence of the ground in worm's eye axonometries also turns the buildings into objects, grating them a certain autonomy, which in turn helps establishing the autonomy of the drawing as well. However, just like Choisy, Moneo was also cautious of the 'floating' nature of the projection – especially when compared to an earlier bird's eye axonometry of the same project. As a result, a 10cm wide strip was cut from the drawing after completion, which focused the attention to the interior of the building instead of treating it as an object looked at from outside (Fig.2.0.3).[68]

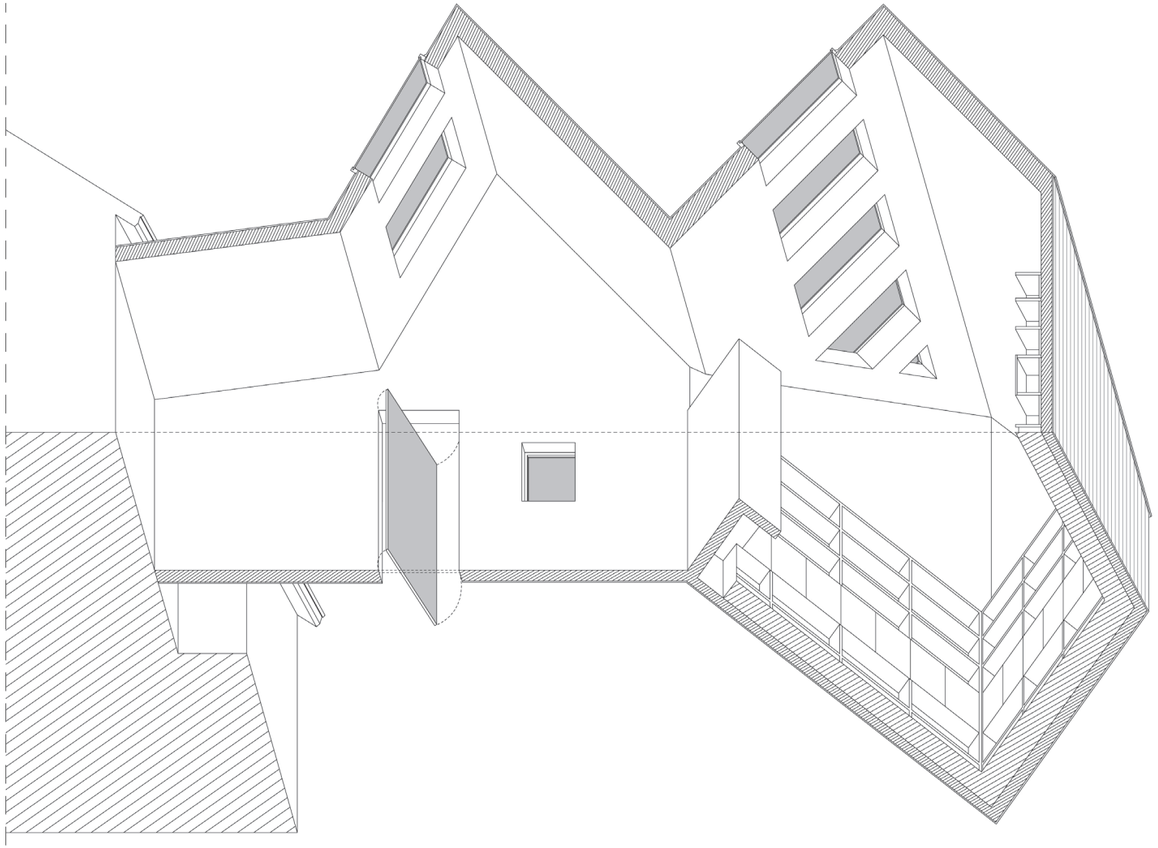
64 Stan Allen, "John Hejduk's Axonometric Degree Zero", 2019. Drawing Matter, https://drawingmatter.org/john-hejduks-axonometric-degree-zero/

65 Stan Allen, "Drawing with Raphael Moneo, Madrid 1984", 2019. Drawing Matter, https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

66 Ibid.

67 Ibid.

68 Ibid.



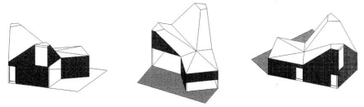


Fig.2.1.1 Stan Allen Architect, *Axonometric studies of K/S Library, Milan, NY,* 2016, Rhino and Illustrator https://drawingmatter.org/review-situated-objects/

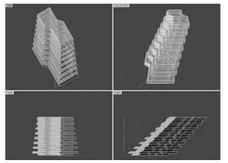


Fig.2.1.2 Screenshot from *Creating an Axonometric View in Rhino* (Switzerland: EPFL), 2

Fig.2.1 Stan Allen Architect, *Sectional axonometric of K/S Library, Milan, NY,* 2016, Rhino and Illustrator https://drawingmatter.org/review-situated-objects/

The pseudo-orthography of recreating Choisy

After leaving Moneo's office, Allen set up his office in 1991, where he practices up until now. Axonometry beccame a pivotal device in his communication; the last chapter of his 2017 monograph, *Situated Objects,* dedicates the last chapter to the meaning and force of the projection, acting as "a quiet manifesto for the work".[69] Stylistically, both the influeces of Hejduk and Moneo are clear in the axonometries illustrating the book; the '90-degree' projection and simple delineation reminiscent of the prior, while the worm's eye of the latter (Fig.2.1). A principal difference is, however, how his tools changed from 2H pencils and 20-gram Canson tracing paper to Rhino and Illustrator – admittedly, he uses the computer to achieve the same output, despite the significant differences between what the different technics lend themselves to.[70]

Historically, a major - and often underapreciated – advantage of axonometry is its ease of execution, which was already highlighted by La Gournerie.[71] By taking an orthogonal view (usually the plan), and mapping out distances from its plane, even complex geometries can be anticipated in space in a very short time, especially when compared to constructing it in perspective. A further simplification is when the base plane is unaltered, which results in 'true' axonometry, as opposed to isometry. It comes as no surprise that this is the technique Choisy used to manage the quantity of illustrations he had to produce, and that most architects in the 20th century – including the previous examples of the Bauhaus and Hejduk – followed suit. Allen is also aware of these advantages, as shown by his remarks during the John Hejduk soundings lecture he held at Harward GSD in February 2023.[72]

As the tools of architectural representation started to change towards the end of the century, however, this method is no longer a given – in the virtual space of CAD softwares, the parallel projection viewport does not allow for true axonometry, as the view is constructed by the scaling of axes when moving away from an orthographic view (Fig.2.1.1).[73]

This reveals the tension between technological change, and the desire for disciplinary continuity: while in the age of orthography, the mechanical construction of axonometries were revealing of the properties of the space they exist in, replicating their aesthetics in virtual space constitutes of *pseudo-orthography*, the "residual psychology of orthography labouring in the abscence of its own technical-gestular basis".[74] A crucial element enabling this phenomenon is *familiarity,* which John May sees as a coping mechanism enabling a certain sylization of history.[75] A closer look at the pseudo-orthographic workflow of recreating Choisy reveals its idiosyncratic nature. For instance, a well-known work-around for the previously mentioned issue of true axonometry not occurring in the

69 Niall Hobhouse, "Stan Allen's Situated Objects (2020) Review & Excerpt". Drawing Matter, https://drawingmatter.org/review-situated-objects/

70 Stan Allen, "Situated Objects". (John Hejduk soundings lecture, Harvard University Graduate School of Design, 15 February 2023).

71 Thierry Mandoul, "From Rationality to Utopia", in *Perspective, Projections and Design* (London: Taylor & Francis, 2007), 155

72 Stan Allen, "John Hejduk's Axonometric Degree Zero", 2019. Drawing Matter, https://drawingmatter.org/john-hejduks-axonometric-degree-zero/

73 Scott Benedict and Stan Allen, *Situated Objects: Buildings and Projects* (Zürich: Park Books, 2020), X

74 John May, *Signal. Image. Architecture.* (New York, NY: Columbia Books on Architecture and the City, 2019), 85

75 Ibid, 87

viewport is a simple macro which shears, then projects the whole model onto a flat surface (Fig.2.1.2).[76] In stark contrast to the constructive process of drawing a fragment of the building from an orthographic projection, the complete whole is modelled first – only to be then destructed to achieve the same effect. Then, extensive post-production is needed[77] to enrich the generic vector data with the inherent properties of drawn lines (colour, weight, stroke type, etc)(Fig.2.1.3): pseudo-orthography fights against the nature of real time by giving priority to one of the possibilites in such a way which hinders the future emergence of any other scenario.

