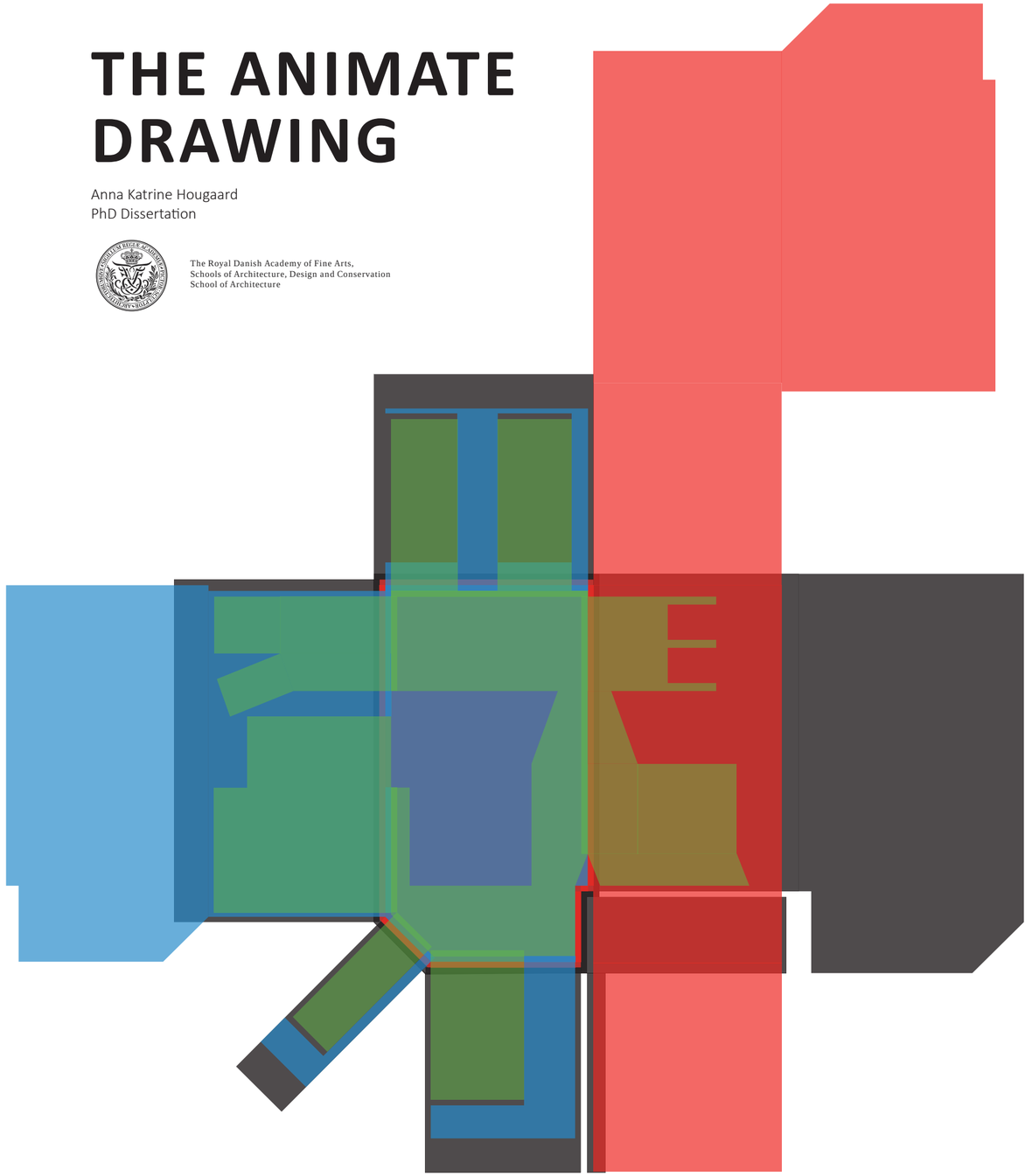
THE ANIMATE DRAWING

The Royal Danish Academy of Fine Arts,
Schools of Architecture, Design and Conservation
School of Architecture

THE ANIMATE DRAWING

Anna Katrine Hougaard
PhD Dissertation

The Royal Danish Academy of Fine Arts,
Schools of Architecture, Design and Conservation
School of Architecture



THE ANIMATE DRAWING

Anna Katrine Hougaard
PhD Dissertation

The Animate Drawing

Graphic design:
Anna Katrine Hougaard

Printing:
Printworkshop

Binding:
Majgrens Bogbinderi A/S

8 copies

Published by:
The Royal Danish Academy of Fine Arts,
Schools of Architecture, Design and Conservation

Supervisors:
Peter Bertram (main),
Per Møldrup,
Martin Søberg

Proof reading:
Sarah Rivière

Copenhagen, 2016

ISBN: 978-87-7830-395-0

The Royal Danish Academy of Fine Arts,
Schools of Architecture, Design and Conservation
School of Architecture

CONTENTS

Blue = Drawing chapters

INTRODUCTION

"It's alive. It's alive!"
Frankenstein, the film, 1931

This Ph.D. project discusses conventional architectural drawing and the intensely discussed role of such drawing in the contemporary computerised context of architectural design. Some architects and architectural theorists prognosticate that conventional drawing is a dying phenomenon due to computational design affordances.[1] However, this is not in accord with the contemporary reality in architectural offices and schools, where conventional drawing techniques such as plan, section and elevation are still very much used. Hence, an *either* conventional drawing *or* computational design distinction seems far too crude and tells us little about the state of conventional drawing today.

This thesis therefore investigates the possibilities of both conventional drawing and computation as a continuum although the emphasis lied on conventional drawing. This investigation is carried out from the point of view that architects do not need to choose between two well-defined architectural media practices, but rather to compile working media in accord with their practice, well aware that the media co-form whatever they are involved in making. Said differently, architects do not only design buildings – in a certain sense they design their working media and the media co-designs the building.

Before computerization it was relatively easy to define drawing as architecture's most important working media with well-defined techniques – plan, section, elevation, axonometric, isometric, perspective – and rules defining how to make and read the drawings. However today it is no longer as easy to point out any one well-defined working medium or practice in architecture. Instead architectural practice uses mixed media, often combining computational and conventional drawing affordances. A medium is an in-between, intermediary device which transports something.[2] For architects, a working medium typically transports ideas about buildings to the building site. Although the thesis focuses on conventional drawing as a medium, the focus is not on how drawing transports information about building from the architect to the site or on how drawing can do so in a determinate way. Rather the focus is on how drawing as a working medium is often overlooked in its role as a co-producing agent in the design process, and how this working medium can be a generative reality of its own – both as an artefact and as a conveyor of instructions and sensations that, in a certain sense, makes the design process fertile. I suggest that an architectural working medium is a reality in its own right, and it is the medium as such, not the relationship between

medium and building that this thesis investigates. This focus has been chosen because the work is carried out as artistic research, which means that the thesis is generated from reflections on my own drawing practice. My drawings could be called diagrammatic, theoretical, and speculative, and are hybrids between conventional drawing techniques and simple computational affordances such as render engines that simulate light and shade, or small computer scripts that simulate movement. The impulse behind my drawings is often a striving to show the drawings as media themselves. But since one cannot draw a medium or a drawing technique without drawing something, things are indeed drawn – often movable or flexible things that underline the animations that are possible in a medium but not possible in the same way in a building. By investigating the media space of drawing almost without thinking in terms of building, this approach to drawing as a medium and as an architectural way of thinking is underlined. And yet, architectural drawing techniques are made to support building, so even when the space of drawing is investigated in its own right, the space of the building is never completely lacking but always presupposed, always suggesting itself as the next step.

Media awareness and some paradoxes of convention

A convention is "a custom or a way of acting or doing things that is widely accepted and followed"[3] and the above-mentioned drawing techniques – plan, section, elevation, axonometric, isometric, perspective – are architectural conventions. For instance, it is customary to draw a plan as a horizontal section through a building seen from above in orthogonal projection. It is also customary to accentuate the cutting surface and to draw to a certain scale which again requires a certain level of detailing. The drawing conventions comprise a combination of projections (orthogonal and perspective), geometrical tools, techniques and procedures for carrying out the drawing activity, together with signs and signatures, the understanding of which is shared by trained architects. Together these elements make up a shared, conventional notational system that can be used in the design process, typically aiming at building. Usually the process begins with sketching, and develops towards an increasingly well-defined set of working drawings.

While conventional drawing has been seen as *limiting* the range of architecture,[4] it is also *open* in several ways. It is open enough to allow the indeterminate first sensations in a project to be sketched out. It is also open enough to draw completely different houses with the same techniques – for instance in plan. As such, conventional drawing is both open and limiting. This double nature of shared drawing conventions in architecture has also been underlined by the anthropologist, Edward Robbins,[5] who sees conventional drawing as enabling a *non*-limiting condition, which allows architects to communicate both with each other and with other actors in the design and building process. On the other hand, Robbins also sees that drawing can also be introvert and unconventional, a conversation with oneself where something is invented, as in a sketching process. Hence drawing conventions are paradoxical because they can both open things up, allowing for example sketching and discussion, and rule things out – as not everything can be drawn along the lines of conventions. The dual nature of conventional drawing makes a completely logical and shared diagram available to architects, a rational framework for exchange and communication, which in turn is used in highly subjective practices that are poetically and sensuously motivated, and which do not themselves always follow shared rationales or conventions. Drawing is both a technical medium 'subjugated' to building, where it simply passes on instructions about the building, but also however, the drawing is an artefact in close relation to its situated maker, itself a *thing* and a *world* of imagination that has the ability to 'subjugate' building to itself.

Interestingly, drawing has also been used to question its own conventions to such an extent that these are transformed, as Bernard Tschumi did in *The Manhattan Transcripts*.[6] Tschumi used drawing conventions as the 'background' from which his inquiry began, and he then sought to open up the conventions towards transformation by introducing notational techniques from film. This thesis gathers inspiration from Tschumi's way of using conventions as a background against which transformations of the medium itself can be seen, a background which is already full of paradoxes, which however can be productive in the inventive phases of design, and these paradoxes remain just as relevant now as they were before. The proposition of this thesis holds that, although changes in the realm of conventional drawing do happen, there are also important aspects in the inventive phases of design process – the sketch phases – where conventional possibilities for cultivating indeterminacy in a productive way are still valid.

Diagrammatic reasoning in artistic and academic practice

Although the technical equipment and notational forms of architectural media undergo change, there are also things that do not change. It is suggested that this situation of 'both change and non-change' can be conceptualized with the diagram concept of Charles S. Peirce, especially as read by Frederik Stjernfelt. Gilles Deleuze's diagram concept, *the diagram as motif*, is also incorporated in the discussion, extending the concept of the diagram towards painting as an art practice, which is a neighbour to architectural drawing. The thesis gives an understanding of conventional drawing as a form of diagrammatic reasoning which is able to not just transform things (which is how drawing is most often used – to invent or transform space), but also to transform itself

as medium. Because the media field is more complex and offers more possibilities, today a heightened media awareness is especially important for architects who materialize the world through media.

Thinking through drawing, it is argued, is a sort of diagrammatic reasoning, but in a different format and 'material' to that of diagrammatic reasoning in academic, scientific practice. Diagrammatic reasoning with drawing forms part of the methodology of this thesis, as it has been carried out as artistic research. In short this means that my own architectural art drawings are placed in proximity to the theoretical parts of the thesis, and that both drawing and theory were used to think about some of the same issues. It also means that some of the thesis' leitmotifs come from my drawing practice, for instance the idea of a hybrid drawing situation – part conventional, part computerized.

The thesis is methodologically experimental because it asks more than answers the question whether architectural drawing can contribute to architectural research. Artistic research is an emerging field of research, so the thesis is to some extent forced to partially invent its own methodology. By placing drawing and theory in immediate proximity to each other the limits of what can be accepted as knowledge production in architectural research are sought and questioned.

According to Peirce the diagram has the ability to structure thought and bring clarity, as well as being helpful for inventing 'the new'. Therefore diagrammatic reasoning has been chosen here as the theory of knowledge that best supports the working method – artistic research – because diagrams are vessels for reasoning in both architectural design and scientific research. This does not in any way claim, though, that these practices are the same, but that a shared zone of diagrammatic reasoning may be found between them. Diagrammatic reasoning is also relevant for the contemporary state of conventional drawing in the context of the computer, since, according to Nelson Goodman, diagrams can be both analogue and digital. Therefore the following research question is asked:

> *What is the potential of diagrammatic reasoning using conventional, architectural drawing both in the context of the computer, and in the context of architectural research?*

Thesis structure

In order to answer the research question, which approaches both issues of drawing in the context of the computer and in a research context, the thesis is structured into two parts, *DRAWING REASONING I, II, III* and *MEDIA MUTATIONS I, II, III*. The first part covers the methodology and diagrammatic reasoning, and forms the background against which the second part can be understood. The second part is more directly concerned with drawing in the context of the computer. In addition, the thesis begins with a state of the arts chapter which outlines the current discourse on conventional drawing within which this thesis is located. On a more fundamental level, one could say that the thesis reflects upon what it means to be precise about indeterminacy and about phenomena in ongoing change such as architectural media and architectural research.

Notes - Introduction

[1] For instance Mario Carpo, *The Alphabet and the Algorithm* (Cambridge, Massachusetts and London, England: The MIT Press, 2011). See also the conference "Is Drawing Dead?" at Yale School of Architecture, 2012 http://www.youtube.com/playlist?list=PL79A5264A0ADED746 (accessed 14.12.2015).

[2] http://www.merriam-webster.com/dictionary/medium (accessed 11.11.2015)

[3] http://www.merriam-webster.com/dictionary/convention (accessed 31.10.2015)

[4] Hans Scharoun's *Berliner Philharmonie*, for instance, was developed in models because the imagined spaces were not supported in any way by conventional drawing techniques. See Robin Evans, *The Projective Cast – Architecture and Its Three Geometries* (Cambridge, Massachusetts and London, England: The MIT Press, 1995), 119, 221.

[5] Edward Robbins, *Why Architects Draw* (Cambridge, Massachusetts, London, England: MIT Press, 1997).

[6] Bernard Tschumi, *The Manhattan Transcripts*, expanded 2nd edition (London: Academy Editions, 1994).

STATE OF THE ART:
THE MANY LIVES AND DEATHS OF ARCHITECTURAL DRAWING

Introduction to the chapter

The situation of drawing has changed considerable since architects started to use computers as a working medium during the early 1980s, a practice which gained a foothold in the profession towards the end of the 90s.[1] Today the situation with respect to architects' working media is complex in comparison to that described by Edward Robbins in his 1994 book *Why Architects Draw,*[2] where he is able to list the conventional drawing techniques – plan, section, elevation, perspective and axonometric – activities that take place at drawing tables with paper, pen, ruler etc.,[3] as *the* way that architects work. This chapter focuses on drawing theory today in order to situate this thesis and to give an overview of the many facets of drawing as architectural working medium.