As we see, using the technics of the virtual does not equal to embracing its logic; yet, both the process and the output is defined by it. On the other hand, there are historical instances in architecture and art which preceded (and anticipated) virtual space by transformations and operations reminiscent of what it allows; the analysis of such projects can greatly aid our understanding of a cyberspace which often conceals its *modus operandi*.[78]

Analogue transformations in virtual space

The first such example is *House X* by Peter Eisenman, who used the term 'transformation' to describe the development of each project in his famous *House* series (1975-85)(Fig.2.2.1). However, as Robin Evans pointed out in his review of Eisenman's *Fin d'Ou T Hou S* exhibition, the use of the term, which comes from mathematics, is factually incorrect.[79] A transformation is a function, which maps a set (in this case a set of points, which constitutes the geometry of a design) to itself; in the process, no new elements can be removed or included, and therefore cannot describe the design. Eisenman's transformational technique is no more than the depiction of different states, "presenting a set of denied projects whose full existence had been suppressed in favour of the one chosen".[80] By capturing moments of the process, and through their representation via a rigorous and systematic set of drawings (despite their explanations being far less so), the project becomes not a defined geometry, but a system capable to yield different results. This shows how architects were already able to conceive the multiplicity of real-time digital models, as the space of descriptive geometry in which they operated, is what forms the mathematical basis of virtual space.

Curiously, there is one instance when a transormation was carried out: after the client decided not to build House X, a 'distorted' model of the project was built (Fig.2.2.2). Reminiscent "of the character of an axonometric projection",[81] it is – coincidentally – a tangible, material execution of the same process Stan Allen uses to produce his axonometries: "a thoroughgoing, unified distortion of a complete and finalised ... design".[82] In the case of House X, the transformation can be described as F(x,y,z)

76 Stan Allen, "Situated Objects". (John Hejduk soundings lecture, Harvard University Graduate School of Design, 15 February 2023).

77 Ibid.

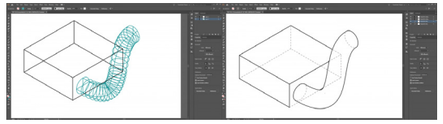


Fig.2.1.3 Screenshot from *Rhino to Adobe Illustrator,* TU Delft, Netherlands http://wikihk.tudelft.nl/toi-pedia/Rhino_to_Adobe_Illustrator

78 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 378

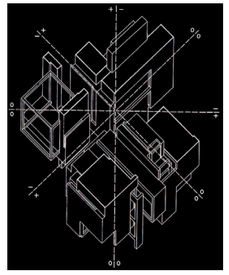


Fig.2.2.1 Eisenman Architects, *House X axonometry,* 1975 https://eisenmanarchitects.com/House-X-1975

79 Robin Evans, "Not To Be Used For Wrapping Purposes" in *Translations from Drawing to Building and Other Essays* (London: Architectural Association, 1997), 129

80 Ibid, 130

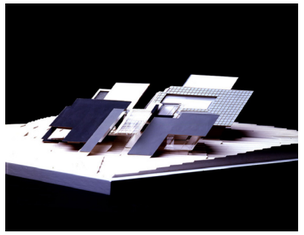


Fig.2.2.2 Eisenman Architects, *House X model photo,* 1975 https://eisenmanarchitects.com/House-X-1975

81 Ibid, 131

82 Ibid, 133

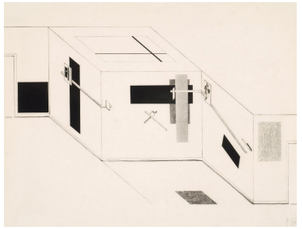


Fig.2.2.3 El Lissitzky, *Axonometric Projection of the Proun Room,* 1923, Installed at the Greater Berlin Art Exhibition, Lithograph on wove paper, 44,3 x 59,9 cm. Canadian Centre for Architecture, Montréal, https://www.cca.qc.ca/en/search/details/collection/object/334319

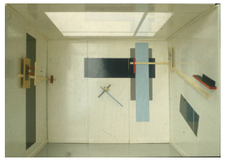


Fig.2.2.4 El Lissitzky, *Prounenraum (Proun Room),* 1923, Great Art Exhibition, Berlin. https://www.atlasofinteriorspolimit/wp-content/uploads/2018/11/ELLISSITZKY-1923-stanzaproun_04jpg

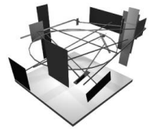


Fig.2.2.5 Sang-Ho Lee, *Movement of Observer's Sight* and *Object's Relationship in Proun-Raum*, in "A Study of the Digital Virtuality on El Lissitzky's Proun". *Journal of Asian Architecture and Building Engineering* 2, no. 1 (May 2003), Fig. 11 and Fig. 12.

83 Ibid, 133

84 Ibid, 130

85 Alberto Pérez-Gómez and Louise Pelletier, *Architectural Representation and the Perspective Hinge* (Cambridge, MA.: MIT Press, 1997), 321

86 Sang-Ho Lee, "A Study of the Digital Virtuality on El Lissitzky's Proun". *Journal of Asian Architecture and Building Engineering* 2, no. 1 (May 2003): 219

87 Ibid, 215

88 Stan Allen, "John Hejduk's Axonometric Degree Zero", 2019. Drawing Matter, https://drawingmatter.org/john-hejduks-axonometric-degree-zero/

89 John May, during the Q&A after Stan Allen's "Situated Objects" lecture

[(x+y/2), y/sqrt2, (z+y/2)][83] – for once in Eisenman's oeuvre, a foreign word imported to architecture was enabled to invade the work, and alter its architectural qualities. Nowadays, these invasions are omnipresent, yet far less visible as they are hidden in the code of architectural softwares; what makes House X such a compelling example is that the transformation is explicit, and is communicated in an extremely transparent method, utilising a traditional architectural mediator – the physical model.

Eisenman claimed that his design operations instinuate movement, a claim of which Robin Evans talks rather dismissively: "there is less movement in a state than in a transformation, and what movement it does bring with it is circumstancial".[84] Even House X is only a static model, bound by the rules of the physical world of our perception. Eisenman neither did, nor did he attempt challenging these rules; for this, we should return to El Lissitzky, our second example anticipating virtual space.

Lissitzky was fascinated by the connection between mathematics and art, especially with regard to space and vision. Praising the advancements of Gauss and Riemann in non-eucledian geometry, he discusses the potential for representing their abstractions in art in what he calls *irrational space,* realising that "we can only change the form of our physical space, not its structure".[85] Instead, he focused on the temporality of embodied experience in order to represent time and movement, not only space.

His Proun Room (1923)(Fig.2.2.3) investigates temporal relativity; flat, two-dimensional abstract art pieces on each surface of the room gain spatial qualities through the movement of the observer, who thus becomes an active participant (Fig.2.2.4).[86] Through the multiplicity of viewpoints and their simultaneous observation, the observer is considered to move "infinitely fast", at the speed of light, thus gaining the ability to perceive multiple sides of an object at the same time. As the topology of the objects change based on the visitor's viewpoint, a new, three-dimensional space is created (Fig.2.2.5). Sang Ho-Lee argues that the Proun Room shows many similarities with digital space and image, and suggests an avenue for approaching Proun as an outcome of excellent computational modeling, executed in the analogue media of the period.[87]

Returning to Stan Allen, the issue regarding the technics of his work is apparent, given his understanding of axonometry today: "committed to a disciplinary discourse, and in conversation with history ... and are open to a wide range of references".[88] His references, from Van Doesburg to Eisenman, are forward-thinking, experimental projects pushing the boundaries of axonometry; in comparison, his approach of accurately recreating these visuals using the computer seems regressive, or "a certain stylisation of the moment",[89] no longer embedded in technics. The question presents itself clearly: will it last?

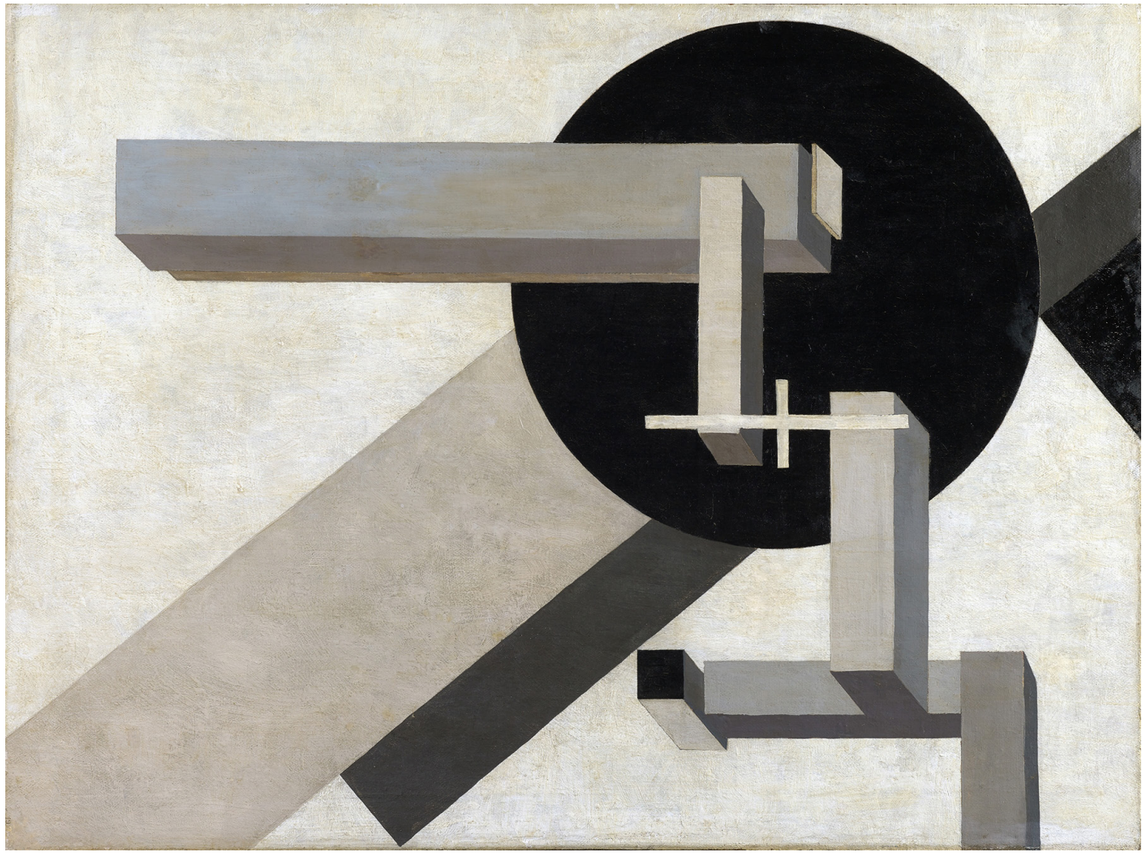


Fig.3.0.1 El Lissitzky, *Proun 2C*, 1920, Oil, paper, and metal on panel, 59.5 x 39.8 cm, Philadelphia Museum of Art. https://philamuseum.org/collection/object/53939

Fig.3.0.2 El Lissitzky, *Proun 19D*, 1920 or 1921, Gesso, oil, varnish, crayon, colored papers, sandpaper, graph paper, cardboard, metallic paint, and metal foil on plywood, 97.5 x 97.2 cm, The Museum of Modern Art, New York. https://post.moma.org/the-many-lives-of-el-lissitzkys-proun-19d-1920-or-1921/

Fig.3.0 El Lissitzky, *Proun 1D*, 1919, Oil on canvas and plywood, 71.6 cm x 96.1 cm. https://kultura.art/artworks/10269/proun-1d

90 Stan Allen, "Drawing with Raphael Moneo, Madrid 1984", 2019. Drawing Matter, https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

91 Yve-Alain Bois, "El Lissitzky: Radical Reversibility", *Art in America*, vol. 76, issue 4, (April 1988): 175

92 Ibid, 175

93 Ibid, 174

94 Ibid, 172

95 Ibid, 176

96 Ibid, 174

III Worm's Eye Aesthetics

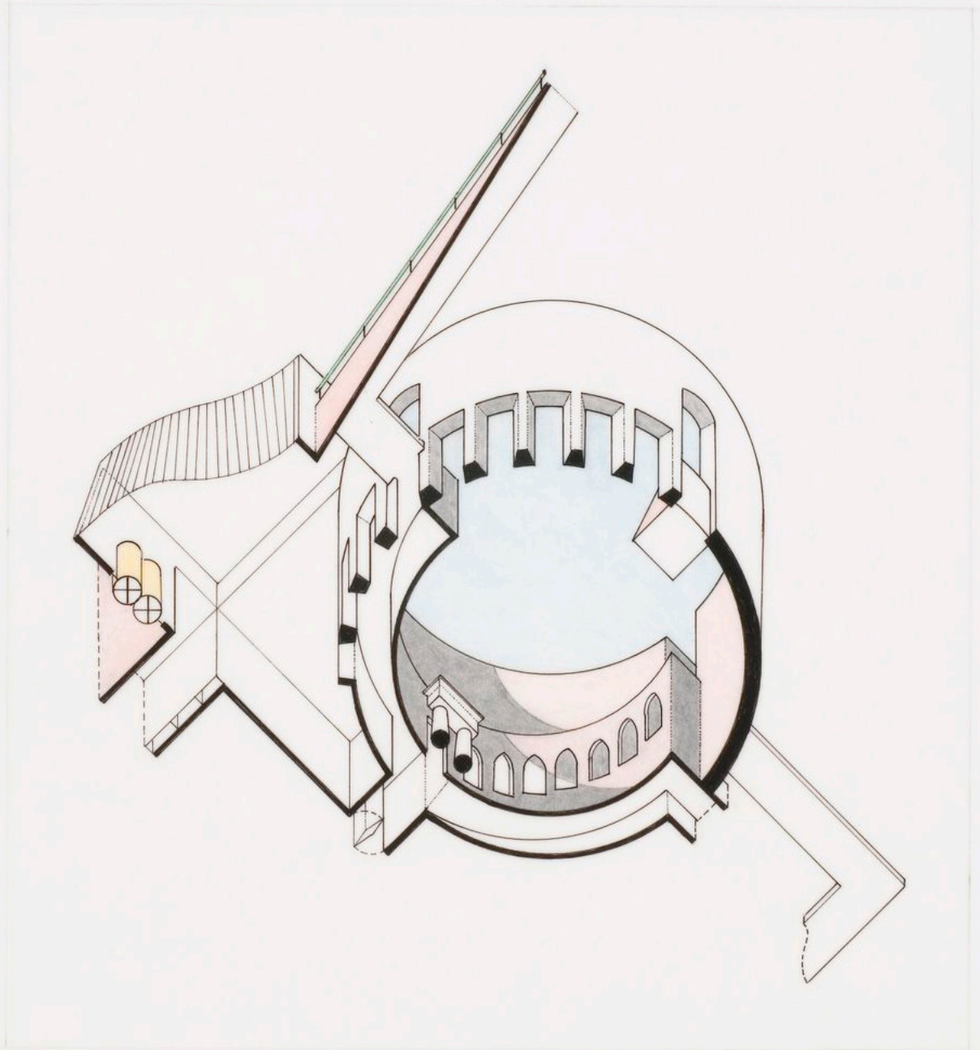
The ambiguity of the Proun series

Regardless of these concerns, Stan Allen's observation that modern axonometric projection signals a desire to link architecture to non-represntational art practices[90] is spot on; although we have seen how in the 19th century, axonometry emerged as a tool for objectivity, connecting mathematics, engineering and architecture, from the 20th century onwards the aesthetic qualities of the projection often took precedent. The 21st century image culture further strenghtens this trend – noone takes dimensions on a screen, yet beautifully presented axonometries are widespread on architecural instagram pages.