Although the situation of working media before the computer was less complex, drawing traditionally plays many different roles during the design process, from sketching to working drawing, and is used and valued differently by different architects: some emphasize drawing as a way to develop ideas and concepts, while others emphasize drawing as a facilitator for building. To this it is now necessary to add the fact that drawing has 'migrated' from a pen and paper environment to the computer, and although this migration has been going on for some time it is currently being discussed with great passion, maybe because it has become almost self-evident that architects de-facto design with computers. This discussion is the locus of much anxiety, and questions have been raised as to whether drawing, as architects have known it since the Italian Renaissance, will persist or surrender in the context of the computer. To think about the situation as being an either–or situation, where architects have to choose between drawing or computer, however, might not be in agreement with practical reality in architectural schools and offices where conventional drawing is still being broadly used *while* done with computers. Nonetheless, these excited discussions are about more than just trying to prognosticate the medium of future. Any discussion of working media is also a discussion about what architecture is and should be, because, as Robin Evans has convincingly argued with regard to conventional drawing, the working media co-produces the architecture that is made. This is particularly relevant to the situation we have today, where media use is changing and its possibilities broadening, and architects are faced with both having to be more conscious of what their working media can do, and needing to ask how the medium relates to the architecture they wish to make. Hence, when we discuss an older medium in the context of a newer one we might unveil presumptions and world-views embedded in earlier conventions.[4] Below I discuss the

role played by conventional drawing as being fundamental for migrations and ramifications into the computer, and not as a medium already outdated. As a conclusion to this chapter a map is drawn of the different theoretical standpoints gathered from drawings by architects and theorists connected to research environments at universities in Britain, Switzerland and the USA, as well as from the School of Architecture in Copenhagen (KADK), where this thesis is made.[5]

DISCUSSIONS AND THEORIES

A falsely posed question

Is Drawing Dead? was the title of a conference at the Yale School of Architecture in 2012.[6] Looking at discussions of this question in sessions composed of ingrained 'drawing architects' such as Peter Cook and Michael Graves together with ingrained 'computational architects', such as Greg Lynn and Preston Scott Cohen, it is clear that that the answer is neither yes nor no, because drawing in architecture is so many different things. There is consensus that technical drafting by hand for building purposes has by and large been replaced by computer-drawn working drawings, but this development was not the main focus in the sessions. Rather the question was aimed at drawing and sketching as an inventive, critical act. To this end Cohen formulates an important distinction, namely between architects who feel *invited* to do architecture by drawing, as opposed to architects, like him, for whom building is the main objective. The distinction is important, because it touches upon two different ways of emphasizing media in the design process. When an architect feels invited to do architecture because of the drawing, the drawing as medium is emphasized as a space in which the architecture starts; a space in its own right, which has its own logics and ways of conveying instructions and sensations. The medium-artefact will then, so to speak, become *suggestive* of the built space, rather than the other way around. Despite the fact that Cohen's practice is computer-led he raises the issue that it is difficult to design buildings without thinking about plans, stairs, elevators and such typological building elements, with which drawing has a close historical relationship. It is not that Cohen defends drawing for this reason, rather he points out that it is difficult to design a building without thinking about these elementary typologies. Said differently, although the working media is changing, conventional drawing answers to the needs of building in the Western tradition in some practical and still very relevant ways.

Another issue that Cohen raises is whether architecture *is* technique and media use or whether architecture *comes after* technique and media use. This is an important point, because this is a question where 'drawing architects' and 'computational architects' suddenly find themselves standing side by side because of other incitements than those that led them to their medium of choice. Cohen argues that architecture (building) comes before technique, a point in line with the previous one that drawing for him is most important in order to facilitate building, and not as a suggestive invitation to create architecture. This is opposed to many of his fellow speakers, including Lynn and Graves, who are on the same side in this regard, arguing that technique, whether it is drawing or computer technique, has to become second nature and from thereon architecture. Hence there seem to be different constellations of alliances that re-form depending on which media are used or on whether the respective media spaces are more important than the building's space. This also reveals that architects have different ideas of where the priorities in architecture lie and that this can cross the 'boundary' drawn by the conference between drawing and computational practice. Lynn and Graves emphasize the space of the medium, Cohen the space of building, a priority he shares with the architect Marion Weiss, who, as opposed to Cohen and in line with Graves, uses hand-sketching as a leading motive in her architectural practice focusing on building.

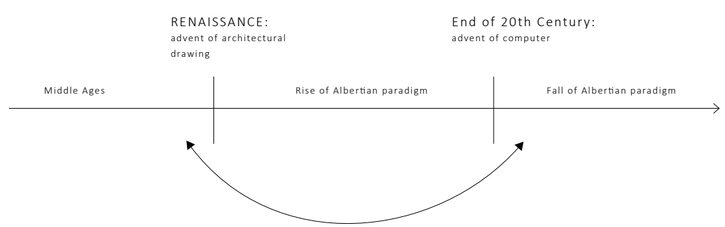
The hand-sketch is another important medium that is currently being intensely discussed, and to which I will return. The elevation of hand-sketching to something almost sacred because of the intimate relation to embodied intelligence flowing through the hand, as Juhani Pallasmaa argues, meets resistance from Antoine Picon who thinks that new digital "sensoriums" might indeed emerge that can replace hand-sketching in this regard. Picon points out that in the history of technology out-dated technical phenomena *do* die out when others appear, which is, however, not to say that sketching has died out nor that it will die. Picon admits that the directness of the brain-hand conversation in hand-sketching has not yet found a corresponding digital interface, but thinks that one might yet be developed. That sketching as such is not necessarily linked to hand drawing is shown by Lynn, who shows how he sometimes uses hand drawing to clarify matters *after* having sketched with computer models. Also Casey Reas, one of the founders of *Processing*, shows how he directly sketches with code in a scripting performance. Reas presents *Processing* as an open source platform for *sketching* (a file in Processing is also called a sketch) with an artistic intent. Such extended notions of sketching are interesting for this thesis, where sketching is later on investigated more for its opening, diagrammatic qualities, rather than for being a pen and paper activity (*MEDIA MUTATIONS III*). To this idea art historian Martin Søberg from the KADK argues in another context that sketches are open to many diagrammatic readings.[7] He emphasizes the aspect of sketching where meanings and readings oscillate so that the sketch becomes suggestive and productive of a potential for developing an architectural practice. This idea is in line with that of the architects at the conference, who emphasize drawing as an invitation and as being suggestive of building. The conference makes clear

the diverse roles that the medium plays towards architects and the different priorities architects have: some prioritize technique and media, some building, but such priorities do not have any clear causal effect on the choice of working media. Each architect at the conference has refined a coexisting interplay of media that suits their architectural practice. The conference also makes clear that just as painting was proclaimed dead due to photography,[8] and cinema due to the remote control,[9] drawing is not dying – but neither is it the 'one and only' architectural working medium that it used to be.

The death of an author

The final talk at the conference was given by the architectural historian Mario Carpo, who presented arguments from his book *The Alphabet and The Algorithm.*[10] His book covers the history of architectural media practices from medieval times of hand-crafting through the era of identical copies and up until the emergence of computer technologies today. Because computational techniques and algorithms enable architects to *not* make identical copies, but rather to make a variety of forms from the same algorithm, Carpo says that we are in a media situation similar to the one of medieval times, where all things were handmade and therefore never identical.[11] The timeline that Carpo projects is hence close to symmetrical[12] as he almost equates computer-made variety with hand-made variety. Although it must be said that on another level these sorts of varieties are not the same, since there is a quite different medium at stake in the process. While the whole book is about this new medium, it is curious that the media as co-creating agents are glossed over. I will devote a number of pages to Carpo here, because his book is important to this discussion precisely because it differs considerably from my own arguments in this thesis. Where Carpo argues that there is one appropriate medium of our times, the computer and its affordances, I argue for a *non*-general condition of media use today, because the situation is multifaceted and always situated in architects' "working nexuses."[13] For Carpo drawing is an out-dated technology that has been architects' straitjacket for centuries and which can now finally be replaced by the computer technology and algorithmic design of our time. The main contentions from Carpo's book which are important for this thesis are firstly, his idea of computational

MARIO CARPO



design and production mending the separation between mind and matter, which historically is related to Alberti's introduction of orthogonal drawing as the prevalent media practice in architecture. And secondly, Carpo's idea that there is lesser value related to *agency* than there is to *authorship* with regard to the way architects use media.

Mind and matter reunited?

Carpo's book contains an ambiguity concerning his interest in the open source possibilities of computational design as a kind of a Wikipedia meets BIM software media use,[14] which can be seen as very democratic,[15] while at the same time he rushes on to declare a new and more powerful author than that of the Albertian drawing.

Carpo argues that Alberti's implementation of orthogonal drawing in plan, section and elevation was already digital and allographic in Nelson Goodman's sense of the term (I return to Goodman later). Thanks to digital notation Alberti created a situation of "notational identicality"[16] between building and drawing, however, he did not have the technical equipment, the computer, to ensure that his notations were transposed correctly, but was obliged to let human scribes carry out the copying and interpretation of his work.[17] Nonetheless, Alberti created a situation of notational identicality between drawings and buildings, which granted architects intellectual authorship and ownership over building despite the fact that they had neither built it, nor owned it.[18] Since a situation of notational identicality had been established through conventions of orthogonal drawing, for Alberti the building was nothing more than a mere copy of the drawing, says Carpo.[19] This claim presupposes that the notational system of conventional drawing is already completely digital, and thus focuses only on working drawings for building while failing to acknowledge Goodman's assessment of architecture as both an allographic/digital and an autographic/analogue art form.Carpo thinks that digital computer notation – the algorithm, the code, the script – liberates architects from the Albertian paradigm and the era of identical reproduction to which conventional drawing is also related by him.[20] Carpo celebrates that the separation and division of labour between drawing and building in architecture has been overcome, a division which came from Alberti and elevated architects to being those who do the mind's work through drawing, while craftsmen do the hand's work through building. While Carpo is being critical of the division between thinking and making that is contained in Alberti's way of designing by drawing, and suggests that the separation has been overcome with computational production procedures, I would question whether this separation of social roles between architect and builder has truly been overcome, and suggest that it is

still the medium and not the building site which is close to the architect, although the medium has changed and have production possibilities that drawing does not.

Although drawing can be both a theoretical tool as well as a tool to reflect ideas, it is also a craft.[21] The materials of this craft are pen, paper, geometrical tools, computers, software surfaces, lines, points, projective systems, etc. Admittedly these are not heavyweight material conditions in comparison to building, but worth pointing out nonetheless, because – contrary to Alberti's arguments – not all drawing starts with an idea fully projected in the mind, which is then transferred to paper. Rather, the above-mentioned drawing 'material' co-forms both the drawing process and what is drawn, and hence we are not really dealing with a clear cut division between mind and matter, where drawing seamlessly reflects an idea, but rather we can see that ideas or sensations transform and emerge *as* they are drawn, being co-formed by the drawing 'material'. Moreover, architects today are not builders in the way that pre-Renaissance craftsmen were, just because 3D fabrication possibilities move production closer to the architect. The gap between drawing and building is indeed, as Carpo points out, bridged in a different and potentially tighter way with computational possibilities than drawing allows for, a way that may indeed require more building and engineering knowledge. But this is not sufficient reason to then claim that we are in an unmediated situation again today or that the division of labour that drawing brought with it has been overcome.[22] The mind is not reinstated in the body, simply because architects can control 3D machines. Rather the mind has been in the body all the time, and architects have always thought with and through their working media, depending on the way these media were used in their own practice. Carpo says:

> Acting almost like prosthetic extensions of the hands of the artisan, digital design and fabrication tools are creating a curiously high-tech analog of preindustrial artisanal practices. Traditional craftsmen, unlike designers, do not send blueprints to factories or building sites: they make with their hands what they have in their minds.[23]

But Carpo's claim that "they make with their hands what they have in their minds"[24] in a way leaps over the question of how exactly the technical equipment that a craftsman has in his hands has changed, or what the effects of this change are, since exactly the same claim could be made for an architect in the process of making a drawing. It could be interesting to ask how the "prosthetic extensions of the hands"[25] co-create that which is made, just as the drawing 'material' co-creates what can be drawn. That is, of course, not an easy task, and Carpo is aiming at conceptualizing the new production possibilities as being similar to the actual making of a building, which differs from the way one works with drawing. However, many computational designers point out that this process of controlling the machine is far from being as seamless as one might think.[26] While it is important, as Carpo does, to try to conceptualize these relatively new possibilities, I do think that he tones down the interfering medium too much. Many architects have claimed that they build when they draw, just as programmers have said that programming is a tool for the mind.[27] That both drawing and programming can be considered to have craft like affinities[28] indicates that it is not drawing that belongs to the mind, nor is it controlling a 3D printer that reunites thinking and making, but it is the experience of what the different media can do which creates a craft-like connection between mind and matter.

Arguing against Carpo is *not* an attempt to argue that drawing did not create the social hierarchy that entered building practice during the Renaissance, where architects rose in both social status and power. It is rather a critique of keeping up a mind-matter distinction while also arguing against it, as if it had now been overcome or set straight and comparing a highly mediated process, like controlling a 3D production machine, with a process that is much less mediated, namely actual building on site. In that way, Carpo actually preserves the idea that he is himself against, namely that there can be something like an un-embodied mind of a generic and primary author.[29]

Agency or authorship?

In an earlier text[30] Carpo points out that algorithmic, computational design is similar to medieval building practice because medieval craftsmen orally carried algorithms for building amongst themselves as shared secrets. Exactly because of this algorithmic, formulaic knowledge one edifice would never become quite like any other.[31] The practice of medieval craftsmen can hence be seen as analogue and yet also algorithmic, whereas algorithms today are usually thought to be part of digital technologies. Algorithms in architectural design can produce a variety of slightly different outputs through the use of computationally controlled machines. If this can be seen as putting architects into a situation similar to that of medieval craftsmanship, it also – because of computational, algorithmic affordances – extends these crafting possibilities to include, for example, enabling non-architects to participate in design processes through social networks. Carpo calls for research on exactly this phenomenon, which he coins as a 'Wikipedia meets BIM´ possibility,[32] where many people can work together on the same architectural model. Carpo is quite right in pointing out that this potential has not yet received much attention. However, he does not go into the extraordinary implications of this question in real depth, and while praising the open source movement he does not reflect the ways in which more commercial social networks are not necessarily only liberating, but rather also comprise a surveillance and sales apparatus. Carpo presents

only the positive way in which these technologies work, where indeed they can also heighten and unify control within the processes of translation from architect to building. But both in drawing and computational design the notation can be both tightened or loosened, a point I elaborate on with regard to drawing in the final chapter (*MEDIA MUTATIONS III*).

The use of 3D production machines holds the promise that bodily labour can be diminished, a point that Carpo is not alone in making. Take, for instance, the highly fascinating work of the architect Skylar Tibbits who is interested in diminishing the "slave labour" of assembling building or model parts that have been printed with the help of computers and fabrication machines.[33] Tibbits' idea is to embody building parts with intelligence in ways that make them self-assemble when a force of some kind is applied, coined as "4D printing." Tibbits' goal is to make the transition from computer-coded model to built object on site happen automatically. Although this might indeed reduce "slave labour" it is also a unification of control over matter, since matter is then directly controlled by the architect sitting behind the computer. However this must be viewed more as an idea in the making than a full-scale possibility.[34] Carpo does not point out the double-sidedness of such possibilities: on the one side diminishing slave labour, while on the other side unifying control, and, as mentioned above, he does not go into the 'Wikipedia meets BIM' idea in any depth. Instead he closes the book by declaring the death of the author of the Albertian paradigm,[35] – the drawing author, but only in order to reinstate a new author, namely the "generic" and "primary author"[36] of digital algorithms.[37] According to Carpo, architects today must choose whether they want to be "secondary" authors of objects, or technologically contemporary, "primary" authors of algorithms. A secondary author is a 'mere' agent similar to that the player of a video game is an agent, whereas the creation of the game is an act of authorship. To this end Carpo draws on Janet Murray's definition of agency, although she gave that definition in the context of computer games and interactive texts and not architecture.[38]

> In this dialectic, the secondary is to the primary author what the player in a video game is to the video game's designer: each gamer invents (or, in a sense, authors) her or his own story, but playing by the rules of the game and within an environment conceived by someone else. As Janet Murray remarked long ago, the player in a digital video game—an "interactor" rather than an author—exerts only a limited and ancillary form of agency. Architects that by choice or by necessity intervene in someone else's digital design environments are to some extent only secondary authors—end users and not designers. […]. And soon designers will have to choose. They may design objects, and then be digital interactors. Or they may design objectiles [digital algorithms], and then be digital authors. The latter choice is more arduous by far, but its rewards are greater. Objects belong to the old, mechanical world of identicality and products, of centralization and authority. Objectiles belong to the new digital world of variability and process, of participation and community. The old world offers a multiplication of choices in an ever-growing catalog of ready-made products, hence consumerism. The new world promises seamless, on-demand customization through Interactive decision-making, hence—ideally—social responsibility in design, as well as parsimony in the use of natural and human resources. To embrace digital authorship in full, however, designers will need to rise to the challenge of a new, digitally negotiated, partial indeterminacy in the process of making form. And this will not be easy, as no architect was ever trained to be a generic author – nor, most likely, ever had the ambition of becoming one.[39]

Following from this, architects who do not write algorithms (objectiles) are secondary interactor-designers, as opposed to primary, generic author designers of algorithms and software. Carpo groups the secondary interactor designer with terms such as "consumerism," "identicality," "centralization and authority," whereas he groups the primary author, the designer of algorithms, with terms such as "participation and community," "social responsibility," and "parsimony in the use of natural and human resources."[40] But, I ask, why does he not disclose the possibilities of digital media in a way that also shows how it can centralize control and authority or increase consumerism? And why proclaim a value-laden distinction where authorship is primary to agency, while at the same time celebrating the potential for co-authorship in the digital format of Wikipedia? Carpo's voice, which is often present in discussions on architectural drawing, makes it clear that this discussion desperately calls for more transparency as to how notational systems work together with technical equipment in often very subjective and situated design processes. It calls for attention to and acknowledgement of the gaps, influences, changes in translations, paradoxes, and discrepancies; i.e. new attention to the well-known fact that there is no such thing as unmediated making or neutral transportation of information. It is relevant to note that the architect Stephan Rutishauser from ETH Zürich argues, in line with Carpo, that working drawings will become:

> […] an obsolete instrument, since the mediation between architects and builders will no longer be necessary when the transformation to matter is carried out by machines, and the machine's transformation code is written directly by the architect. On the other hand, the person who is programming (the architect) will have to understand a great deal more about the material and technology of construction. Thus, […] the job profile of architects will change and the drawing architect will again become a designing engineer.[41]

Rutishauser argues that there will then be no part of the building process that the programming architect cannot control or optimize in the future, but notices in passing;

"[o]f course, any architect who stakes a claim to creativity dismisses this idea."[42] This is a paradoxical statement since creativity is involved in the making of algorithms.[43] Maybe Rutishauser's intention here is to outline a difference between more general software development as opposed to software development directed at unique design processes, a difference which Jacob Riiber outlines in his PhD thesis on generative processes in computational, architectural design, where he coins the term: "the agency of scripting"[44] in relation to unique design processes.