To understand the roots of this *axonometric aesthetic*, we should have a closer look at the composition, and technics of El Lissitzky's *Proun* series. *Proun* is a Russian acronym for "new art", which Lissitzky himself described it as an "interchange station between painting and architecture".[91] As Yve-Alain Bois describes, they are not directly applicable architectural projects, but analytical investigations from which such projects can be developed.[92]

In the first Prouns, axonometry is used rather conventionally – a single projection axis is used, just like in architectural rendering (Fig.3.0). One main difference, characteristic of all Prouns, is already present when compared to 19th century architectural axonometries: the reversibility of axonometry, the "protention/retention or plus/minus effect"[93] is intensified, a property which Choisy and his contemporaries fought against by the use of shadows. An axonometry of the Proun Room, both a bird's eye and a worm's eye viw, is a real puzzle to grasp, which would "force the spectator to make constant decisions about how to interpret what he or she sees". [94] In his later work, the multiplication of projection axes further increases this effect

Although one is able to grasp these visual effect when looking at images of Proun, digital formats fall short of conveying the full experience of the works, rooted in their technics, Lissitky's talent as a craftsman. Glued pieces of different textures and materials adobt the characteristics of construction materials; when they are painted, the signage is further accentuated by their colour (Fig.3.0.1).[95] Transcending the traditional notion of painting, Lissitzky woud refer to the pieces as *documents*, supposed to lie horizontally on a surface (Fig.3.0.2),[96] which emphasies *making*, the technics of execution. From his approach stemmed a lineage of architectural representation, consciously taking advantage of the time spent making, which became associated with the painterly qualities of axonometry.



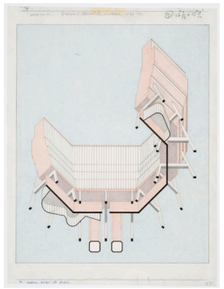


Fig.3.1.1 James Stirling and Partner, *Florey Building, Oxford, UK: Worm's-eye axonometric*, 1966-71, Ink, graphite, and coloured crayon on tracing paper. Canadian Centre for Architecture, Montréal, https://www.ccaqcca/en/search/details/collection/object/393488

Fig.3.1.2 Friedrich Weinbrenner, *Section of Stadtkirche, Karlsruhe*, 1807-15. Stirling referred to Weinbrenner's watercolours as a source of inspiration for his drawings.

Fig.3.1 James Stirling and Partner, *Staatsgalerie, Stuttgart, Germany: Worm's-eye axonometric*, 1977-84, Pen and ink, graphite, and coloured pencil on translucent paper, Canadian Centre for Architecture, Montréal. https://www.ccaqcca/en/search/details/collection/object/392100

Encapsulated movement: Stirling at Stuttgart

One of the most widely-published worm's eye axonometries are that of James Stirling, and not without good reason: as someone whose oeuvre spans from modernism to post-modernism, these works unite the accurate delineation of Choisy with the abstraction and ambiguity of the avant-garde.

James Stirling established his name with four iconic university projects in the late 60s; and while an axonometric publication drawing was made for all of them, it is the worm's eye view of Florey building that received the most attention, having featured on the cover of the catalogue from the James Stirling drawings exhibition at the RIBA Heinz Gallery in 1974 (3.1.1). Originally a fine-line black ink drawing, it has been subsequently revised by Stirling, who coloured it himself – although he was only commenting on drawings during the hard-line draw-up phase, he retained control over their completion, as John Tuomey explains.[97]

The difference between the two states of the drawing is indicative of the aforementioned shift to the post-modern, which characterises Stirling's later work; consequently, the tension between the original world of the design and its architect's later ambition to change the narrative around it is very important to consider when discussing his axonometries. A prime example is the Neue Staatsgalerie in Stuttgart, where, in stark contrast to the Florey building, the colouring of the drawings stemmed from, and emphasised the conceptual origins of the project – which architectural historian Charles Jenks would later describe as the epitome of first-stage postmodernism (Fig.3.1).[98]

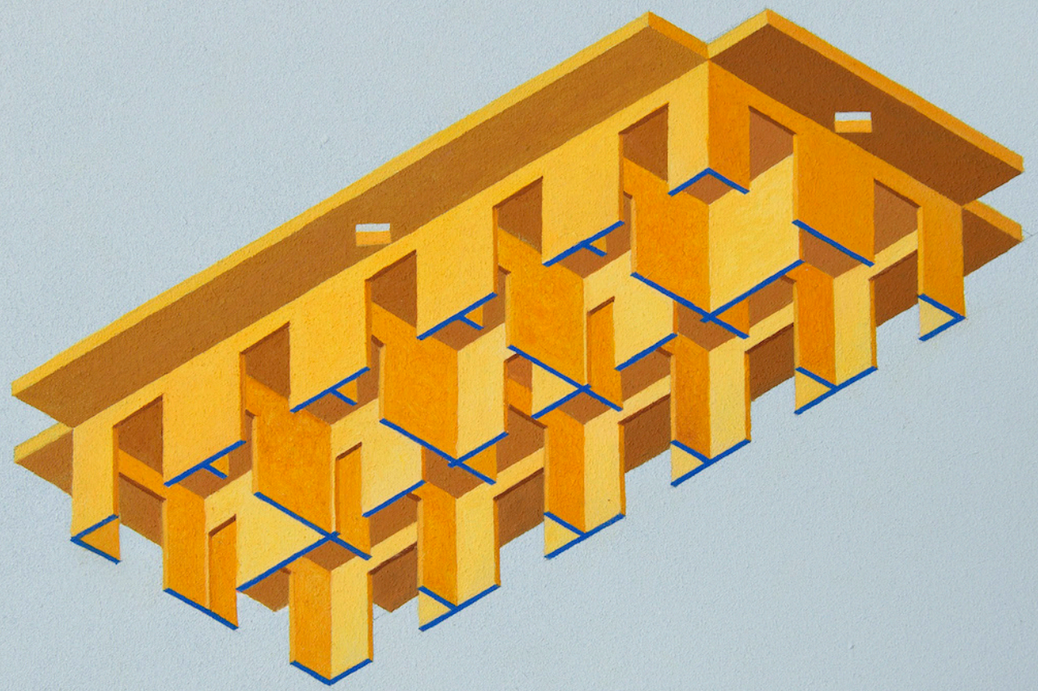
The main aim of this axonometry is depicting the visitor's experience when traversing through these spaces – a challenging task, especially for an office that prided itself on the lack of machines used for drawings,[99] which made the process more time-consuming. At the same time, through the consideration of the axonometry as a painting, a clear reference to Lissitzky's art is being made, which in turn evokes movement though the multiplicity of possible viewpoints. Since all spaces are presented equally, an active observer is able compile the pieces of what going through the museum would be like. Meanwhile, the low viewpoint allows for conceiving the different heights of the spaces; and by only applying colour for the external parts and the sky, the distinction between in- and outside was made.

Stirling's axonometries have a special place in the history of the projection; made at a time when CAD was still in its infancy, these worm's eyes synthesise axonometries made with analogue technics, and mark the end of architectural representation in the age of orthography.

97 John Tuomey, "Stirling at Stuttgart: Rear view/up views," 2020. Drawing Matter, https://drawingmatter.org/stirling-at-stuttgart-rear-view-up-views/

98 Charles Jencks, Style of the Man", 2014. *The Architectural Review*, vol. 235, issue 1411.

99 John Tuomey, "Stirling at Stuttgart: Rear view/up views," 2020. Drawing Matter, https://drawingmatter.org/stirling-at-stuttgart-rear-view-up-views/



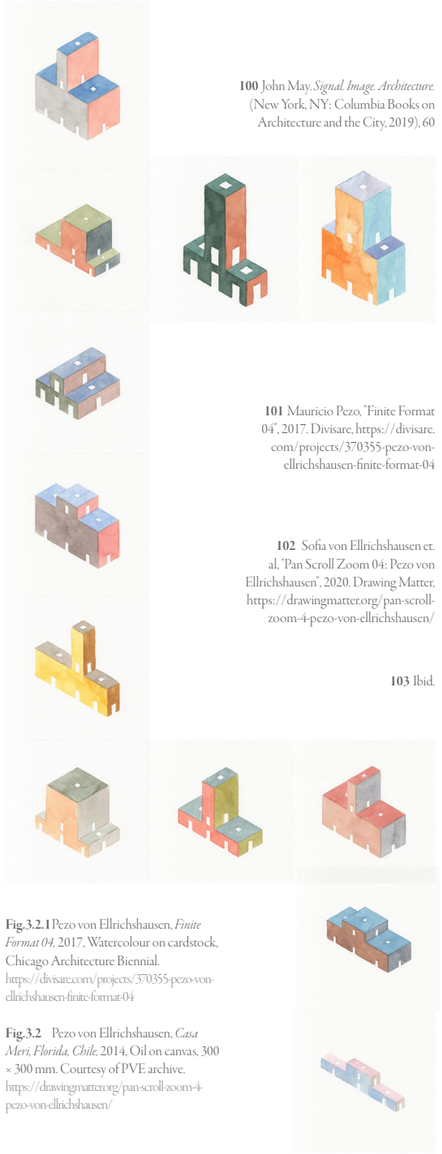


Fig.3.2.1 Pezo von Ellrichshausen, *Finite Format 04*, 2017, Watercolour on cardstock, Chicago Architecture Biennial. https://divisare.com/projects/370355-pezo-von-ellrichshausen-finite-format-04