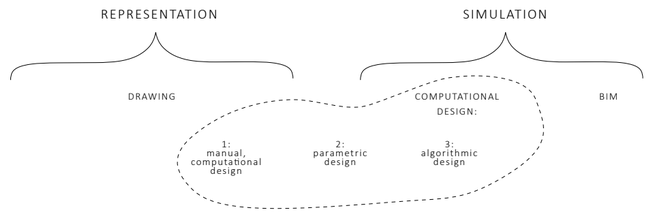
Through the arguments above it is becoming clear that even though only a handful of drawing techniques could be outlined as being architectural media (plan, section, elevation, perspective, axonometric) before the computer, these drawing techniques could be used in very different ways. They could be used to create suggestive drawings, which would eventually be developed in the direction of building, or they could be used more practically to support pre-conceived ideas of building. The same opportunity to set different emphases on how computational media can be used has been reflected by Tibbits, Rutishauser and Carpo, who emphasize the role of media in supporting building. In contrast to this, Reas and Lynn emphasize the role of media as spaces themselves, in that they become suggestive of space that could be built. Hence, just as conventional drawing is not linked to one particular way of practicing architecture, nor is computational design. Thus it can be concluded that we are not dealing with an easy, bi-polar distinction where the architects who use the same media have the same ideas of what architecture is.

Drawing as a social and cultural act

Curiously, the anthropologist Edward Robbins uses many of the same arguments as Carpo in *Why Architects Draw*, but Robbins uses them to other ends. His intention with the book is to disclose the social use of drawing in architecture, how it empowers architects and how it limits them. As mentioned in this chapter's introduction, in 1994 Robbins was easily able to pin-point the conventional drawing techniques: plan, section, elevation, perspective, and axonometric, as *the* ways of working that existed,[45] and thus set a limitation on what is meant by the term *conventional* drawing. Today the situation of working media is more difficult to outline in any simple way, but the architect David Ross Scheer tentatively outlines such an overview of media practices in his book *The Death of Drawing*.

Scheer categorizes drawing under the heading of *representation* and representational thinking. All computational design practices are *simulations*, which use computational affordances to organize geometry.[46] Scheer distinguishes between computational design and the use of BIM software, where BIM is about economical and functional performativity, in Scheer's view, while computational design is rather related to an interest in bespoke software and various 3D fabrication possibilities. The computational designer is a programmer capable of thinking in relationships located amongst abstract codes based on mathematics and syntax, as opposed to drawing thinking, where spatial relationship between objects are represented in geometrical drawing space with a visual similarity to the spaces being represented. According to Scheer there are three categories within computational design: the first category has similarities to my own drawing practice, which can be seen as not computational, but rather as a representational way of using the computer, an extended way of miming conventional techniques by including some computational affordances.[47] In this practice editing is generally difficult because it is carried out by the architect self, who must check if adjustments are being implemented correctly and coherently in a project, and not via updating a system of algorithmically interrelated parameters that secure coherent corrections.[48] Since this computational practice follows a 'drawing way of thinking' this practice does *not* use computers in an optimal way. The second category, *parametric* design, describes architects who generate shapes from a set of parameters and algorithms. Designers formulate "relationships that will generate an object."[49] Once an object is generated the designer becomes the one who chooses amongst the objects and sets the values of the parameters.[50] The third category, *algorithmic* design is parametric design that uses computational logics even more extensively. Algorithmic design includes "populational thinking" and criteria of "fitness" for the selection of objects amongst generations of objects generated by algorithms set into a system with each other. It may, for instance, simulate emergent processes from nature. Although this way of designing would not be possible without computers, it is nonetheless the designer who chooses the criteria for generation and fitness of shape, and who makes the final choice amongst objects that have reached a stable condition.[51] Although Scheer is critical of simulation, and especially of BIM, he encourages architects to become familiar with these ways of thinking, and is particularly optimistic about the craft-like aspects of computational design. Crafting, according to Scheer, includes an exploration of what the tools can do.[52] However, he argues that it is fundamental *not* to hide how the computer works.[53] Digital craftsmanship which Scheer sees as addressing the craftsmanship of coding can, like drawing, be considered to be both a craft and a medium.[54] I refer to

DAVID ROSS SCHEER



these newer distinctions in a more complex field of media use throughout the project, but use the term *computational* design to describe parametric and algorithmic design rather than 'manual, computational design' as used in my practice, which involves using the computer in a predominantly representational way. But here I will now discuss Robbins' conclusions that architects use drawing in their practice in a very differentiated way. Architects do not limit themselves to using the conventions, but even when 'only' drawing was available, they directed drawing use specifically towards their own ideas of what architecture is and should be.

Similar to Carpo, Robbins argues that drawing has become an instrument in architecture that maintains a discourse of "mental production" over material production[55] where architects are the expert makers and readers of drawing.[56] This has become a way in which architects can maintain their status in the building process and as cultural actors in society.[57] It is interesting – and here Robbins differs from Carpo, who does not address media use in ideation processes at all – that Robbins tries to catch sight of the drawing as being a medium that enables both the movement between idea and building as well as being a social and cultural medium, because this shows an attention on Robbins' side to drawing's dual nature. Robbins is suspicious of taking it to be self-evident that architects draw,[58] arguing that when drawing has become a naturalized instrument, it is easy to forget that architecture can be made without drawing, and that drawing is a specific historical media practice; this again is an argument similar to Carpo's. But when drawing as cultural and social agent is overlooked we are blinded by its impact on social production and power relations, and such blindness will limit architects, claims Robbins.[59] Hence it is necessary to inquire, to open up – so to speak – the medium of drawing in quite another way of investigating the medium than that of Carpo.

Robbins points out that the conventions of drawing were themselves made and only became widespread practice during the sixteenth century.[60] Although the historical division of labour introduced with drawing is not the main scope of this thesis, it is important because it brings with it the dual nature of drawing as both a conceptual activity for inventing architecture as well as a technical and social facilitator for building. Within this dual nature, for Robbins it is the broad, shared notational system of drawing, the convention that makes it possible to communicate, that is the most important quality. He finds drawing and sketching used to invent architecture to be less important, but rightly sees that these two qualities cannot really be separated:

> Architects have the capacity, on the one hand, to conceptualize completely new and experimental or even completely visionary or fantastic possibilities on paper using only their own time. On the other hand, drawing provides a conventional basis with which architects can communicate with others in the social production of and materialization of a design.[61]

Robbins then relates the drawing conventions to what he calls a "social act"[62] of drawing. The social act of drawing has to do with it being a broad, shared system of communication enabling different actors in architectural processes to talk to each other. The convention makes it possible to remember complex information, to link, for example, responsibility to a particular architect who did a particular drawing; it enables drawings to play the role of a legal document,[63] and to save time, since it is quicker to draw first than to build without first drawing.[64] Moreover, drawing allows architects to transform the outer world into their own world.[65] The benefit of this, says Robbins, is the social interaction that drawing allows for: sharing knowledge and intelligence, and the ability to "transform the needs of others."[66] The dangers include a lack of transparency in the way that drawing is used – a sort of agreement amongst architects so as to maintain their social status:

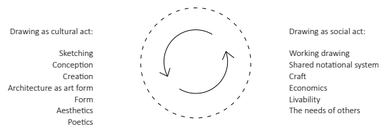
> Other forms of architectural drawing are left more abstract, legible to fewer actors and drawn by still fewer. Drawing in this instance remains a cultural act, not directly encumbered by the process of production even if eventually it is to be used in that process. When used in this way, drawing can be as unconventional, as poetic or idiosyncratic, as the individual who drawing wants it to be.[67]

Robbins encourages using drawing as dialogue,[68] and this shows his standpoint: that it is as a social act that architecture and drawing, as such, play their most important roles. With emphasis on this aspect, Robbins foregrounds the convention's potential for openness as being dialogical:

> [t]hrough the drawing offered by the architect, others are made privy to the interior world of architectural creation and are asked to comment, correct, and reshape that creation. At this moment, architectural dialogue is the most open, generous, and sharing of dialogues, as each participant not only provides insights into his or her ideas but shares with others the way those ideas came to be what they are.[69]

But Robbins is aware that the cultural and the social act of drawing cannot really be separated.[70] This is an important point because the distinction still remains between emphasizing architecture and media either as a more of a social act or as more of a cultural act, despite the fact that media use is increasingly complex today, as seen in the

EDWARD ROBBINS



Is Drawing Dead? conference. In fact these are poles in a continuum, not completely separate acts. Drawing as a cultural, conceptional act "provide[s] the basis for what will become working drawings."[71] However if drawing as cultural act is given too much emphasis, "issues of craft, the limits of convention, the notions of livability, and the social realities of everyday life, [...], have become secondary to issues of form, aesthetics, symbolism, poetics, and structure."[72] In particular architects who take drawing and the media space as a primary architectural concern argue against this,[73] as I do myself, saying that drawing does indeed *support* the invention of architecture. This is confirmed by Robbins, following his series of interviews with architects about the way they use drawings.[74] The movement between drawing as social act and as cultural act remains at the heart of discourse in this area; some emphasize media space and its techniques, such as Graves and Lynn, for instance, while others emphasize building, such as Cohen and Weiss, although they use different compilations of media. This does not mean that building space is social per se, or that media space is cultural per se. But it means that building created the need for the shared conventions in the first place, and for this reason the conventions, which are related to enabling building, inherently have a social aspect allowing for communication. On the other hand, this also means that even unconventional drawings made with conventional techniques have a presupposed relation to building, and thus the use of conventions always offers an entrance to building. Robbins does not negate the dual nature of drawing as an architectural working medium, but highlights the two tendencies as being related to each other.[75] But he also gives a distinction as to whether architects are more interested in media space or building space, in architecture as a cultural act and art form or as a social act. Ideally, of course, these would form a synthesis, and here Robbins adeptly asks what the visions for architecture are, and how these can be supported through the ways architects use media, instead of trying to determine which media and which way of using it is, per se, better.

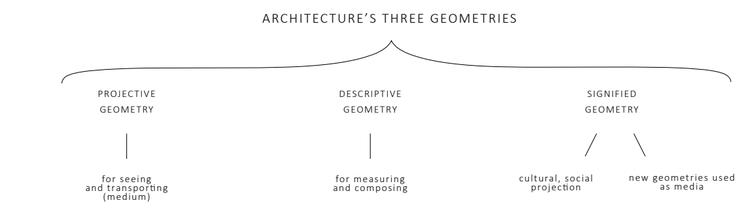
Drawing, projection and geometry

Robbins dedicated *Why Architects Draw* to Robin Evans, who too focuses on drawing as medium with a dual nature. In *The Projective Cast,*[76] posthumously published in 1992, he describes architecture's relationship with projection and geometry,[77] while in his earlier essays in particular he discusses the mutual influences between life form (way of living), buildings and plans.[78] It is only later that projective drawing and geometry becomes yet another component in that same investigation.[79] While being critical of too much emphasis on artistic, architectural drawing,[80] Evans' focuses on periods in history where architecture's relationship with geometry changed, where new drawing techniques emerged or died out, and on how such developments relate to developments in culture.[81] He looks for mutual influences amongst life form and geometry as "sets" of "related practices"[82] and sees drawing as "embedded in a nexus of other events,"[83] where drawing techniques and the architecture desired can be in "near perfect accord"[84] (as with classical Renaissance architecture and conventional drawing techniques), or in not so easy "accord"[85] (as with social ways of living, and architectural agendas and desires). He puts forth that, although working media such as projection and geometry are close to invisible, they are highly generative of the architecture they are used to make.[86] This insight makes Evans still highly relevant to this discussion. In relation to conventional drawing he shows that parallel and perspective projection influence how a plan can or cannot be drawn, while these projections only reveal themselves indirectly in the drawing, having played the role of guiding principles. This, I argue later, is also a trait of diagrams. When a house is built following a plan, the influence of the projection – which is closely related to the drawing technique and the tools – can be traced in the building. Perspective, for instance, is not simply a way of drawing in order to transport a building already imagined in the mind. Indeed imaginations are 'caught' with perspective and made both tangible and buildable, but at the same time the perspective construction is itself built.

> Alberti's [perspective] construction is a set of conventions without any necessary relation to reality. Using it, we can go fishing for real objects to catch within its net. We can also use the net to make imaginary objects that exist only in the picture. These phantoms, so very easy to produce as long as they stay in line and follow directions, are contrivances of the technique. Once the phantoms have been formed in the image of their construction, it is possible to make real things in the image of the phantoms. Alberti's perspective has the power to make reality in its image precisely because it is not like reality. If reality were already arranged that way, his perspective could have had no impact, and the issue of its power would not arise. In this sense the real world has latterly recorded the image implicit in Albertian perspective, standing the accepted relation on its head.[87]

Hence Evans argues that perspective, which interfaces with orthogonal projection, was not just 'used' to make buildings, but, through being used, its own, otherwise invisible, constitution becomes expressed: invisible lines of projection were thus ultimately built, and formed reality in their own image.

ROBIN EVANS



The anthropologist Tim Ingold also argues in his theory of notation that those invisible projective lines that fill the gaps between drawings and the physical world can have a huge impact on life, as we shall see later. In this thesis this impact is described by the diagram, which is seen as being able to operate in the gap between thinking, drawing and building, as a sort of non-neutral, interstitial device with the ability to relate heterogeneous entities to each other and make them operational. This is complex, because it means that diagrams, projections, and drawing techniques leave marks on whatever they are used to produce, while not determining the outcome completely. A drawing technique will supply some kind of operationality, for instance, but not a qualitative value. Evans also makes that same point with regard to building, by saying that a drawing technique does not determine how anybody will live in the building, but the drawing technique together with the ideas of the draughtsman will nonetheless be directive of how life can unfold in that building.

> Certainly it would be foolish to suggest that there is anything in a plan which could compel people to behave in a specific way towards one another, enforcing a day-to-day regime of gregarious sensuality. It would be still more foolish, however, to suggest that a plan could not prevent people from behaving in a particular way, or at least hinder them from doing so.[88]

The working nexus between ideas, drawing techniques, building and socio-cultural life is mutually affective, both determining and not. This outlines a zone of mutual influences, which will be conceptualized as diagrammatic in the next chapters. When a medium co-produces a drawing that can be translated into building, it becomes very important to understand the influences of the medium. At some point architects start *to think with* their techniques (remember Lynn argued that a technique needs to become second nature) and the imagination and the techniques work "well together, the one enlarging the other," to the extent "that the forms in question – [...] – could not have arisen other than through projection."[89] The important thing with regard to this 'enlargement of imagination' is that it is not a neutral transportation of ideas into drawing into building. It is translation,[90] and that which is to be transported may very well change as it moves through, which is where translation occurs. However, we can only see what deviates and changes in translation on the basis of an ideal possibility for translation without change.[91] Orthogonal drawing, according to Evans, is that ideal, geometrical foundation of predictability in architecture, however, in architecture where geometry is the translatory medium "[w]hat comes out is not always the same as what goes in."[92] Projective drawing not only co-creates but also enlarges what can be imagined,[93] while, on the other hand, its conventions can also be a limitation. Moreover, it struggles with an affinity to painting, which is not where Evans wants to go. Rather his interest lies in knowing more about how conventional drawing has been co-creating architecture in "the gap between drawing and building."[94]

Evans is one of the only theorists who establishes that drawing co-shapes the built architecture in both causal (transportation) and non-causal (translation) ways. He finds inconsistencies between drawings and buildings[95] despite the fact that drawing is capable, as Carpo underlines, of creating notational identicality between drawing and building. This has to do with architectural drawing not being 'just geometry', but geometry used as a medium. But nor is it only geometry used as medium,[96] it is many geometries *on top of each other* used as medium: projective geometry for seeing, descriptive geometry for measuring and composing, and "signified"[97] geometry (a concept that Evans creates) that has to do with how geometry is sometimes used in expressive ways, and not just for the sake of practical function. Therefore the geometrical foundation on which architecture stands is not as stable, inert or as neutral as some might think, and this has been and is still being overlooked[98], so that when a complex of geometry and projection are *used as media* together with imagination in the socio-cultural context, these media have both causal and non-causal effects. Some geometries, Evans says, are so well-tested that we can be sure of the way they work and what they can be used for. But as a foundation, geometry is neither dead nor stable, because geometry evolves, as we see today. Reading Evans' today, when the computer is used as medium, and when geometry can be handled with the help of computational processes, it still is a very reasonable claim that geometry can be generative of architecture in more or less signified ways, i.e. to more or less expressive and artistic ends, and in more or less functional, practical ways (optimisation etc.). Geometry when handled with computers still co-produces, while also still being used as medium that reveals itself indirectly in the architecture produced. Similarly it is a mistake to believe that drawing is simply a "technical facilitator,"[99] as the geometrical and technical aspects of drawing activate imagination just as much as they facilitate building. This argument still applies: neutrality has not been heightened through computational design possibilities. But in each case the level of transparency is a matter of choice.

For the above-mentioned reasons geometry makes the relationship between drawing and building both stable (it is possible to build according to projective drawings) and unstable (imagination and socio-cultural projection co-form too, just as projective geometry develops as a discipline itself). Spatial imagination may not be related to geometry and projection at the outset, but geometry is employed to make the imagined buildable, and Evans points out how technical and geometrical *intelligence* is already embedded in drawing conventions. This already embedded intelligence can be "animated to lesser or greater effect to various ends every time the technique is used."[100] This can for instance be felt in the predicative character of the conventional

ways of drawing: when a plan is drawn or even simply sketched out, it already holds information about the elevations and the sections. The technique then is a kind of memory, which already knows more. Conventional ways of drawing have always been embedded with geometrical intelligence directly aimed at building.[101] So although building and drawing are two different realms in terms of their materiality and logic,[102] whenever a medium has been previously created to 'serve' building, some presuppositions are inevitably embedded within it. To put this another way – and to repeat Robbins' argument – because there is a gap between drawing and building, drawings can be pure imagination, but due to the drawing conventions made to facilitate building, even imaginary drawing opens up an entrance to building.

Old and new working drawings

Robbins discussed conventional drawing as both a cultural and a social act and emphasized its importance as an open dialogue. Evans and Robbins share an interest in architecture playing a social role, while having a good understanding of the 'sets' of practices – cultural, social and practical – that are generative of both imagination and building. Robbins emphasized the social act as having to do with the shared drawing conventions that are used to orchestrate building, while in particular the handmade technical working drawing, which was in the past the vehicle of communication, has by and large been phased out, as *Is Drawing Dead?* established. On the other hand many architects still make technical working drawing with computers miming conventional drawing. The editors of the book *The Working Drawing*,[103] Anette Spiro and David Ganzoni of ETH Zürich, have looked into the archives and found a selection of hand-drafted working drawings, as if making a homage to a kind of drawing that is slowly disappearing. However, even as it disappears, new signs of life are emerging alongside a lot of information covering the qualities of working drawing. Working drawings put into focus the moment where the emphasis shifts to the building site.[104] Shared drawing conventions make communication possible here to an extent that a drawing can be read irrespective of the language in which the text is written.[105] The book shows that the conventional symbol system of drawing is, even in these working drawings that cannot tolerate much imprecision, *tweaked* in order to accommodate the practicalities of building. In an essay in this book the architect Tom Emerson says, as if in a comment to Carpo (who claims that architectural design is a "purely informational operation"):[106]

> They [working drawings] may be seen as a means to an end and nothing more. But of course this has never been entirely true. The architect has always invested in the working drawing with more than pure information and data to share with builders. Either deliberately or inadvertently, the working drawing is laced with conceptual and ethical values underpinning the architecture.[107]

Emerson wonders why architectural drawing has endured for so long despite changing culture and technology.[108] He thinks that it is because building materials and basic human needs have not changed profoundly, which relates to Cohen's point about still needing classical building typologies despite other media possibilities. Emerson says that "[a]lthough it is no longer drawn, in the original meaning of the word, to pull a pencil across a surface, the plan retains a uniquely autonomous position in architecture between the architect and the built architecture."[109] In another essay the architect Jonathan Sergison from Sergison Bates says that hand drawing has a "sense of doubt and represents an attempt to work things out, …"[110] whereas the computer is too precise for him, an argument he shares with both Graves and Paolo Belardi, as we shall see. Sergison longs for *tolerance* in computer drawings and says, "it would be illogical to demand a high level of craftsmanship for a low cost housing project […] in a remote location."[111] Instead of trying to keep tight control of a distant building site, Sergison provides tolerance in his drawings. This consideration of closeness or distance to the building site having an influence on the way working media is used shows an awareness of the different way notational forms carry information with more or less openness to interpretation; a theme I treat in the last chapter.

Where in some ways the book says goodbye to the hand-crafted technical drawing, there are other ways in which the book presents new sorts of working drawings. There are the well-known sorts of computer drawings that follow the conventional drawing rules, and are only different from pen and paper drawings in that they are computer drawn.[112] Then there is Gramazio Kohler's script for a brick-stacking robot,[113] which accentuates the role of the script as a new sort of working drawing talking directly with the production machinery. An interesting new demand on architectural drawing also arises due to complex assembly processes of computer generated building parts – exactly those processes that Tibbits wishes to dispense with – where figurative maps for assembly become an important interface between human and machine.[114] Furthermore, the *working sketch* used as an on-site aid is extrapolated with sketches from Studio Mumbai[115] and Carlo Scarpa's sketch for the façade of *Castelvecchio*. These 'working sketches' intentionally leave space for on-site negotiation, opening up the conventional working drawing by allowing the control over building to be loosened when placed on site.[116]

Hand drawing and sketching

Where Sergison's statement about 'tolerance' being related to hand drawing together with Studio Mumbai and Scarpa's sketches expose some of the qualities that come with drawing's *imprecision*, Graves' sorrowful declaration of drawing's death in a newspaper article, *Architecture and the Lost Art of Drawing,*[117] fights a fight already lost. Graves advocates that computers are only of use in the final stages of design process where precision is required for working drawings. Too early use of computers in the design process blocks ideation, says Graves. Graves' argument is that the clarifying and inventive process of sketching and thinking *at once* cannot be replaced by a medium that works with precise definitions in advance. This raises the question whether this classical idea of sketching could be subject to development itself? Which does not necessarily imply a new digital device that can replace pen and paper, as Picon implied in *Is Drawing Dead?*, but is a suggestion that we could turn towards Evans' idea that techniques can enlarge imagination just as much as they can enlarge functionality. Something similar was indicated by Lynn, and more so by Reas in his concept of scripting performance. In addition Søberg has expanded the typical understanding of sketching to include even quite elaborate drawings with a high degree of finish. Søberg sees elaborate drawings, such as Daniel Libeskind's *Micromegas* drawings (1979) as sketches, where it is the openness in meaning that becomes a foundation for a later building practice.[118]

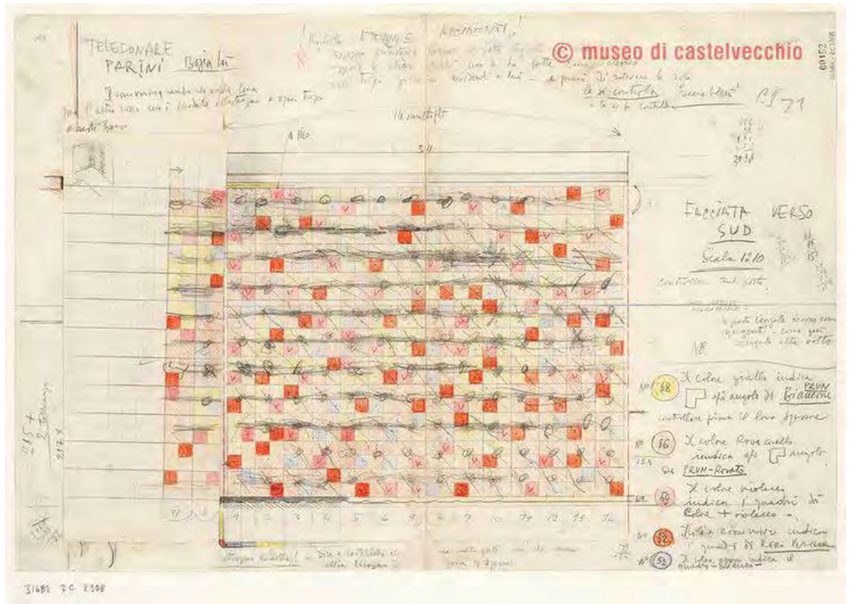


Fig. 1.
Carlo Scarpa's sketch for a part of the facade at *Castelvecchio.*

This raises the possibility that metric precision as such is not the determining factor as to whether or not a drawing is a sketch, but that the sketch as an opening and inventive gesture that can happen through many different media could become another way of fulfilling the role conventionally taken by the sketch. In fact, Graves exposes the qualities of hand-sketching as he describes how he and a colleague secretly start a drawing dialogue at a meeting, one sketch leading to the other, and, suddenly "the game was on."[119] Because of the shared conventions the two architects were able to lead a conversation as a mixture of rule-based-ness and playfulness, which is, in itself, interesting because it suddenly shows how conventions can be used socially while also being an inventive gesture. This is also underlined in an article about the Texas Rangers, a group of architects including John Hejduk, who together sketched plans both as an inventive and a social event where the drawings were progressed to become city-like plan drawings reminiscent of Piranesi's fantastic maps of Rome.[120]
In *Why Architects Still Draw* Paolo Belardi also reflects the fear of hand-sketching being lost. He gives a very useful definition of sketching, given with regard to drawing quickly, anywhere, any time and on anything, but it could be read as fitting other ways of sketching too.

> Sketching, [...], is able to continuously regenerate itself, always offering new suggestions [...]. The sketch, then, is an 'open' tool that is ready to perform a destabilizing role that, immediately after its definition, can renew itself as often as one desires – all based on an actual act of parthenogenesis.[121]

In a review of Belardi's book, Francis D. K. Ching, who wrote the seminal *Architectural Graphics*[122] also points out that sketching might be a generative mode of *thinking* and *acting* in relation to design, which does not belong to drawing alone. The sort of openness that Belardi finds important might also apply to different ways of using the computer too, Ching says:

> ..., because I straddle the analogue and the digital worlds, I am interested in the relation between hand drawing and the use of digital media in design. There could very well be more overlap than we care to imagine between analogue and digital drawing. While Belardi sees a proper role for hand drawing in the creative sketch, in making visible the genesis of an idea that incorporates how the idea will be fully formed, it might also be argued that using Sketch Up or some other 3-D modelling program can serve as a valid engine for creative thinking.[123]

This suggestion is much in line with my argument. Other arguments *for* hand drawing are provided by the anthropologist Tim Ingold, who like Robbins is not so interested in sketching as a cultural act. Rather he is interested in what has been called the social and environmental impact[124] of the ways architects use media. In the book *Lines – a brief*

History[125] Ingold is very critical of conventional projective drawing. Whereas Robbins argues that it is conventions that set up a social act of communication, Ingold is more interested in hand-sketching dialogues. Ingold's question is: how did the line become straight?[126] He wonders why the straight, "ghostly"[127] line of projection became the prevalent line, when there are many, many other lines in our environment, crooked, un-straight, and physical. He gives an alternative understanding of lines as being physical and as taking part in the continuous becoming of the world: indexical, physical lines, such as threads, open-ends, wrinkles, life-lines, inscriptions, calligraphic strokes, traces, scents, trails etc.. Meandering lines in and of lived-in environments are the real lines, says Ingold. Geometrical lines of projection with non-accessible, non-physical points of view are not grounded in the lived world, and for Ingold, who as an anthropologist looks to aboriginal culture and religion, such lines relate to ghosts and death.[128] He questions why *straightness* is assumed to better in modern Western thought and scientific development, where it is taken to be better to "think straight" as opposed to having a "crooked," "twisted" or "wandering" mind.[129]

In architecture, this assumption is obvious in the work of Le Corbusier who advocated rationality and straightness,[130] echoing the straight, projective line of Alberti that runs between two points and 'seamlessly' puts ideas into matter.[131] But Ingold argues that lines that involve thinking through projections are distanced from actual life. This point is exemplified with the difference between *travelling as transportation along a pre-planned route* as opposed to *travelling as way-faring*, where *life is travel*. Evans already provided the distinction between transportation where, ideally, that which is transported does not change, as different from translation where it does. However, this distinction is maintained in Ingold, regarding the differences between projection and hand-drawn sketches. Ingold compares transportation with a "sledge path" of a dead animal, and the line that transports and projects is, for him, the line of death.[132] When wayfaring, as opposed to this, a traveller lives her own movement.[133] These two kinds of movement are compared to the difference in drawing with rulers (straight line/transportation/death) and drawing free-hand (un-straight lines/wayfaring/life). Ingold here invokes Paul Klee's dictum about drawing being a line that "goes out for a walk."[134]

As to the question of how the line became straight, Ingold traces an answer in historical separations, such as the separation of speech and song, reading and speaking, drawing and writing, and – in architecture – building and drawing. These divorces and borders between practices which, in the case of architecture, invoke projection, are very influential and dictate actual, human behaviour, states Ingold.[135] He is against the detachments and separations that such lines introduce into the lifeworld, the discrepancy between a plan (the word here used in a wider sense than an architectural plan drawing) that has to add up and the way in which life unfolds *not* according to plan.

Although the problematics of such separations are at the heart of projective, architectural drawing, I accept projection as part of making architecture, but think that we can still heighten attention to the changes that happen in the gaps between the world as it is, the imagined, the drawn and the made. Where Ingold works with an understanding of lines as being gestures of movement by living creatures, the lines of projection are more indirect, although they too come from gestures of movement. He thinks that there is more life in traces of lived movement, like a pencil line on a piece of paper, than in any projective line, and indeed he is informed by Pallasmaa[136] in this point. But elevating hand-drawing as an architectural practice because of its closeness to life is somewhat romantic and unrealistic, I think, in the media world today. But Ingold's arguments are still important because they offer resistance to imposing technocratic systematics onto life. The question is, whether hand-drawing and sketching is the best or the only means to avoid this. I suggest that other kinds of drawing and sketching might work with the same kind of attention to life that Ingold links to hand drawing. Ingold sees life in certain architectural drawings, namely hand-drawn sketch maps made by many people in a conversation. These are taken to be lived drawings that enhance understanding and communication.[137] Sketch maps integrate "knowledge *along* a path of travel,"[138] and, like wayfaring, support the building up of knowledge while going along in the becoming of life.[139] Thus we also find an indirect critique of metrically ordered, projective, cartographic maps; a point I will also address (*DRAWING REASONING III*). While my own drawing practice does not follow the preferences of Robbins and Ingold (since it is done through projective drawing as well as being more of a cultural act than a social act) there is a point that I share with them, relating to an understanding of drawing as *reasoning*-in-movement being always situated within the practices of an architect.