Fig.3.2 Pezo von Ellrichshausen, *Casa Meri, Florida, Chile*, 2014, Oil on canvas, 300 × 300 mm. Courtesy of PVE archive. https://drawingmatter.org/pan-scroll-zoom-4-pezo-von-ellrichshausen/

100 John May. *Signal. Image. Architecture.* (New York, NY: Columbia Books on Architecture and the City, 2019), 60

101 Mauricio Pezo, "Finite Format 04", 2017. Divisare, https://divisare.com/projects/370355-pezo-von-ellrichshausen-finite-format-04

102 Sofia von Ellrichshausen et. al, "Pan Scroll Zoom 04: Pezo von Ellrichshausen", 2020. Drawing Matter, https://drawingmatter.org/pan-scroll-zoom-4-pezo-von-ellrichshausen/

103 Ibid.

The (anti) technological approach of PvE

Some things can only be seen once they have disappeared. (...) "the orthographic age" This age no longer exists.[100]

It wasn't long after the initial breakthough of softwares in architectural production that an anti-technological counter-movement was born; the fear for loosing centuries of knowledge on architectural representational techniques reignited the passion for mechanical labour over drawings and paintings.

The work of Chilean office Pezo von Ellrichshausen is particularly fascinating, as they claim that their work is devoid of many tropes engulfing contemporary architecture, such as precedents, concepts, or methaphors.Instead, they believe in the self-referentiality of their work, which they are continuously expanding by building on their own domain of knowledge.[101]

In lieue of disciplinary references, Pezo von Ellrichshausen tend to turn their attention towards the intersection of art and architecture. As founding partner Sofia von Ellrichshausen explains, they "tend to use time consuming techniques, such as painting, to increase the level of consciousness in the elements of a building and its representation"[102] – in other words, they consciously utilise orthography to reap the benefits of the historic time embedded in the process (Fig.3.2). For example, starting a painting which might takes a week to complete makes them choose more carefully what to frame when compared to a render which can be produced at a speed which "goes ahead of the mental processing".[103] In this workflow, pencil, watercolour and acrilyc are used for preliminary studies, while final proposals are cemented by oil on canvas.

Apart from the paricular cases of built projects, morphological excercises dealing with architectonic ideas form the other main branch of the office's output (Fig.3.2.1). Here, the use of paint is more ambivalent; on one hand, the inaccuracy of the technique signifies the topological nature of the work, as in the exact dimensions of the geometries are inconsequental, for the meaning resides in the interrelations of the elements. On the other hand, the benefits of the time spent on representation is hard to see – the final result is known when the parameters are set out; and whether they use computers or not to calculate the (finite number of) options does not matter, since the thinking process is the same. The computational logic is further accentuated by the use of isometric projection, which evokes a video game aesthetic; as a result, it is hard to tell whether painting is an integral part of the process, or just a mask trying to conceal the virtual embedded i the thought process.

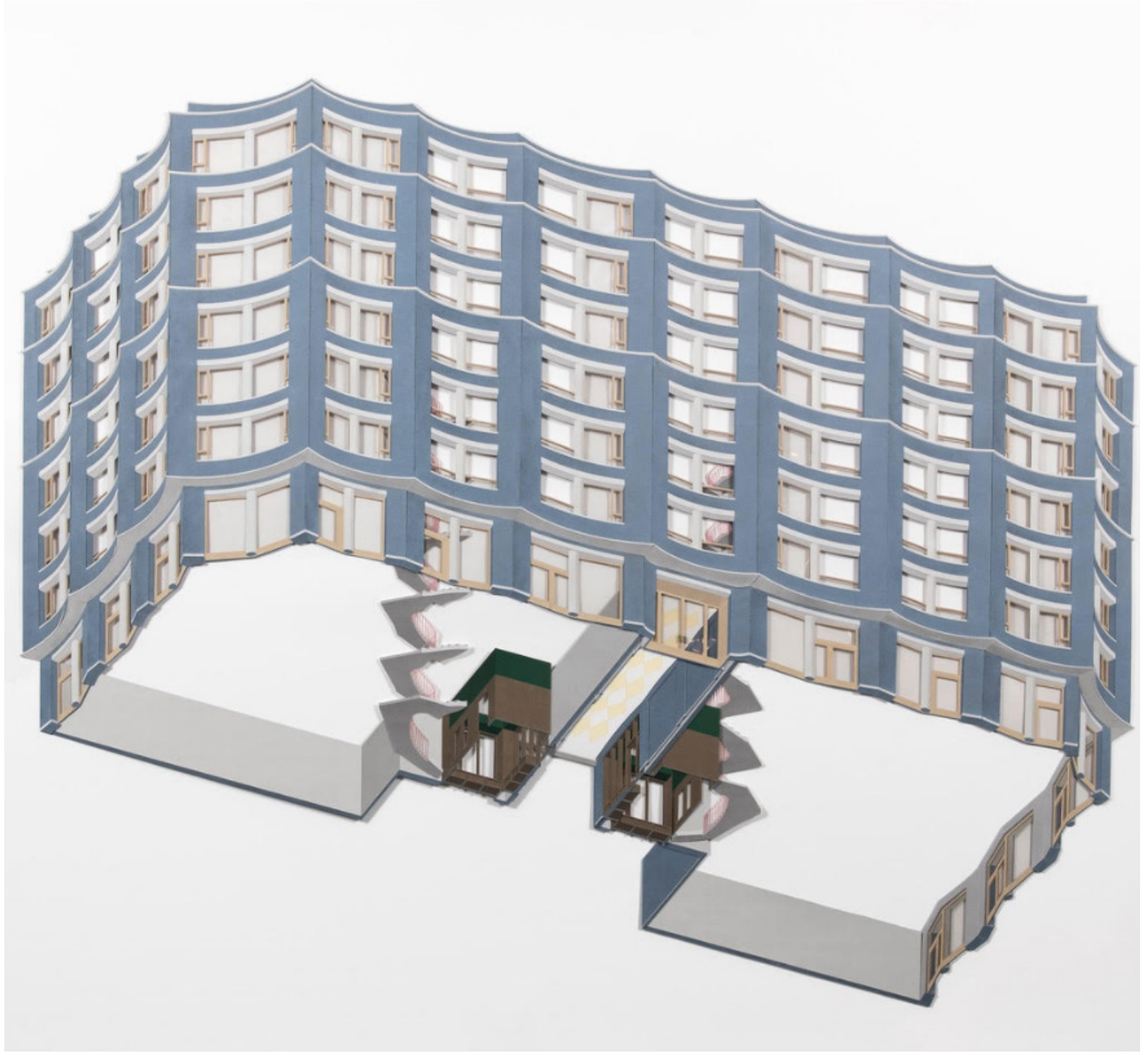


Fig.4.0.1 bovenbouw.architectuur, "Shooting for our upcoming monograph". *Instagram*, February 5, 2019. https://www.instagram.com/p/BzfkhqBFYim/?utm_source=ig_web_copy_link

Fig.4.0 Nicolas De Paepe for Bovenbouw Architectuur, *Cadixstraat Housing, Antwerp*, 2019. Coloured cardstock, 141 × 166 mm https://drawingmatter.org/bovenbouw-one-paper-model-and-three-paper-collages/

IV Reflecting Through Education

As shown in previous chapters, the worm's eye axonometry is an extremely powerful projection to summarise a project in a single artifact. In many cases, including previous case studies of the Bauhaus model housing or the museum in Merida, the drawings were made after completion, and stood for themselves in publications, or at exhibitions. Still, they are representations of built projects, and as such, their success is tied to that of the building. This is not true for university projects: if we have established at the outset that architects never work directly on the subject of their thought, we should note here that students of architecture do. Their projects (in the overwheling majority of cases) only ever exist as representation; this grants even more importance to the processes that are behind the final output. Therefore, this last segment is dedicated to different approaches towards architectural representation in education; and although some case studies are professional work, they are from offices heavily invested in the future generations, running studios based on the same methodologies.