Computer and drawing

Where Graves, Ingold and Carpo take what seem to be extreme positions regarding the use of drawing in architectural practice, there is also a field of architects to whom drawing is important, irrespective of whether it is done by hand or computer. These architects hold in common an emphasis on drawing as a cultural act and an art form specific to architecture. In an issue of *AD, Architecture + Drawing,*[140] from 2013, the editor Neil Spiller opens with the statement "the drawing is dead, long live the drawing!"[141] Thus he coins the paradox that drawing is breeding and flourishing from the cross-over with computational possibilities, even while other sorts of drawing are fading

away. The issue is full of hybrid architectural drawings, most of which are representative of a British tradition springing from the Bartlett and the AA with instigators such as Peter Cook, CJ Lim and Perry Kulper, but also including a younger generation that is very aware of media, but is not hand or computer minded in an orthodox sense. Instead for them it is important to compile drawing techniques and media that supports their practice. Some of Kulper's drawings, for instance, are 3D renderings, as are some of mine: this way of drawing with rendering is probably what the British architect Sam Jacob would call a "post-digital" sort of representation.[142] On his blog Jacob has posted a manifesto encouraging rethinking drawing in the post-digital age. Post-digital representation refers to drawing made with computers, but where "…Photoshop rather than Grasshopper […] is the real site of productive digital speculation."[143] As opposed to finding it necessary for architects to make their own algorithms or software, as for instance Carpo and Rutishauser do, Jacob is content with the ways architects can use existing software. He argues for an understanding of drawing not as *tracing* following from hand-eye coordination, but as collaging, editing, assembling and curating in gestures of world-making – a way of working which could also describe my drawings. To take drawing as the starting point for creating architecture by making it inviting and suggestive is a quality which, as Cohen pointed out, does not engage all architects. But Kulper and Jacob are representatives of a tradition where drawing plays that role: where drawing and media are themselves an environment for architecture. The environment around drawing at the KADK represented by Cort Ross Dinesen, Jacob Bang, Anders Abraham, and Peter Bertram, and in which this thesis is situated, places similar emphasis on drawing as an cultural act of world-making in close relation to architecture.[144]

The difference between the drawn and the made

Nat Chard is also representative of a current of British drawing that emphasizes drawing as a cultural act. Chard thinks of drawing not just as 2D but also as 3D and 1:1 in scale.[145] Although Chard is not directly discussing the impact of the computer, he shares with Bob Sheil an interest in technology that arises from the idea that drawing can be something 3D: a built machine, or a three dimensional or moving object. Sheil, as opposed to Chard, has a voice in the discussion of drawings in relation to computers, and argues that drawing with the computer *already* transgresses being two-dimensional and representative. In *Transgression from drawing to making*[146] Sheil argues that the drawing and the architect are intertwined to the extent that when the role of the drawing changes, the role of the architect also changes.[147] With the computer Sheil finds himself in a situation of doing design through *making*, as opposed to doing design through *drawing*. To some extent Sheil's arguments follow the same logic as Carpo's in pointing out the change that occurs in the design process when using computers directly connected to fabrication machines. 'Drawing' with computers is, in Sheil's sense, *already* making. Sheil's distinction between *drawing* and *making* implies that *making* digitally crafted models replaces drawing in a conventional 2D sense and that digital practice, writing algorithms and coding etc., *is* the new drawing. Sheil, like Carpo, Tibbits and Rutishauser, points out that it is possible to bridge the gaps that drawing brought with it with computers in other ways. Laser cutting, for instance, is a production technique very close to tracing a flat drawing, and a digital vector drawing *already* informs the laser cutter. Sheil, however, differs from Carpo in that he does not see *making* as a seamless process of bridging of the gap between maker to drawing to building. Instead, and importantly, Sheil insists upon a difference between the drawn and the made,[148] a point that Carpo does not make. In an issue of AD on *Material Computation*[149] which features several pavilions that have been digitally crafted, Sheil challenges these very computational crafting practices that he forms part of himself. (In Sheil's work with *Sixteen Makers* he articulates the threshold between the drawn and the made as an interactive scene with responsive models.)[150]

In arguing that there should be a difference between the drawn and the made, the representation and the represented 'object', Sheil points out that these pavilions run the risk of being but "a physical render of a projected image."[151] Scheer also makes the point that there is too little difference between the drawn and the made, as we will see, which is often mentioned as a problem of computer simulation when combined with fabrication.[152]

Curiously, Evans had already tentatively formulated a similar phenomenon with regard to drawing, as part of his concept *signified geometry*. According to Evans, geometry becomes signified and metaphorical when it is used to carry meaning itself, when geometry becomes a leading motif itself, or when buildings are made 'in the image' of geometry.[153] Signified geometry both has to do with developments in science which directly make new kinds of geometry available to architecture, and also with the socio-cultural affect that scientific developments have on art and architecture. As an example of where geometry has become signified, Evans mentions Eric Mendelsohn's *Einstein Tower* in Potsdam (1919-1921). The *Einstein Tower* does not use the principles of Einstein's theory *as a medium*, but instead seeks to express the theory metaphorically through an organic formal language.[154] The *Einstein Tower* is therefore just "a built sketch,"[155] a building made too literally in the image of its sketch, not with techniques from Einstein's theory, although it is meant to be conceived as a "continuously altering field," it becomes more of a metaphor for the space-time continuum.[156] Another example of where geometry has become signified, in Evans' opinion, is found in the making of the roof for *Ronchamp* by Le Corbusier. What puzzles Evans is the co-play

between Le Corbusier's hand-sketch for the chapel and Iannis Xenakis's use of ruled-surface geometry to achieve the form that Corbusier wanted, and how exactly the roof was made possible within this interaction between a free-hand sketch and a geometrically-controllable notation. It is not geometry used in the easiest way, but an agency between a desire for form and how that could eventually be built.[157] The *Einstein Tower* and *Ronchamp,* according to Evans, are examples of geometry not being used in a completely proper way, while the pre-19th century stonecutters in France who developed stereotomy[158] did manage to work with "double vision"[159] and to distinguish between the drawn and the made "such that one operation could produce two results in different modes, each of equal finesse,"[160] says Evans. I think that this last way of distinguishing between the drawn and the made, which Evans describes, is also what Sheil is asking for, but it is a difficult point to express, because this double vision is not only granted by how complex geometry is employed in architecture, but is also granted in relation to what ends the architects desire to use it. Hence, it is not that drawing as such will warrant that architects do not build mere 'images' per se, nor that computational simulations per se will end up as 'built images'. Whereas the tendency towards the built image might be stronger in the simulation, the result will have much to do with the architect's awareness of media and appreciation of the difference between the drawn and the made.

Because Sheil argues that the drawn and the made are not the same, he encourages architects to be conscious of the "room for negotiation"[161] that exists when the drawn is being translated into the built. Sheil says that switching between the drawn and the made requires "a sequence of challenging translations,"[162] and that architects "…need to remain aware of the difference as well as the similarity between drawn and made things, …."[163]

The dilemma here is that while Sheil thinks that architects working directly with 3D fabrication machines are in a situation where the gap between design and production is being narrowed, as it should be[164] (bringing more power back to the architect, he thinks), we should still be aware that translations happen within the process as more than transportations. I agree with Sheil that the concept of translation does not leave architecture as soon as architects are able to 'talk' directly to production machines. But it is a decisive part of my project to find out more about the qualities of the gap at the place where Sheil thinks that, with drawing, the gap is regrettably widened,[165] a theme I treat in the last two chapters (*MEDIA MUTATIONS II and III*).

Drawing and simulation

In *The Death of Drawing* Scheer also addresses the same problem that Sheil outlines through building pavilions too directly in the image of their simulation. But Sheer argues from a different place than Sheil: Scheer is not, unlike Sheil, located in an educational environment, but is a BIM expert who used to be a technical drawing architect dealing with commercial building in the USA. Inspired by Evans' idea of a double intelligence which encompasses both a logic of drawing and a logic of building, Scheer argues that drawing, more than computer simulations, trains architects to be aware of the difference between the media space and the building space. Because of this belief Scheer proposes that architects should approach simulations as if they were representations, and then, maybe, the desired difference will emerge.[166] Theoretically, and to some extent also practically, simulations (such as Disneyworld, flight simulators, and computer games) make immersion complete. Scheer reminds us:

> Simulation thus tends to erase the distinction between itself and reality, converting reality into simulation and vice versa, because they are both experienced as the participant's world.[167]

But although Scheer thinks the danger increases because of simulation, he does not for that reason encourage architects to mime conventional drawing space with computers, but rather to not forget that a simulation is also a representation that shapes reality in its own picture as much as it depicts it. This argument is similar to Evans' theory of buildings being cast in the projective lines of drawing, and not just being transported neutrally by them. Evans pointed out that drawing, as such, does not guarantee that there is a difference between the drawn and the made (*Einstein Tower* as a "built sketch"), and therefore this argument by Scheer might not hold its ground completely. It might be that the simulation tends towards this *more* than drawing does, but this point remains open until determined by further research. I would think that it a matter of how different architects chose to do architecture, and to what extent they are aware of the difference between the drawn and the made. Architects – and here I sketch a thought which needs development – such as Zaha Hadid have already built images with drawings, and still do with computational techniques.[168] This is not a matter of the medium of choice alone, but a matter of knowing what a medium can do and working with it through one's own ideas about what architecture is.[169] But Scheer's concern comes from a social agenda, in that he sees a connection between BIM software and built environments in the USA that simulate historical architecture, where the theme of the simulacrum (in the sense of an empty sign) is already present. Scheer links this to the relationship between a BIM model that is controlled by a performative mindset and which replaces a mindset of physical building.[170] As mere products of a market economy and industrialized building processes,

BIM environments are built as "simulacrums"[171] that "induce desired patterns of behavior"[172] onto people in a far too generalized way, says Scheer. This development should be resisted, and Scheer sees drawing as a possible location for resistance, (an idea similar to Ingold's, who sees hand-drawing as a sort of resistance against technocracy projected onto life) because it might heighten awareness that the sign and that which it refers to are different things. As said above, the drawing as medium might not, per se, grant that resistance, but an awareness of how architects use media might. He also sees possible resistance coming from reflected and critical computational practices which,[173] perhaps like Sheil, are aware of the difference between media space and built space.[174]

Will a 'drawing way of thinking' architecture be the answer to not building images? Not quite, as Evans shows, but maybe if we think of drawing-thinking as a diagrammatic way of thinking, then awareness of the ways that an idea travels from the mind through media to matter can be heightened. As Anders Hermund points out in his PhD thesis about BIM, BIM is founded on diagrams too, parametric diagrams that is, and there is an opening potential within all diagrams which will also apply to BIM.

> […] the consciousness and employment of the parametric diagram [is] a suggestion for containing the complex balance between technology and experience, because a diagram of this type can open up towards that which is outside its own original domain, and thus be, in its very idea, creative. [175]

Like Hermund I argue that diagrams are, in their basis, open, as are sketches, and for that reason awareness of the diagrammatic aspects of drawing and how they mutate into a computer environment could be of great relevance. Simulation, immersion and seduction are potentials of all diagrams; however, they are, as we shall see, also important in order to keep a diagrammatic process going, in order to allow us to learn more.[176]

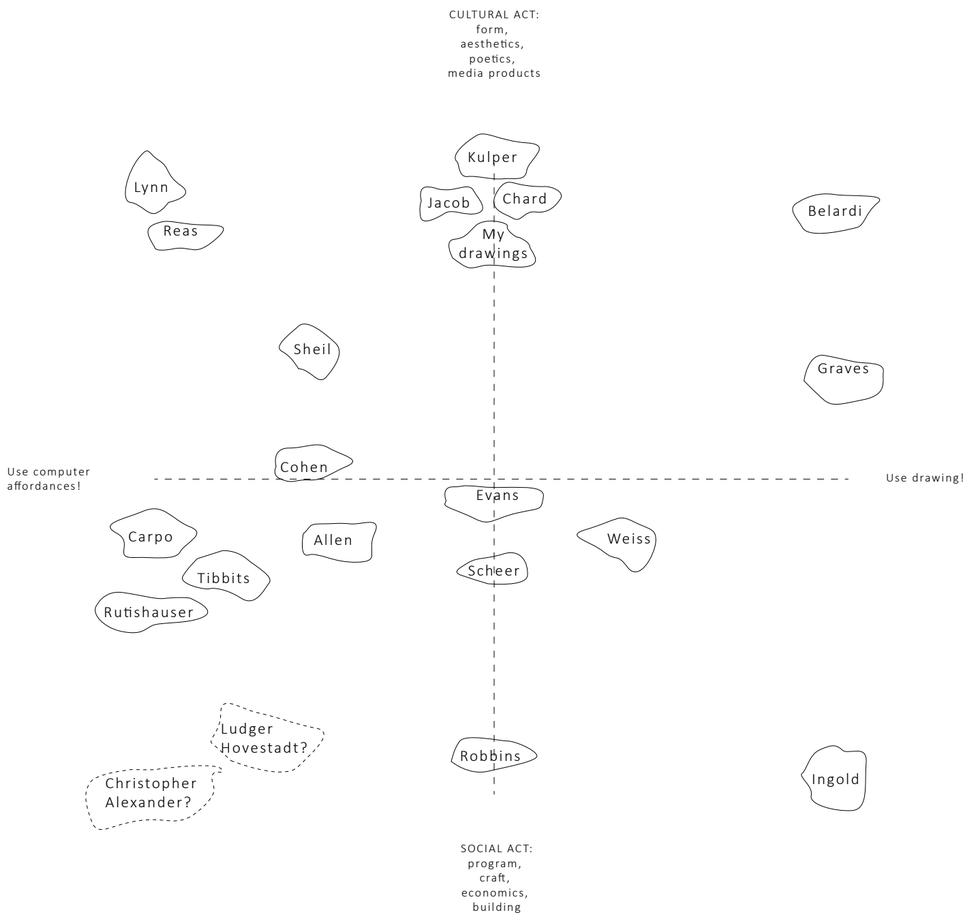
CONCLUSION

Understandings of drawing span from drawing *as* life to the death of drawing. It seems clear that elaborate handmade working drawings: complex, geometrical constructs made with a ruler etc. at the drawing table, are a retrograde phenomenon, whereas the same kind of working drawings made with computers are relatively widespread. However, to use the computer to mime a traditional drawing design space could be seen as a mistaken way of using computers, a dead-end ramification where a newer medium is used to mime an older one, before the newer medium has been fully discovered and created. On the other hand, traditional ways of looking at and reading architecture through orthogonal and perspective projection seem to be thriving in design software, as if these aspects of conventional drawing have already migrated and settled in their new technical surroundings, and this is a less emphasized fact. Projective geometry for looking is still active in the gap between mind to medium and to building, but has, with the computer, become separated from the descriptive geometry for drawing, which in the traditional pen and paper drawing space co-existed with traditional, hand-held tools. Maybe these ways of looking at and reading architecture make up one kind of link between tradition and new possibilities? Projection has travelled from one technical environment to another, as an "agency of observation,"[177] in a way that has not profoundly changed projection as such. However, today conventional projections combine with descriptive geometry that can be computationally handled, which could be considered to be a 'mutation' within the projective convention. Concerning more speculative, conceptional drawing and sketching as a cultural act: this is a current in architecture which seems to be creatively nourished by computer possibilities. Here drawing is positively alive, exactly because its premises are changing, and its conventions are destabilized.

The accusation that has been levelled against computer drawing and design, namely that it is too precise and can therefore not be used to sketch and invent the initial phases of a project, meet resistance from different positions, for instance from Ching, but also from Lynn and Reas, who show that computational design and scripting can be a kind of sketching that develops through experimentation. Hence new concepts of sketching seem to be emerging, and against this background the ability often attributed to hand-drawing and sketches, that they are open to many readings[178] and are an opening device with space for negotiation through indeterminacy, is likely to belong to other compilations of media too. This problematic is discussed in more depth in the chapter *MEDIA MUTATIONS III* where I develop an idea of sketching as having to do with the diagram and its opening potential.

The fact that drawing, in the process of building architecture, works with gaps and indeterminacy is a recurrent theme, which is sometimes emphasized as a problem to be finally overcome with the computer's direct link to fabrication, while at other times this link to fabrication is seen as increasing the risk of ignoring the difference between the drawn and the made, and not translating enough. To complicate matters, drawing has *also* been held responsible for building sketches too exactly, or too literally. How to 'best' bridge the gap is probably one of the most dense problematics outlined in this chapter, taking up the thread from Evans' way of conceptualizing drawing as a medium that co-creates, although this co-creation only shows itself indirectly and although it is not only the medium as such, which can account for too much or too little translation. I elaborate this discussion in the chapter *MEDIA MUTATIONS II*.

AN ARCHIPELAGO IN THE SEA OF ARCHITECTURAL MEDIA USE



The current state of affairs concerning drawing can perhaps be conceptualized as a *migration* from one technical environment to another, where the two environments mix, and, as this migration happens, ways of drawing ramify. Here the distinctions given by Robbins' "cultural and social act" may help to give some direction. Also Scheer's outline of 'new' sorts of media practices in architecture – representation/drawing and simulation/computer – can offer distinctions that can help to give an overview. I have made a map derived from Robbins' and Scheer's distinctions combined, and have placed the architects and theorists discussed as 'islands in a sea' of different ways of using media in architecture. This should emphasize that we are dealing with a connected continuum between different practices, and not one contemporary convention.

To the left we have those who work with or encourage architects to work with computational affordances. To the right we have those who work with or encourage architects to work with conventional drawing and hand-sketching affordances. At the top we have those who work with architecture more as a cultural act, emphasizing architecture as an art form where media space is just as primary as built space. Here weight is put on issues of form, aesthetics, and poetics. Emphasizing architecture more as a cultural act encompasses that architecture can be thought of as more than building, for instance, that a drawing or an animation can be products of architecture too, which can potentially lead to building. At the bottom we have those who work with architecture more as a social form. Here media use is secondary to the social agenda, to building program, economics, craft, and to building. This map provides the insight that although the working media changes, one new prevailing way of practicing architecture does not exist; there is not one new convention, but rather, architects who use similar compilations of media prioritize the question differently of what and how they believe architecture should be, both socially and culturally.

Lynn and Reas are placed in the area of the spectrum where computer affordances are used as part of a cultural act of architecture, which must not necessarily result in large scale building or building at all. Sheil is placed somewhat closer to the middle field, because he encourages elaboration of the difference between media space and built space. Carpo argues for computational design as *the* way of working with regard to building, and emphasizes that the gap between drawing and building has been finally overcome. Thus he is placed towards an emphasis on building and architecture as a social act, although, as I have argued, his intentions with regard to the relation between the social and the media are not developed. Tibbits is placed in the same area, not for his social concerns in diminishing slave labour while unifying the architect's control, but for his emphasis on using media in relation to building. Rutishauser argues for the architect as a strictly computational figure, working as an engineer with craft, building and economics and is therefore also placed here. (Christopher Alexander and Ludger

Hovestadt are tentatively placed as representatives of a combination of architecture as a social act and computational affordances, but this would need more elaboration). Cohen uses the affordances of the computer mostly with regard to building. Allen, whose theory of notation I address in the last chapter, is also placed here because he encourages architects to use digital notation in relation to complex urban, social, and field-like conditions. Kulper, Chard, Jacob and my own drawings reflect architecture as a cultural act, where media use is important but extremely mixed; hence they are placed in between computational and drawing uses. Sheer is also placed between computer and drawing, because he encourages the use of simulations as if they were drawings. Robbins is prevailingly interested in architecture as a social act, however, his theory is from a time before the computer, and therefore he is placed centrally. Belardi argues for the creative, inventive potential of hand-sketching as a cultural act itself, and Graves is similar, but relates sketching to the initial phase of a building process, and therefore he is placed further towards the social use of drawing. Ingold argues for hand-sketching as a dialogue and an activity of becoming in the social field. Finally, Evans is centrally placed, because of the balance between media awareness with regard to both social and cultural agendas that he argues for, and because his theory, like Robbins', is from before the time when the computer played a role in architecture.

The conclusion is that, even though much is changing when architects draw with computers, the dual nature of media forming a continuum between social and cultural agency remains, while media uses ramify. What is often overlooked is that situated makers' architectural ideas co-create the way media is used to create architecture.

I develop my contributions to the ongoing discussion of drawing in more depth in the chapters *MEDIA MUTATIONS I, II, III*. Before this, the project's working method is presented, and with it the idea of drawing reasoning being diagrammatic reasoning, on which understanding the final parts of my thesis will rest.

[1] Mario Carpo, "Ten years of Folding," *Folding in Architecture*, revised edition, ed. Greg Lynn, *AD Architectural Design* (2004): 14-19.
[2] Edward Robbins, *Why Architects Draw* (Cambridge, Massachusetts, London, England, 1994).
[3] Ibid., 20-7.
[4] cf. David Ross Scheer, *The Death of Drawing* (London and New York: Routledge, 2014), 61-63.
[5] Parts of this chapter has been published in Anna Katrine Hougaard, "Architectural drawing - an animate field," *Open House International* 40, no. 2 (2015): 44-54. www.openhouse-int.com/pdf/OHI%20Vol.40%20No.2.pdf (accessed 7. 1. 2016).
[6] All the lectures from the conference are available on Youtube: https://www.youtube.com/playlist?list=PLFawc5CN1zEKeBxr4XZ7-5CTJRcrystQn (accessed 20.8.2015)
[7] Martin Søberg, *The Oscillating Sketch* (PhD thesis, Royal Danish Academy of Fine Arts, School of Architecture, Copenhagen, 2013).
[8] Paul Delaroche in 1839.
[9] Peter Greenaway in 1983.
[10] Mario Carpo, *The Alphabet and the Algorithm* (Cambridge, Massachusetts, London, England: The MIT Press, 2011).
[11] Ibid., 10, 79.
[12] Ibid., x.
[13] The idea of architectural media being part of a more complex working nexus comes from Robin Evans and will be deepened later.
[14] Carpo, *Alphabet*, 118, 123.
[15] For counterpoints and critique of participation see Markus Miessen, *Albtraum Patrizipation* (Germany: Merve Verlag Berlin, 2012).
[16] Carpo, *Alphabet*, 123.
[17] Ibid., 24.
[18] Ibid., 23.
[19] Ibid., 26.
[20] For instance, Carpo refers to Rem Koolhaas' *S, M, L, XL* approach to architecture as a way of thinking in terms of identical reproduction which is outdated. Ibid., 106.
[21] Scheer, *The Death*, 3, 5-7.
[22] "...unlike the medieval craftsman, who was a maker and thinker in one, the modern thinker is not allowed to make, and the modern makers are not allowed to think." Mario Carpo, "Craftsman to Draftsman" in *The Working Drawing - The Architect's Tool*, ed. Anette Spiro and David Ganzoni, trans. Lisa Rosenblatt (Zürich: Park Books, 2013), 278.
[23] Carpo, *Alphabet*, 45.
[24] Ibid.
[25] Ibid.
[26] cf. Fabian Scheurer, "Signal to Noise - What is Quality in Digital Architecture," in *Structuralism Reloaded - Rule-Based Design in Architecture and Urbanism*, ed. Tomás Valena, Tom Avermaete, Georg Vrachliotis (Stuttgart, London: Edition Axel Menges, 2011), 269-74.
[27] Casey Reas and Chandler McWilliams, *Code + Form In Design, Art and Architecture* (New York: Princeton Architectural Press, 2010), 17.
[28] Scheer says this of both conventional drawing with pen and paper and computer programming. Scheer on drawing as craft. Scheer, *The Death*, 5-7, 9, 15, 72-82. Scheer on programming as craft: Ibid. 173-80. Reas says that programming is a craft in *Code +*, 17.
[29] Carpo, *Alphabet*, 126-27.

[30] Mario Carpo, „Die Entstehung des typografischen Architekten," in *Architekturwissen Band 1 - Grundlagetexte aus den Kulturwissenschaften – Zur Ästhetik des sozialen Raumes,* ed. Susanne Hauser, Christa Kamleithner and Roland Meyer (Bielefeld: Transcript, 2011), 114-24.
[31] Ibid.
[32] Carpo, *Alphabet,* 113.
[33] Skylar Tibbits' TED talk on 4D printing is available on: http://www.youtube.com/watch?v=0gMCZFHv9v8 (accessed 20.11.2015)
[34] Skylar Tibbits, "Design to Self-Assembly," *AD Material Computation* 82, no. 2 (March/April 2012): 68-73.
[35] "For what is at stake today, and what may indeed be lost, is not The Author, as a timeless category of the spirit, but a very technologically specific kind of author. The falling star is, simply, the author of reproducible identical copies—a vast and influential category for sure, but not an indispensable one." Carpo, *Alphabet*, 116.
[36] Ibid., 123-8.
[37] Ibid., 48, 126.
[38] Janet H. Murray, *Hamlet on the Holodeck – The Future of Narrative in Cyberspace* (New York: The Free Press, 1997), 126-53.
[39] Carpo, *Alphabet*, 126-27.
[40] Ibid., 105.
[41] Stephan Rutishauser, *The Working Drawing*, ed. Spiro and Ganzoni, 282.
[42] Ibid.
[43] cf. Scheurer, "Signal to," or Jacob Riiber, *Generative Processes in Architectural Design* (PhD Thesis, KADK, School of Architecture, 2013).
[44] Riiber, *Generative Processes*, 247.
[45] Robbins, *Why*, 20-7.
[46] Scheer, *The Death*, 223.
[47] Ibid., 139.
[48] Ibid., 141.
[49] Ibid.
[50] Ibid., 142.
[51] Ibid., 143.
[52] Ibid., 152, 173-8.
[53] Ibid., 180.
[54] Ibid., 156.
[55] Robbins, *Why*, 43.
[56] Ibid., 47.
[57] Ibid., 39-41.
[58] Ibid., 47.
[59] Ibid., 9.
[60] Ibid., 19.
[61] Ibid.
[62] Ibid., 35.
[63] Ibid., 35-7.
[64] Ibid., 30.
[65] Ibid., 38,45.
[66] Ibid., 38.
[67] Ibid., 45.
[68] Ibid., 6,35.
[69] Ibid., 298.
[70] Ibid., 301.

[71] Ibid., 45.
[72] Ibid., 45.
[73] cf. Peter Cook, *Drawing - the motive force of architecture* (Great Britain: Wiley, 2008).
[74] Robbins, *Why*, x-x.
[75] Ibid., 35.
[76] Robin Evans, *The Projective Cast - Architecture and Its Three Geometries* (Cambridge, Massachusetts, London, England: The MIT Press, 1995).
[77] Ibid., xxv-xxxvii. He also says it in a lecture available online: http://sma.sciarc.edu/lecturer/robin-evans/ (accessed 10.7.2015).
[78] See for instance "Figures, Doors and Passages" and "Rookeries and Model Dwellings," in Robin Evans, *Translations from Drawing to Building and Other Essays* (London: Architectural Association Publishers, 1997), 55-117.
[79] Background article on Evans by Joseph Bedford, "In Front of Lives That Leave Nothing Behind" *AA Files* 70 (2015): 4-18.
[80] cf. Evans, *Translations*, 160, and the essay "Not to be Used for Wrapping Purposes: A Review of the Exhibition of Peter Eisenman's Fin d'Ou T Hou S," *Translations,* 119-51. Moreover Evans is critical of Libeskind's drawings in the essay "In Front of Lines That Leave Nothing Behind," *AA Files* 6 (May 1984): 480-93. It is also expressed in "From Axes to Violins," *AA Files* 1 (1981): 116-20, and in the conclusion of *Cast*, 366-70.
[81] This is done throughout *Cast* and in particular in "The Developed Surface: An Enquiry into the Brief Life of an Eighteenth-Century Drawing Technique," in *Translations*, 195 -231.
[82] Evans, *Translations*, 200, 227.
[83] Ibid., 200.
[84] Evans, *Cast*, 119.
[85] Ibid., 221.
[86] Evans, *Translations*, 156.
[87] Evans, *Cast*, 140. (His emphasis).
[88] Evans, *Translations*, 89.
[89] Ibid., 180.
[90] Ibid., 154.
[91] Ibid., 154, 181.
[92] Ibid., 181.
[93] Ibid., 183.
[94] Ibid., 186.
[95] Ibid.
[96] Evans, *Cast*, 37-38.
[97] Ibid., 349.
[98] "[…] geometry does not always stabilize architecture; […] geometry in architecture was not always dead at the time of its employment, although it may have died later; and [...] in architecture expired geometry sometimes gained a life after death. […] the perception of geometry's role has been vastly affected by a collective oversight. […] geometry has been active in the space between and the space at either end. What connects thinking to imagination, imagination to drawing, drawing to building, and buildings to our eyes is projection in one guise of another, or processes that we have chosen to model on projection. All are zones of instability." Ibid., xxx-xxxi.
[99] "… is there not, in fact, a constant interplay between the passive portrayal and the active remodelling of reality? … If the activating imagination is permanently removed from consideration, drawing very easily slips into the category of a mere technical facilitator, and this results in two illusions: first, that it makes no difference to what is drawn (unless done incorrectly); second, that drawing can propagate things, but never generate them. These illusions will persist as long as we regard good drawing as a simple truth-conveyor. As much can happen in the drawing as out of it." Robin Evans, "Architectural

Projection," in *Architecture and Its Image,* ed. Eve Blau and Edward Kaufman (Montreal: Canadian Centre for Architecture, 1989), 20.

[100] "Reference has already been made to the active imagination of the observer of the drawing; there is also an active imagination **in** the drawing itself. This has nothing to do with the mental faculty of imagining. Obviously, drawings do not think. But, because a drawing technique like orthographic projection was itself the product of intense imagination, this massive effort of imaginative intelligence lies dormant in it, animated to lesser or greater effect and to various ends every time the technique is used." Ibid., 21, his emphasis.

[101] Evans, *Cast*, 107-21.

[102] Ibid., 208.

[103] Anette Spiro and David Ganzoni, ed., *The Working Drawing - The Architect's Tool*, trans. Lisa Rosenblatt (Zürich: Park Books, 2013).

[104] Ganzoni, *Working*, 265.

[105] Spiro, *Working*, 7.

[106] " […] architectural design is a purely informational operation, […]. A key issue in the modern, notational theory of architectural design, this technical, point-to-point exchange of building and construction data is once again a matter of recording and transmission—a media problem." Carpo, *Alphabet*, 12.

[107] Ibid., 274.

[108] Tom Emerson, "Lines on Paper" in *Working Drawing*, 273.

[109] Ibid., 275.

[110] Jonathan Sergison, "Working/Drawing" in *Working Drawing*, 276.

[111] *Working Drawing*, 277.

[112] Ibid., 40-1, 70-1, 94-5, 116-7.

[113] Ibid., 31,36.

[114] Ibid., 21.

[115] Ibid., 19.

[116] Ibid., 161, 174.

[117] Michael Graves, "Architecture and the Lost Art of Drawing," *New York Times*, September 1, 2012. http://www.nytimes.com/2012/09/02/opinion/sunday/architecture-and-the-lost-art-of-drawing.html?pagewanted=all&_r=0 (accessed 31.01.2014).

[118] "Not all of the drawings by Daniel Libeskind that I will discuss in this chapter are proper hand-drawn sketches. Yet since they share qualities that, as we have seen, are typical to sketches, such as oscillation, ambiguity, and potentiality regarding semantic content and formal appearance, we may nevertheless include them in this dissertation. Indeed, as Jeffrey Kipnis has argued, Libeskind's drawings constitute a kind of sketchbook in which many of the ideas used in later building projects were formulated for the first time, thus having constituted an architectural poetics to guide proceeding work." Søberg, *Oscillating*, 237.

[119] Ibid.

[120] Mark Morris, "All Night Long: The Architectural Jazz of the Texas Rangers," *AD Drawing + Architecture* 83, no. 5 (Sept/Oct 2013): 20-27.

[121] Paolo Belardi, *Why Architects Still Draw*, trans. Zachary Nowak (Cambridge, Massachusetts, London, England: The MT Press, 2014), 30. Parthenogenesis means development of an egg without fertilization. http://dictionary.reference.com/browse/parthenogenesis (accessed 7.1.2016).

[122] Francis D. K. Ching, *Architectural Graphics*, fifth edition (Hoboken New Jersey: John Wiley & Sons, 2009).

[123] Francis D. K. Ching in a book review of *Why Architects Still Draw* by Paolo Belardi in *The Architectural Review*, vol. CCXXXVI, 1409 (July 2014), 95.

[124] cf. Wendy Gunn, *The Social and Environmental Impact of Incorporating Computer Aided Design Technologies into an Architectural Design Practice* (PhD Thesis, Department of Social Anthropology, University of Manchester, 2002).

[125] Tim Ingold, *Lines - a brief History* (Abingdon, England and New York, USA: Routledge, 2007).

[126] Ibid., 151.

[127] Ibid., 47 and throughout the book.

[128] Ibid., 47.

[129] Ibid., 153.

[130] Ibid.

[131] Ibid., 157.

[132] Ibid., 78.

[133] Ibid., 77.

[134] Ibid., 73. He quotes Paul Klee, Notebooks, Vol. 1, ed. J. Spiller, trans. R. Manheim (London: Humphries) 105.

[135] Ibid., 81, 155.

[136] cf. Pallasmaa's lecture at the symposium *Is Drawing Dead?*

[137] Ingold, Lines, 85.

[138] Ibid., 88, his emphasis.