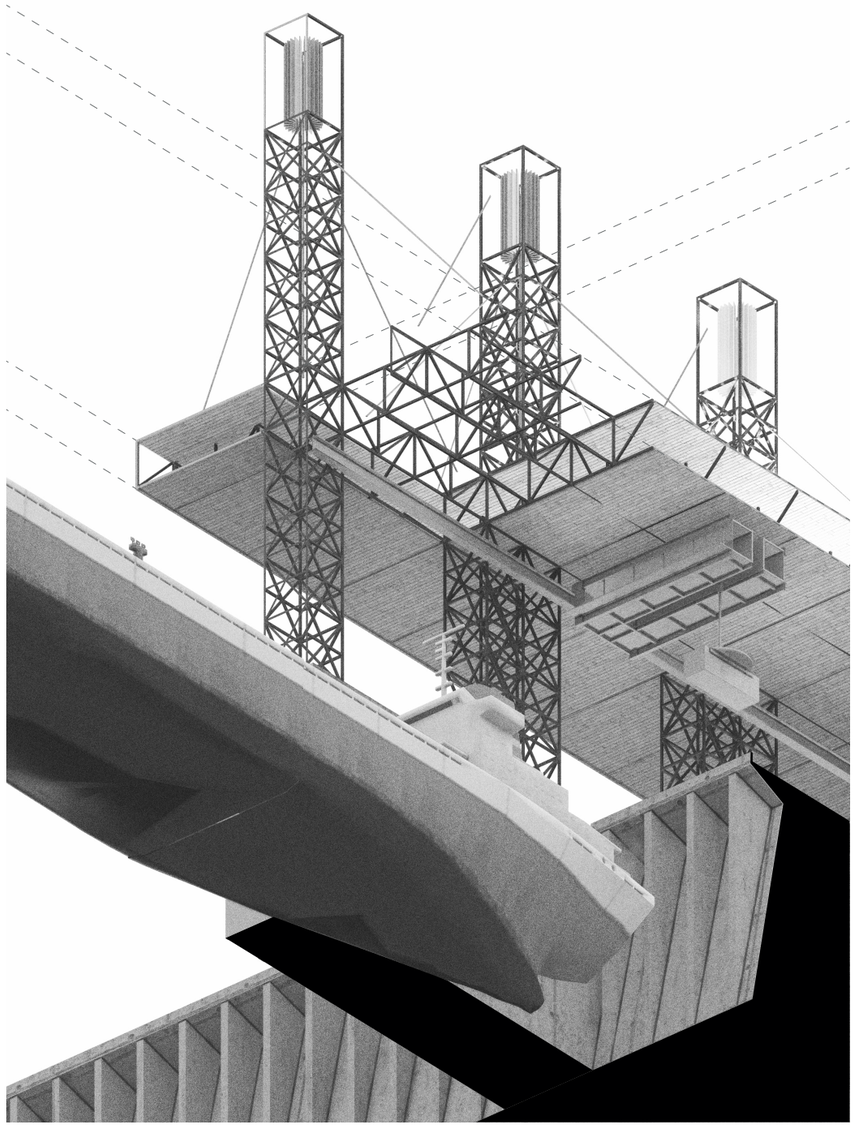
Time spent being detached

The first such example is Bovenbouw Architectuur, whose lead designer Dirk Somers teaches at the Interiors, Building, Cities studio at TU Delft – a studio whose methodology revolves around physical models, driven by the same idea of the value of time spent making which characterises the work of Pezo von Elrichshousen.

Although models play an important role in the design process of Bovenbouw as well, they are usually limited to sketch models due to resource and time pressures. Instead, when they have some spare time in the office, they "like to waste it on pretty drawings", [104] as Somers revealed at a Berlage Keynote lecure. These drawings are usually worm's eye axonometries, such as the one of the Cadix housing project in Antwerp (Fig.4.0). It is a drawing about the facade: walls and other structures are reduced to surfaces, losing their weight and floating ambiguosly in space. Despite being published as a 'Choisy-style' axonometry, it actually is the opposite of it – in fact, it is more similar to a Proun than an measurable drawing. Nonetheless, the naming highlights a wish to establish the work to be in conversation with the history of the discipline, rather than art.

With regard to technics, the piece is a collage which comprises of 2500 (!) pieces of paper – even the instagram post revealing this fact jokes about howits author can now resume his private life (Fig.4.1). Such time expenditure is not easy to justify even in a professional environment

104 Dirk Somers, "Takeaways and Projects". (Berlage Keynote lecture, Delft, 15 September 2022).



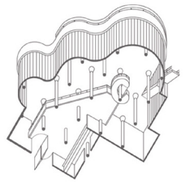


Fig.4.1.1 James Stirling (firm), *Olivetti HQ, Milton Keynes*, 1970, Ink on paper. Canadian Centre for Architecture, Montréal. https://www.cca.qc.ca/en/search/details/collection/object/393933

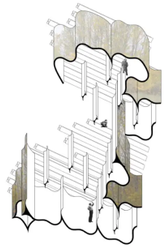


Fig.4.1.2 Enkhbat Minjmaa, *Worm's eye axonometry*, Studio 09, KTH Stockholm, 2018 https://09architecturalnotationsfiles.wordpress.com/2018/12/Enkhbat_Minjmaa_Project02_FinalBoards4.jpg?w=768

Fig.4.1 Szymon Kaniewski, *Choisy axonometry*, MSC1 Borders & Territories studio, TU Delft, 2023, Rhino and Illustrator, printed at A1. Courtesy of the author.

– this piece was made for a monograph – but in education, it is even harder. Time spent designing is time spent learning, for which the use of analogue, time-consuming methods can have a positive effect; but what do students actually learn through the 'execution' of their design, once it is done? Can a more considerate approach unify the advantages of orthography during the design phase with the instantaneous output of post-orthography for presentation material?

The “Choisy-excercise”

The Borders & Territories studio at TU Delft prides itself in drawing theory, often engaging with the subject of analysis through its tracing and mapping, resulting in impressive visual material. This approach is also reflected in their MSc1 design studio assignment, where students are asked to produce only a few drawing, exectued to a high standard. For one of the posters, a 'Choisy-style' worm's eye axonometry is required; in this case, it functions as a real synthesis drawing, which is meant to achieve no less than to convey the difficult whole in the absence of a built project.

The poster of Szymon Kaniewsky is characteristic of the output of the studio (Fig.4.1), which resides somewhere between the pseudo-orthography of Stan Allen and the unfiltered nature of virtual space. It is an isometry, which means the process is devoid of the Eisenman-esque transformation; also, it is presented as a textured model, rather than delineation, which greatly simplifies post-production (in this case, the addition of some dashed lines and a solid fill for the cuts). It accepts being an image, a snapshot of a rendered model; at the same time, that model is not of the whole, but one made specifically for this purpose. With its peeled-back layers, and carefully placed cuts, it is hard to imagine any other views taken from it – meaning that time is being spent on the (destruction of a complete) model, in exchange for approximating the original reference of Choisy.

Admittedy. the final product succeeds at that: the build-up of the represented structure is explained clearly, and the visual intricacies are echoing the hatched materials and shadows of Choisy's litographies. Moreover, the prescence of such excercises in education is indispensable for the continuity of the history of the worm's eye; by introducing it to the next generation of architects, not only is it preserved, but important conversations on the state of architectural representation can be initiated (Fig.4.1.2). However, it is important to note that history never repeats itself and thus cannot be replicated; therefore, a constant re-evaluation of its potential use is needed.