[139] Ingold here points out the inspiration from Henri Bergson's vitalist philosophy. "I have argued that, as inhabitants of the world, creatures of all kinds, human and non-human, are *wayfarers*, and that wayfaring is a movement of self-renewal or becoming rather than the transport of already constituted beings from one location to another. Making their ways through the tangle of the world, wayfarers grow into its fabric and contribute through their movements to its ever-evolving weave." Ibid., 116.

[140] Neil Spiller, ed., *AD Drawing + Architecture*, vol. 83, no. 5 (Sept/Oct 2013).

[141] Ibid., 19.

[142] http://strangeharvest.com/drawing-as-project-post-digital-representation-in-architecture (accessed 20.8.2015).

[143] Ibid.

[144] cf. Peter Bertram, *Intuitiv Metode* (Copenhagen: Kunstakademiets Arkitektskole, 2009), 46-8.

[145] cf. Nat Chard, *Drawing Indeterminate Architecture, Indeterminate Drawings of Architecture*, Consequence book series on Fresh Architecture, vol. 3 (Wien, New York: Springer, 2005).

[146] Bob Sheil, "Transgression from drawing to making," *Research Quarterly,* 9, no. 1 (March 2005): 20-32. http://journals.cambridge.org/action/displayJournal?jid=ARQ (accessed 7.1.2016).

[147] Ibid., 20

[148] Bob Sheil, "Distinguishing between the Drawn and the Made," *AD Material Computation,* 136-141.

[149] Ibid.

[150] cf. ed. Bob Sheil, *55/02 A Sixteen* (Makers) Project Monograph* (Canada: Riverside Architectural Press, 2012).

[151] Sheil, "Distinguishing," 138.

[152] cf. Claus Peder Pedersen, "Greg Lynn's topologiske ontologi," unpublished but accessible at http://www.blankspace.dk/lynn.htm (accessed 20.11.2015).

[153] Evans, *Cast*, 348.

[154] Ibid., 346-9.

[155] Ibid., 346.

[156] Ibid.

[157] "The draftsman creates the effect of a modeled surface as a consequence of the orthographic juggling of circular arcs and straight lines. The most basic elements of geometry are now cast in the alineaments of the form. Through the agency of technical drawing, these elements deftly imposed themselves on the hand-modeled surface derived from the charcoal sketch, altering the form." Ibid., 303. See also 307-8.

[158] Ibid., 179.
[159] Ibid., 208.
[160] Ibid., 207-9.
[161] Sheil, "Distinguishing," 137.
[162] Ibid., 138.
[163] Ibid., 139.
[164] Sheil, "Transgression," 22.
[165] Ibid., 22.
[166] Scheer, *The Death*, 216-7, 227.
[167] Ibid., 33.
[168] cf. Fredrik Skåtar, PhD thesis in progress.
[169] cf. Evans, *Cast*, 339.
[170] Scheer, *The Death*, 197.
[171] Ibid., 198-9.
[172] Ibid., 206.
[173] Ibid., 170-1.
[174] Ibid., 34.
[175] Anders Hermund, *Anvendt 3D-modellering og parametrisk design* (PhD Thesis, Copenhagen: KADK, 2011), 182. My translation.
[176] This will be deepened in the chapter *DRAWING REASONING II.*
[177] This concept comes from Karen Barad and will be deepened in *MEDIA MUTATIONS II.*
[178] cf. Søberg, *Oscillating*, 9.

DRAWING REASONING I: METHOD - ARTISTIC RESEARCH

Introduction to the chapter

This PhD project is carried out as artistic research, a branch of research still developing both locally at the KADK[1] and worldwide.[2] The thesis aims at contributing to the ongoing development of artistic research as a research branch by using architectural drawing as an active part of the research, and by addressing it through existing concepts from the theory of knowledge. This is carried out over three chapters under the shared heading *DRAWING REASONING*. This first chapter discusses artistic research as a method for doing research and producing knowledge particular to architecture. The second chapter covers how architectural drawing reasoning can be conceptualized with Peirce's idea of *abduction*, and with Frederik Stjernfelt's reading of Peirce's diagram, conceptualized as *diagrammatic reasoning*. In the third chapter the discussion covers how maps and drawings can be considered to be epistemic artefacts in which drawing reasoning may be 'bounded'.

This project follows a tradition at the KADK where artistic research has been conducted amongst the school's researchers as a so-called development activity.[3] The KADK's criteria for making artistic research, especially in a PhD thesis, are still being developed, but a working paper authored by a group of the school's established researchers was released in 2015 suggesting in more detail some of the criteria for artistic research.[4] Although the guidelines given in this working paper are not pointedly directed towards doing artistic research in a PhD project, the working paper might be helpful for readers from outside the school's context for summing up what has hitherto been discussed in the research milieu to which this project also belongs. The most straightforward definition of artistic, which I have set out in the working paper, is that artistic research is a maker's *reflection* on her or his own *practice*.[5] The research is, so to speak, the reflection; subsequently it can be discussed which criteria this reflection must live up to – for instance academic, research criteria of transparency, originality and stringency or peer review. In the working paper different possibilities on the part of the reflection are specified; one of these, which is important for this project, is the criteria for reflection of an artistic research *PhD* project, requiring that it meet *general scientific or academic claims*.[6] Whereas this claim thus insists on the scientific character of a PhD project, the production of singular art works is still possible, indeed encouraged, and in order to make an interplay of this kind possible, it is stated that the reflection and the production of art works must be appropriately *dimensioned* to each other. Moreover, it is stated that the difference between an artistic process – which must not necessarily meet claims

such as transparency or repeatability, but can have a dynamics of its own – and an academic or scientific process which must live up to such claims, should be respected.[7] The way this difference between an artistic and a scientific or scholarly practice is described has yet to be specified, but its consequence for this thesis is that architectural works, in this case drawings, can form part of a PhD thesis as long as the reflection, in this case an academic, humanist theory, fulfils the following requirements: relevance to the chosen research field; being to some extent informed by the maker's art practice; and transparent communication. This form of reflection makes it possible for an otherwise autonomous art practice to form part of a PhD project, and framing two such practices in direct proximity to each other holds both the promise and the challenge of artistic research. More specific criteria are listed in the working paper, but only tentatively followed in this project, because the details of these criteria are still to be developed.[8] Moreover, the possibility is not excluded that a project such as this one could form part of other, broader definitions of *architectural research*, where design practice plays an active part in the research. For instance, the *EAAE Charter on Architectural Research* states that:

> Architectural research is original investigation undertaken in order to generate knowledge, insights and understanding based on competencies, methods and tools proper to the discipline of architecture. It has its own particular knowledge base, mode, scope, tactics and strategies.[9]

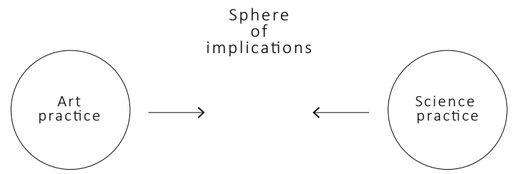
Having indicated in this introduction how the field of architectural research exists in continuous development, this thesis follows the most important criteria of artistic research at the KADK, and I reflect on my drawings through writing the theoretical parts of the project and by anchoring them in ongoing discussions and existing theories. Moreover both the drawing and the writing practices are staged in close relation to each other, so a receiver may see mutual fertilisations within this double practice.

DOUBLE PRACTICE

My way of working with two practices is different from, for instance, having already done a body of architectural works and then reflecting upon them in a separate PhD thesis.[10] In this PhD, the drawing and the theory have both come into existence as part of the same project.

The above diagram of an art practice and a science practice (academic, scholarly practice) that impinge upon each other in a sphere of implications has been a guiding motif for the thesis and shows a model which has been developed by my supervisor, Peter Bertram for working with an artistic, architectural practice in a PhD.[11] This model can also be retrieved in the above-mentioned working paper. More specifically, I work concurrently and alternately with two lines of reasoning, a track of drawing reasoning and a track of theoretical reasoning, which meander around each other and treat some of the same themes in different formats. The diagram metaphorically shows the movement trajectories between the practices. Sometimes a line of argument and a series of drawings are very far from each other, while at other times they become very close, even cutting across each other. The idea behind working like this is to maintain a level of equality between the practices, so that it is neither the job of the written part to explain and dismantle the drawn parts fully, nor that of the drawn parts to illustrate the written ones. Rather, the same themes are discussed in different formats of reasoning which might be fertile for each other, precisely because they are not the same. The hope is that this can be understood as an architectural way of reasoning, and that new insights can be gained from exactly this interplay of two practices in one dissertation, as they impinge upon each other and perhaps push each other into new places.[12]

An idea of *practice* as not being in opposition to theory, but of theory being also *a practice*, was put forth by the architect and theorist, Stan Allen, who says that theory does not follow from practice nor vice versa.[13] In fact there are only practices, he says: theoretical, academic, scientific, discursive practices of writing, and material practices of making. Allen's idea that all ways of producing both architectural theory and architecture are practices, but that the 'products' differ in kind, assists in framing how this project works. Discursive practices, according to Allen, are better at producing criticism and making arguments, whereas material practices are closer to the material world in which architecture is eventually drawn and built. Material practice in architecture is instrumental, proposing, affirmative, and occupied with the being of things, so Allen, whereas discursive practice is logical, critical, argumentative and explaining.[14] A material, architectural practice is insecure and driven by "an erotics of doubt,"[15] because it creates new relations between heterogeneous entities, such as ideas, sites, materials, and programs; i.e. material practices may be in movement, may be inconsistent, changing, open and unpredictable.[16] Material practices are therefore typically less secure than discursive practices. Discursive practices are more certain and relate to other discourses, but have a greater distance to the material world.[17]



Doubt may be insecure but is also *open* and therefore also a fertile starting point for reasoning which should not be prejudiced to begin with. Therefore forms of reasoning, such as abductive and diagrammatic reasoning, which can work with complexity before certainty exists, and can cross the boundary between – in Allen's terms – a material and a discursive practice, offer themselves for the conceptualization of reasoning processes shared with drawing in architecture, as I argue in the next chapter.

To point out that discursive and material practices differ in the context of this thesis would imply that drawing is a *material* practice. This could be seen as contrasting to a more usual understanding of drawing as related to the mind's work and to ideas, as opposed to matter. Where Allen's distinction is not aiming at drawing practice in a teaching environment, but at building practice in an architectural office, I take drawing to be playing the role of a material practice in this thesis in the sense that it is insecure (open to many readings), instrumental (made with techniques, sometimes passing on technical instructions), and proposing (a design, idea or image): all characteristics that Allen ascribe to a material practice. Moreover, drawing can be thought of as a material practice where the 'material' consists of pen, paper, geometrical tools, computers, surfaces, lines, points, projective systems, calculations and more or less explicit ideas of architecture, etc.. Informed by Evans I argue that, in the interaction between mind and drawing, ideas are materialized in a way that has more in common with what Allen calls a material practice than with what he calls a discursive practice. Material, in this sense, refers to the way in which drawing is embodied in the world, as opposed to separated from it, and what it represents is co-formed and emerges through following another 'material and technical logic' than that from which a discursive practice emerges. On the other hand, it is quite possible to treat theoretical and abstract ideas in architectural drawings, as we shall see in my analysis of Bernard Tschumi's *The Manhattan Transcripts*. Tschumi himself says that *The Transcripts* is a theoretical series of drawings, a specific mode of architectural *research*, not to be confused with scientific research;[18] but Tschumi's drawings are still also works of art. Tschumi's way of investigating drawing as a mode of research particular to architecture has been very inspirational to the way drawing is also used here in this thesis. Moreover, architectural drawings can indeed function as geometrical proofs, not just as part of scientific research, but also in architecture theory, as Evans has famously done – where he has constructed drawings to support his theoretical ideas.[19] But in this thesis the drawings align themselves as art works that treat themes derived from theory in another format of reasoning – one perhaps closer to material practice – than would be possible in discursive text. It should also be underlined that, to say that discursive and material practices differ is not the same as saying that material practices are more *creative* than discursive practices. In fact, in terms of processual, creative formations, I believe that these practices may share some aspects, as otherwise it would probably not be possible to use existing theories of knowledge to conceptualize reasoning through architectural drawing.

Differences and similarities

Even if one takes all the above as being different forms of practice, it is important to remember that *epistemological traditions* in art schools (academies) and universities in the Western world differ. In effect a PhD, a university format, is being opened up using artistic research methodology to meet an art school format with studio-based ways of working. The philosopher of knowledge, Donald Schön, outlines the difference between the different epistemological traditions of architectural art academies and universities like this:

> [Architects] cannot escape their profession's core of artistry; for they are designers and, although ancillary sciences may contribute to specialized design tasks, there is no general science of design. […] In its most generic sense, designing consists in making representations of things to be built. In contrast to analysts or critics, designers put things together and make new artifacts. […] a process in which, […], there are no unique right answers and no moves that have only their intended consequences. With its web of moves, discovered consequences, and implications, designing is a reflective conversation with the materials of a situation.[20]

Schön grasps here a core issue: that there is no easily definable general science of architectural design, but that design is about making and thinking in advance about things that are supposed to become materialized. He thus points out a difference similar to that pointed out by Allen, but Schön suggests that there might be some similarities in the "before-the-fact inquiries",[21] as he calls it, of art school and university epistemological practice. It is this more general and epistemic process of reasoning that I also conceptualize as being abductive and diagrammatic in *DRAWING REASONING II*. Diagrams can support reasoning in all practices, scientific as well as artistic, and a diagram can be a very general and everyday-like device for reasoning, but it can also become very singular and bound to very subjective and specific practices. Diagrams can wander and be shared between practices and spaces of knowledge, and diagrams can investigate the gap between different practices, as is argued in the next chapter.

Allen warns us to not mistake the precision and referentiality of architectural media with theory,[22] and indeed drawing has been discussed as a kind of language.[23] Without deepening the discussion of whether drawing is a language or not, I will briefly mention similarities and differences between drawing and the discursive language of which theory is made: similarities and differences that concern *notational forms*, *techniques*, *reading of*, *using references*, *ways of passing on clear meaning, and instructions*. Here, the context of the drawings is theory, and, with the potential of being both an artistic expression and a technical instrument simultaneously, architectural drawing – it is argued, and this is different from Allen's approach – can be epistemic and theoretical, both generative of a theoretical consideration as well as an architectural work – while not being the same as a theoretical, discursive argument. Conventional drawing does indeed share with academic and theoretical writing the fact of working with reference systems – drawing refers to sites, building parts, how they should be mounted, etc. – but procedures for making and reading a drawing differ from those for making and reading a theoretical text. In art practice, architectural drawing does not necessarily refer to things outside its own space, although it uses techniques that inherently do so (a plan drawing technique, for instance, is completely able to refer to something outside its own space, but what if the plan drawing is still a sketch, or simply not conform to the shared conventions of communication?), and hence references may be lacking or indeterminate. Architectural, artistic drawing can *lack* reference and proceed by subjective, poetic, intuitive moves. Of course a scholarly text can spring intuitively and be poetic, but its product must still be discursive and anchored in existing discourse. Moreover, there is a difference in reading architectural drawings and academic texts, because drawings read more like images, a point I discuss later with respect to the art historian Gottfried Boehm. So although there are some liberties that an artistic drawing practice can take, and which the scholarly theory cannot, there are also certain ways in which architectural drawing – especially mappings working with mathematical projections, and legends that provide clear references and meaning – resemble theory, as also the anthropologist David Turnbull says. However, when human-made conventions, such as those for making maps, come into existence – and artistic research as such could be seen as a convention with many different working methods and models coming into existence – there is an "interstitial space"[24] between epistemological traditions, which must also be *wanted* and emerges from specific socio-cultural conditions. Hence there is also a social movement: different environments that try to obtain consensus on these themes of interest.

Turnbull says,

> ..fertilisation between differing knowledge traditions […] requires the establishment of a third space. A third space would be an interstitial space, a space that is created through negotiation between spaces, where contrasting rationalities can work together but without the notion of a single transcendent rationality. […] For differing knowledge traditions to coexist in a common third space they need to simultaneously agree to build such a space and to perform together.[25]

This quote expresses well the kind of third space located between differing knowledge traditions, the making of which this thesis attempts to contribute to, and which involves ways of reasoning that can move between scholarly, academic practices and artistic, architectural practices, and thus moves in an interstitial third space: the space between practices.