Fig.4.2.1 MOS, *Screenshots, Videos, Photographs, Mugs, ...*, Solo Exhibition, Liberty Gallery, Taubman College of Architecture and Urban Planning, University of Michigan, Ann Arbor, Michigan. November 13–20, 2015. https://drawingmatterorg/wp-content/uploads/2021/02/DSC_0267-1024x683.jpg

Fig.4.2.2 MOS, *Community Center, No. 3, Lali Gurans Orphanage*, 2016, screenshot with mark-ups. https://assets.mosnyc/sites/default/files/styles/optimize/public/2016-09/051Mos%20Portfolio0252_1.jpg

Fig.4.2 MOS, *House, No. 9, House with 6 Rooms*, 2015, screenshot. https://assets.mosnyc/sites/default/files/styles/optimize/public/2016-08/House%20no%209_Wormseye_1200x800.jpg

Converging towards the digital

MOS is a New York-based architecture office, whose partners, Michael Meredith and Hillary Sample teach separately at Princeton University and Columbia University, respectively. Underpinning their practice and teaching is a weariness for the disciplinary habit of finished representations and projects, or as Meredith explains, the "exessive emphasis on representation as the objective in itself, not a medium for teaching and designing".[105] In their studios, they are trying to shift that: instead of prescribing technics or output, students are free to express themselves however they want; moreover, they "err on the side of the unfinished, the raw, the incomplete",[106] alleviating the pressure that the demand for polished representation can put on students.

MOS is very aware of is the space of media, in which all kinds of architectural output, from drawings and diagrams through renderings and simulations to technical data have been flattened into the same space of the screen.[107] This sparked their interest in screenshots, which are often their preferred mode of representation, sometimes even the final images (Fig.4.3). As Matthew Allen explains in an essay he wrote for MOS' monograph, screenshots "instantify the myth of computation";[108] the projects are represented as overexposed digital models, creating a sense of authenticity. Of course, MOS is deliberate about their screenshots, which often include viewport frames, world axes, or base grids – features unique to the virtual space in which the model exists. It wouldn't take much effort to turn these objects off, or to take smaller snapshots; however, by staging the screenshot as authentic digital representation, they become "a critique of what they are not".[109] Why should they approximate the appearance of orthographic drawings? Why should they preserve measurability, when noone is taking measurements from a screen?

Screenshots are not only reducing the gap between model and image, but are also initiating a conversation within the discipline about the culture of architecture (Fig.4.3.1). The screenshots appear "overly simple, too easy"[110] – *architecture lite,* which thematises the metaphysical shallowness of the profession. If an unfiltered screenshot with some finger mark-ups is all we need to communicate, why spend more time on production? (Fig.4.3.2) Screenshots take architectural representation from the front office to the back, from marketing and showing off to the 'drawing board' where architects work and discuss their work – the computer screen. Through embracing the *screenshot aesthetic*, MOS shows that they are aware of the technological framework they operate in, they are accepting it, and they are appropriating in to serve their aims.

105 Michael Meredith et. al, "Pan Scroll Zoom 07: MOS", 2021. Drawing Matter, https://drawingmatter.org/pan-scroll-zoom-mos/

106 Ibid.

107 Michael Meredith, Hillary Sample, *MOS: Selected Works* (New York: Princeton Architectural Press, 2016)

108 Matthew Allen, "Screenshot Aesthetic", in *MOS: Selected Works*, Michael Meredith and Hilary Sample (New York: Princeton Architectural Press, 2016), 272

109 Ibid, 274

110 Ibid, 274

Conclusion

The numerous and diverse examples we ecountered during the journey through the history of the worm's eye axonometry illustrate the flexibility and adaptibility of the projection; from technical-analytical drawings, through ambiguous paintings, to digital model screenshots, it has been utilised for a variety of reasons, executed in a wide range of media.

The secret behind its continuous re-appearance in architectural representation lies, I believe, in the way architects think about space, which changed less in the analysed period that we may think first. The rational space of Durand, based on the descriptive geometry of Mongue did not only enable axonometry to emerge, but provided the scientific background for all architectural drawings, reinforcing the Renaissance conventions of the discipline. Modernism, despite its proclaimed breakage of history, relied heavily on this framework; and when architectural production moved to computers, the properties of the virtual space of softwares were coded to in accordance with the rules of descriptive geometry in eucledian space. Infinite and homogenous, unitised and measurable, there is a certain consistency in the kind of space in which architects imagine – in this light, the current popularity of axonometry is logical: CAD softwares present this space with an unprecedented visibility, instantifying the connection between axonometry and space

With regard to the worm's eye, the fact that Choisy is being referred to not only when a drawing is used to cover similar aspects (such as the works of IBAVI), but also when it communicates very different ones (such as the collage of Bovenbouw) shows how his name became synonymous with the projection. If anything, this proves the outstanding quality of his work, and how architecture is aware – and proud – of its historical representation. At the same time, the analysis of the technics of case studies revealed the dilemmas behind recreating works with completeley different tools. A clear distinction can be made between the pseudo-orthographic, orthographic and post-orthographic approaches of contemporary practices.

It is important to note that what was an immense technical feat of Choisy at the end of the 19th century can be now easily replicated; the question is, what can someone gain ot of it? Undoubtedly, nostalgia is an important factor; the loss of much of the knowledge of orthographic drawing, combined with the inconceivable speed of imported technics gave birth to pseudo-orthography, the simulation of orthography using computers. As the case study of Stan Allen showed, the underlying processes are often idiosyncratic; caught up in all this is time, which becomes a focal point of contention if we are to understand the importance

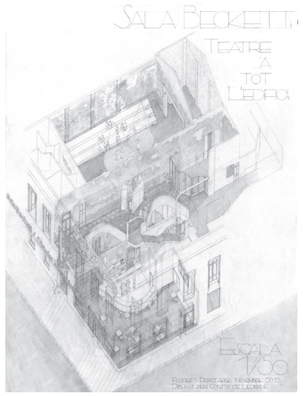
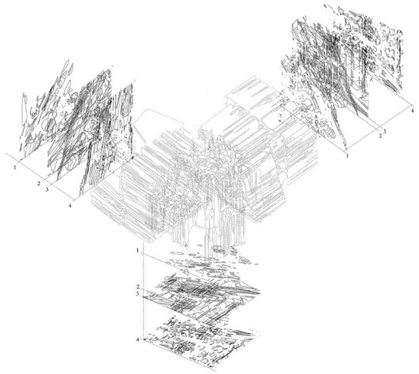
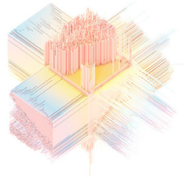


Fig.5.0.1 Flores & Prats Architects, New *Sala Beckett theatre*, 2015. https://florespratscom/archive/sala-beckett-project/

Fig.5.0.2 Judith Casas, *Students with Ricardo Flores and Eva Prats before lockdown*, 2019. https://drawingmatter.org/pan-scroll-zoom-2/





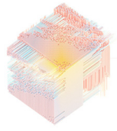


Fig.5.0.3 MILLIONS, *Projectors I*, 2017, digital axonometries. http://www.millionsarchitecture.com/projectors-i/1w686wrb2clh599dcttoaczifnycm

of technics in architecural production. Pseudo-orthography, although it aims to replicate (or continue) history, the time spent on execution happens in cyberspace, without the act of superseding, and thus does not contribute to a gradual build-up of knowledge that characterised the age of mechanical production. Meanwhile, the simultaneity of the real time of cyberspace is not utilised either: additional time is being spent on simulating outputs embedded in different technics – time that does not amout to learning or understanding.

The conclusion is by no means that mechanical production with all its history should be abadoned; on the contrary, the examples of Pezo von Ellrichshousen and other practices such as Flores i Prats (Fig.5.0.1) illustrates the power of working with hand, valuing the time of labour and the heightened consciousness it brings to the process (Fig.5.0.2). However, it is important to note that present-day orthography has its limitations: wrapped in the bubble of the history of architecture, it is unable to reflect on, and engage with the changes in society caused by the technological advancements it rejects.

Politics takes space in the public sphere, which in modernism meant the shared phsical domains of our environment;as the actors responsible for the spatiality of public sphere, architects took on massive social responsibility during the 20th century.[111] What we see now is that the public sphere is increasingly virtual – post-orthography is not only a paradigm shift of architecture, but society at large, and with the hybridisation of politics, architects need to be involved in establishing the social framework of cyberspace if they want to retain the political agency the profession seems to be so attached to.

It is hard to see any avenue for achieving this when architects do not have agency over even just their own toolkit; the discipline is frozen in a state of perpetual amateurism,[112] reduced to being end users who are blindly acceptant of the limitations of the operational framework they are being subjected to. As architect and AR product designer Lucia Tahan explains, it is the appropriation of pre-defined tools that can yield unexpected results,[113] a notion which echoes the approach of MOS, and what John May is also exploring in his projects (Fig.5.0.3).

If anything, the worm's eye is exemplary of architect's advanced spatial thinking, and their skill to synthesise complex geometries. It is the profession tranied to see space; and when we consider the social sensitivity integral to the discipline alongside this knowledge, I see how architecture could live up to the expectations it sets for itself.

111 Tom Avermaete et. al., *Architectural Positions: Architecture, Modernity and the Public Sphere* (Amsterdam: SUN, 2009), X

112 John May. "Field Notes From "The Instruments Project."" *Journal of Architectural Education* 69, no. 1 (2015): 59

113 Lucia Tahan, "From Model to Environment" (Berlage Sessions, Delft, January 20, 2023).

Bibliography

Andrews, Noam “From Delineation to Drawing” (Berlage Sessions, Delft University of Technology, Delft, NL., 25 November 2022).

Allen, Stan. “Drawing with Rafael Moneo, Madrid 1984”. Drawing Matter, 14 March 2019. https://drawingmatter.org/stan-allen-on-drawing-with-rafael-moneo-madrid-1984/

Allen, Stan. “John Hejduk's Axonometric Degree Zero”. Drawing Matter, 23September 2019. https://drawingmatter.org/john-hejduks-axonometric-degree-zero/

Allen, Stan, “Situated Objects”. (John Hejduk soundings lecture, Harvard University Graduate School of Design, Cambridge, MA., 15 February 2023).

Avermaete, Tom, Klaske Havik, and David MacKay. Architectural Positions: *Architecture, Modernity and the Public Sphere.* Amsterdam: SUN, 2009.

Benedict, Scott, and Stan Allen. *Situated Objects : Buildings and Projects.* Zürich: Park Books, 2020.

Bingham, Neil. *100 Years of Architectural Drawing: 1900-2000.* London: Laurence King Publishing, 2013.

Boekraad, Cees, Ruth Koenig, and Tom Haartsen Jr, eds. *Het Nieuwe Bouwen: De Nieuwe Beelding in De Architectuur = Neo-Plasticism in Architecture: De Stijl.* Delft: Delft University Press, 1983.

Bois, Yve-Alain. "El Lissitzky: Radical Reversibility".*Art in America,* vol. 76, issue 4, (April 1988): 160-181.

Bois, Yve-Alain. "Metamorphosen Der Axonometrie = Metamorphosis of Axonometry." [In English]. *Daidalos,* no. 1 (September 1981)

Carpo, Mario, and Frédérique Lemerle. *Perspective, Projections, and Design: Technologies of Architectural Representation.* London: Francis & Taylor, 2007.

Cocozza, Fabiano. "Axonometry: The Grip of Thought on Space—a Short Survey on the Relation between the Act of Planning and a Visionary Visualization Technique." *Proceedings* 1, no. 9 (2017)

Colonnese, Fabio. ““Unorthodox Orthographies”: Projective Deregulation for Depicting Time from Le Corbusier to Oma.” Paper presented at the Design Communication Conference Proceedings, Southern Polytechnic State University, Atlanta, GE., 2014.

Crary, Jonathan. *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century.* October Books. Cambridge, MA.: MIT Press, 1992.

Ellrichshausen, Sofia von, Fabrizio Gallanti, and Maurizio Pezo. "Pan Scroll Zoom 4: Pezo von Ellrichshausen". Drawing Matter, 18 November 2020. https://drawingmatter.org/pan-scroll-zoom-4-pezo-von-ellrichshausen/

Evans, Robin. *Translations from Drawing to Building and Other Essays.* AA Documents 2. London: Architectural Association, 1997.

Flores, Ricardo, Fabrizio Gallanti, and Eva Prats. "Pan Scrool Zoom 2: Flores & Prats". Drawing Matter, 1 September 2020. https://drawingmatter.org/pan-scroll-zoom-2/

Farrah, S. "The Technology of Axonometry in 1960s Britain: Kenneth Frampton and Peter Eisenman." Paper presented at the Historiographies of Technology & Architecture: Proceedings of the 35th Annual Conference of the Society of Architectural Historians of Australia and New Zealand, 2018.

Gallanti, Fabrizio, Michael Meredith, and Hillary Sample. “Pan, Scrool, Zoom 7:MOS”. Drawing Matter, 25 February 2021. https://drawingmatter.org/pan-scroll-zoom-mos/

Hiryczuk, Elodie, and Sjoerd van Oevelen. " Seeing of Course is also an Art". *Philosophy of Photography,* vol. 4, no. 2 (2014).

Hobhouse, Niall. "Stan Allen's *Situated Objects* (2020): Review & Excerpt". Drawing Matter, 24 February 2021. https://drawingmatter.org/review-situated-objects/

Ickx, Wohne. "The Hidden Promise of the Parallel Projection." *Arquine,* no. 60 (2012): 118-123.

Jasper, Adam. "God's Eye View: An Essay on Axonometric Drawing as a Symbolic Form." *This Thing Called Theory.* London: Routledge, 2016.

Jencks, Charles. "Style is the Man". *The Archtiectural Review,* vol. 236, issue 1411. (Septermber 2014): 96-103

Jones, Dora Epstein. "Little People Everywhere: The Populated Plan". *Log* 45, (Winter/Spring 2019): 59-71

Krikke, J. "Axonometry: A Matter of Perspective." *IEEE Computer Graphics and Applications* 20, no. 4 (2000): 7-11.

Koreitem, Zeita, and John May. "Projectors I". Millions. http://www.millionsarchitecture.com/projectors-i/yzzouewu60bnhpepdzyx4xfc0c9yo6

Lissitzky, Lazar Markovich. "K. und Pangeometrie", in *Europa-Almanach,* eds. Einstein, Carl and Paul Westheim (Potsdam: Kiepenheuer Verlag, 1925), 103-113.

Lee, Sang-Ho, Leem-Jong Jang, and Jin-Goo Kang. "A Study of the Digital Virtuality on El Lissitzky's Proun." *Journal of Asian Architecture and Building Engineering* 2, no. 1 (2003/05/01 2003): 215-22.

May, John. *Signal. Image. Architecture.* New York: Columbia University Press, 2019.

May, John. "Everything is Alreay an Image". *Log* 40, (Spring/Summer 2017): 9-26

May, John. "Field Notes From 'The Instruments Project.'" *Journal of Architectural Education* 69, no. 1 (2015): 58–61.

Meredith, Michael, and Hillary Sample. *Mos: Selected Works.* New York: Princeton Architectural Press, 2016.

Panofsky, Erwin. *Perspective as Symbolic Form.* Cambridge, MA.: Zone Books; Distributed by the MIT Press, 1997.

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

Pezo, Maurizio. "Finite Format 04". Divisare, 7 November 2017. https://divisare.com/projects/370355-pezo-von-ellrichshausen-finite-format-04

Reichlin, Bruno. "Reflections – Interrelations between Concept, Representation, and Built Architecture", *Daidalos* 1 (Berlin: Bertelsmann, 1981)

Scannell, Ciaran. "Bovenbouw Architectuur: One Paper Model and Three Paper Collages". Drawing Matter, 12 May 2021. https://drawingmatter.org/bovenbouw-one-paper-model-and-three-paper-collages/

Scolari, Massimo, and James S. Ackerman. *Oblique Drawing: A History of Anti-Perspective. Writing Architecture.* Cambridge, MA.: MIT Press, 2012.

Somers, Dirk. "Takeaways and Projects". (Berlage Keynote lecture, Delft University of Technology, Delft, NL., 15 September 2022).

Stiegler, Brian, *Technics and Time 1* (Stanford, CA: Stanford University Press, 1998)

Tahan, Lucia, "From Model to Environment". (Berlage Sessions, Delft University of Technology, Delft, NL., 20 January 2023).

Tuomey, John. "Stirling at Stuttgart: Rear views/up views." Drawing Matter, 15 June 2020. https://drawingmatter.org/stirling-at-stuttgart-rear-view-up-views/

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