Implications of this way of working

Bertram's diagram states that there is a sphere of implications between an art and a science practice, and that implications occur within this interstitial, third space, which in this thesis is the space between drawing and theoretical practice. Here, the decisive points are located when the movement trajectories strike fertile sparks that can jump from one trajectory to another. At those points, ideally, theory feeds drawing with concepts and inspiration, or drawing withdraws from the possibility of being dismantled through theory and may demand or require new theoretical concepts. In a bottom-up way, a drawing process can follow its own logic and progress move by move, a process that does not necessarily regard any existing theory, and therefore may push any intended theoretical ideas *off track* and provide a drawing material that subsequently may require new concepts or support older, under-illuminated ones. Working from the top downwards: drawing and writing processes can be structured, for instance

thematically, in relation to each other, as seen in most of the chapters of this work which treats the same theme in various formats, that is, a theoretical, academic format of writing together with drawings with the intention of creating a resonance space between the two formats. By rearranging drawing and theory in several turns, resonances between them have been both found and established. In particular, this has been the case in the discovery of a resonance between Peirce's theory of knowledge and semiotics – abductive and diagrammatic reasoning – and architectural drawing reasoning as I know it from experience. In Peirce's semiotics particular signs and notational forms convey or lack meaning and depend on different sorts of reasoning. Abduction 'opens the ball': it is the first transformation of a sensation or intuition into a sign, which, when abductive reasoning then turns into diagrammatic reasoning, meets with deduction and forms a mutually affective 'circuit' of both clear and unclear signification and reasoning. This tension is very similar to the one found in architectural drawing's dual nature, which, as Robbins argued, can be both an inventive, sensuous, subjective practice and a transparent, logical and shared system of communication. I mention this here to exemplify a point where in my opinion a spark has sprung between the two practices.

Furthermore, these forms of reasoning can be bound in epistemic drawing and map artefacts. I argue this inspired by the architect Jan Bovelet,[26] who based this idea on a 'resonance' between his experience with architectural drawing and the work of the philosopher of science, Hans-Jörg Rheinberger. Abduction, diagrammatic reasoning and being epistemic are concepts derived from philosophy of science and which I find suitable for describing how I have worked with theory and drawing as a double practice in this thesis, and these may also have a more general application. Moreover, these concepts touch upon how it is possible to be very precise about indeterminacy, uncertainty and openness; concepts that are also descriptive of the general situation of architectural drawing as a working medium. Therefore the first part of this thesis – *DRAWING REASONING I, II, III*, – is not just a methodological 'explanation' of the thesis, but also forms a foundation for the last part which concerns architectural drawing and how it is changing.

The drawings that are placed as series throughout the thesis can themselves be understood as epistemic artefacts in that they are artefacts that bind reflections, just as they lead to reflection. In binding reflexion they are part of an analytical process, while also themselves being artefacts that can stand alone and be addressed from other contexts.

Notes - Drawing Reasoning I: Artistic Research

[1] At the KADK the English term 'artistic research' is used to describe the Danish term 'kunstnerisk udviklingsvirksomhed' which can be directly translated as 'artistic development activity'. The practice of artistic research is a longstanding tradition at the KADK and has been described as a research activity in several internal reports and papers at the institution, some of which have become the basis for ministerial legislation for the KADK and appear as part of official reports (2009, 2012). These are listed here chronologically:
- *Notat fra arbejdsgruppen vedr. kunstnerisk udviklingsvirksomhed*, Cort Ross Dinesen, Carsten Juel-Christiansen and Steen Høyer, 1996.
- An issue of *Nordic Journal of Architectural Research* was dedicated to the subject artistic research featuring several KADK researchers. *Nordic Journal of Architectural Research, Theme: The Autonomy of Architecture? Artistic Development Work* 18, no. 3, (2005).
- *Forskningsstrategi for Kulturministeriets område,* 2009
http://kum.dk/servicemenu/publikationer/2009/forskningsstrategi-for-kulturministeriets-omraade/
(accessed 10.12.15).
- *Arbejdsudvalg vedr. kunstnerisk udviklingsvirksomhed,* Anders Abraham, Carsten Juel-Christiansen, Steen Høyer, Henrik Oxvig, 2011.
- *Kunstnerisk Udviklingsvirksomhed, udredning om vidensgrundlaget på de videregående kunstneriske uddannelser,* research report by the Danish Ministry of Culture, 2012.
- In December 2013 a symposium on artistic research was held at the KADK, *Kunstnerisk udviklingsvirksomhed i arkitektur og design*. A link to the conference program is available:
https://kadk.dk/search?query=symposium+on+artistic+research (accessed 10.12.2015).
http://kum.dk/servicemenu/publikationer/2012/kunstnerisk-udviklingsvirksomhed/
accessed 10.12.15).
- A complete issue of the KADK internal 'newspaper' addressed research and artistic research: *KADK Fagavis*, Ida Engholm and Henrik Oxvig, 2013.
- *Kunstnerisk Udvikling. Forslag til Kriterier for Kunstnerisk Udvikling ved KADK*, Sofie Beier, Mary-Ann Hansen, Mette Ramsgaard Thomsen, Anders Abraham, Peter Bertram, Martin Bodilsen Kaldahl, 2015.
- In addition, a publication on artistic research at the school is currently in preparation authored by Martin Søberg, Elise Lorentsen, Kristine Annabell Torp and Christoffer Thorborg and myself with the working title *Refractions - Artistic Research at an Architectural Academy*, and is expected to be published in 2016 by Arkitekturforlaget B.

[2] For an extensive survey and relatively critical discussion of artistic research programs worldwide, see James Elkins' homepage for his book *Artists with PhDs: On the New Doctoral Degree in Studio Art*, (Washington DC: New Academia Publishing 2009). http://www.jameselkins.com/yy/2-list-of-phd-programs-around-the-world/ (accessed 10.2.2015). A good example of a cooperation addressing these issues specifically for architecture is the ADAPT-r network. ADAPT-r stands for *Architecture, Design and Art Practice Training research* and is a cooperation between architectural schools in Belgium, Denmark, England, Estonia, Spain, Australia, Slovenia and Scotland. http://adapt-r.eu/ (accessed 4.12.14). Also the EAAE (European Association of Architectural Education) have published a charter on architectural research including research by design and practice-based research, which could include artistic research. http://www.eaae.be/old/research.php (accessed 10.12.2015).

[3] See note 1.

[4] Ibid.

[5] Ibid.

[6] For a discussion of whether it is at all possible to talk about 'general scientific claims' see the article "Framing artistic research - a Correspondence" by Henrik Oxvig, head of research at the KADK, and Claus Peder Pedersen, head of research at the School of Architecture in Århus; in *Refractions*, ed. Søberg, Lorentsen, Torp, Thorborg and Hougaard, in publication, expected 2016.

[7] See note 1.
[8] The first criterion, distinctness, (my translation of the Danish *tydelighed*) addresses the distinct expression of the work, how *distinctly and clearly* the artistic research is presented, as regards both the reflection and the art works. The second criterion, density, (*tæthed*) addresses how the influences between techniques, materials, and ideas are brought together in a work. The third criterion, depth, (*dybde*) addresses contextualizing the work: putting it in relation to other art works and cultural currents.
[9] http://www.eaae.be/old/web_data/documents/research/120903EAAECharterArchitecturalResearch.pdf (accessed 19.10.15)
[10] This is one of the research methods in the already mentioned ADAPT-r collaboration, which is, for instance, practiced at the RMIT in Australia and Spain.
[11] Bertram has presented the diagram in lectures and during supervision. See also Peter Bertram, *Frembringelse* (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2011), 223.
[12] Ibid., 24.
[13] Stan Allen, *Practice: Architecture, Technique and Representation*, 2nd expanded ed. (Abingdon and New York: Routledge, 2009), XIII.
[14] Ibid., XIII-XIV.
[15] Ibid., XIII.
[16] Ibid., 48.
[17] "If theoretical reflection entails being at a certain remove from the world, doubt returns thought to openness before the world; it involves a loss of mastery and control which places thought in a more vulnerable relation to the world than before." Ibid., XV. Allen quotes Norman Bryson, "The Erotics of Doubt," *New Observations* 74, ed. Jeremy Gilbert Rolfe and John Johnston, (1990): 11.
[18] I deepen this claim in the chapter *MEDIA MUTATIONS III.*
[19] See for example the chapter on stereotomy in Evans, *Cast*, 179-208.
[20] Donald A. Schön, "Toward a Marriage of Artistry & Applied Science In the Architectural Design Studio," *Journal of Architectural Education* 41 (summer 1988): 4.
[21] Ibid., 10.
[22] "Deliberately executed, architecture's procedures are capable of producing systematic thought: serial, precise, and clinical; something that resembles theory but will always be marked by the constructive/creative criteria of practice." Allen, *Practice*, XIII.
[23] Peter Eisenman has famously insisted that architectural drawing is a sort of text with syntax and grammar, like language. See for instance this interview with Eisenman from archdaily.com from sept 2013.http://www.archdaily.com/429925/eisenman-s-evolution-architecture-syntax-and-new-subjectivity (accessed 11.12.2015).
Adrian Forty discusses architects relationship to respectively drawings and language and emphasizes that architecture would not work without both. Adrian Forty, *Words and Buildings* (2000; repr., London: Thames & Hudson Ltd, 2013), 29-42.
[24] David Turnbull, *Masons, Tricksters and Cartographers* (2000, repr., Abingdon: Routledge, 2003): 228.
[25] Ibid.
[26] Jan Bovelet, "Drawing as Epistemic Practice in Architectural Design," *Footprint – Delft School of Design Journal* 4 no. 2 (autumn 2010): 75-84.

DRAWING REASONING II: ABDUCTIVE AND DIAGRAMMATIC REASONING

Introduction to the chapter

The field within which this project's problematic lies has been introduced and contextualized in ongoing discussions of architects' media use, and the working method has been clarified above. In this chapter the idea of working through the binary approach of practice and reasoning in different formats is connected to existing theories of knowledge. I argue that drawing reasoning is diagrammatic reasoning, and that diagrammatic reasoning neither belongs solely to a scientific, scholarly reasoning practice nor to an architectural drawing practice, but rather to both. The diagram is a concept that can relate the two practices; not 'merging' but connecting them. Diagrammatic reasoning in Peirce and Stjernfelt contains yet another form of reasoning, namely abductive reasoning, and both sorts of reasoning – abductive and diagrammatic – describe creation and emergence processes: how something new enters or emerges from a scientific process where reasoning is expected to progresses in logical, argumentative steps by deduction. One such acknowledged reasoning pattern is to pose a hypothesis and then affirm or deny it, enabling new knowledge and insight to emerge in transparent ways. But how did the hypothesis itself emerge? Abduction is a concept that attempts to answer this. As forms of reasoning that involve the inception of something new, while also being dependent on shared conventions and meaning, both abductive and diagrammatic reasoning comply with the dual nature of architectural drawing as both a clearly understandable technical facilitator and an inventive, intuitive act. The first part of this chapter addresses abduction, while the next is concerned with diagrammatic reasoning and discusses how these forms of reasoning relate to conventional, architectural drawing.

ABDUCTION

The basis of a method is to infer and reason, says Peirce.[1] Understood as logical form, an abductive inference is weak, but Peirce nonetheless thought of abduction as a method: as a way of producing knowledge and of steering a scientific process.

The most basic definition of abduction is to pose a hypothesis, which happens in a weak logical form namely as a "qualified guess."[2] To this one must add that abduction is a way of reasoning in close contact with the reasoner's own field of experience, i.e. with what is sensed and felt by the reasoner in a local context. This aspect of abduction has to do with transforming the sensed into signs.[3] It is unique to Peirce that he is convinced that

abductive reasoning plays a very important role in scientific reasoning and argumentation, since it is only a weak logical form conterminous to intuition. But abduction is important because it is the only kind of reasoning that can allow anything new into the reasoning process or that can lead to the emergence of new discoveries.

Abduction as logical form

Peirce works with three kinds of arguments in which reasoning happens in different ways: abduction (also called hypothesis or retroduction), induction, and deduction.. Peirce's idea of abduction changed during his life; at the outset it was primarily an attempt to guide choosing between different hypotheses.[4] But, and this is important to this thesis, as he developed the concept over the years its meaning shifted to that of how hypotheses come into being at all, that is, how creative formations happen in the first place, and how this relates to abductive reasoning.[5] Hence the concept itself develops, while also having several facets. One facet is abduction as a logical form: an act of qualified guessing, also known as the posing of a hypothesis. Amongst the three arguments in Peirce, abduction is the only one that can allow something new to enter into the premises of a problem. This has to do with abduction being a *qualified* kind of guessing, as opposed to random guessing.[6] To claim that it is reasoning and not coincidence that lies behind the formation of a hypothesis in the first place, and also that guessing and reasoning have something in common, is quite unique in Peirce,[7] who, as opposed to other theorists of knowledge,[8] saw the formation of a hypothesis as the only way a scientific processes could acquire a level of new insight.[9] The assumption is that, as a qualified guess, abduction guides scientists in the right direction, albeit on vague foundations that need to be tested. But how can it be accounted for that abduction is then also a logical form? Peirce's famous bean example might be helpful.

DEDUCTION.
Rule.–All the beans from this bag are white.
Case.–These beans are from this bag.
.·.*Result*.–These beans are white.

INDUCTION.

Case.–These beans are from this bag.
Result.–These beans are white.
.·.*Rule*.–All the beans from this bag are white

HYPOTHESIS.

Rule.–All the beans from this bag are white.
Result.–These beans are white..
·.*Case*.–These beans are from this bag.[10]

When we make a deductive inference we have two premises, a rule and a case, of which we are already certain. The conclusion (result) is arrived at by holding the two premises together giving us knowledge of the beans which we could have arrived at without looking at the beans without any sense input: we already know that all the beans in this bag are white, and therefore, when these beans are from this bag they will be white. It will always be like this in terms of logic, so the conclusion is secure. In induction we also know two premises, but the connection between them is unsure: we do not already know that the beans from this bag are all white, but we assume they are by holding the premises together and drawing a conclusion, which is, however, not totally certain. In induction we do not yet know the rule, unlike deduction, but we do know that the beans stem from this bag, and since the beans are all white, we can assume that being white is a general characteristics of beans from this bag. Thus our conclusion (now a rule) is well documented empirically, but is not completely secure.[11]
When we pose a hypothesis we start out from a rule, as in deduction, while at the same time being faced with a peculiar fact (these beans are white). But our guess is more daring than the inductive one, which concludes to a rule. In abduction we conclude to a case, which is more singular and specific than a rule. But our guess runs parallel to a known rule (all the beans from this bag are white). The guess, hence, can be explained as follows: I already know that all the beans from this bag are white. Meanwhile, I have some beans here. Maybe, they come from this bag? The conclusion is a *maybe*, and therefore the conclusion is a hypothesis or suspicion that must be tested, but it is still a logical form.
In Peirce's pragmatic approach to reasoning grounded in the material world and in human perception, abduction is the kind of reasoning closest to the world, and it takes very basic, common-sense aspects of the world into consideration, which more secure forms of logic, such as induction and deduction, no longer take into consideration but rather presuppose. For Peirce the world is the insecure source informing human reasoning, similar to Allen's "erotics of doubt"[12] above. The closeness to the world makes abduction insecure, but, Peirce thought, what abduction lacks in security it accounts for in "uberty":[13] that is, richness, fruitfulness, and a tendency to be affirmative.[14] Although Peirce thought of abduction as the lowest kind of reasoning because it is insecure, it is the only kind of reasoning that can lead to the emergence of a

new idea or concept. In that way it is the lowest and highest form of reasoning simultaneously. Where induction and deduction are, strictly speaking, closed circuits of logical reasoning,[15] abduction is open to the world and therefore more uncertain. This has to do with another aspect of abduction, namely a kind of primary abduction that is continuously happening as lived process and that underlies all reasoning.

Primary abduction

As inference, abduction is a weak logical form – a guess – for choosing a hypothesis, and abduction can also be an "explanatory hypothesis":[16] a theory that explains a "surprising fact."[17] But later, as the concept developed in Peirce, the philosopher Douglas R. Anderson says, abduction becomes more of a "procedural view in which abduction comes to consist in examining some facts, sometimes surprising facts, and in allowing these facts to suggest a theory. Peirce lays the foundation for a type of reasoning which has a logical form but which is also a lived process of thought."[18] Anderson continues; "[h]e suggests that logic is not merely a matter of closed system of thought, but of open human inquiry."[19] This aspect of abduction describes the interplay between some facts that are allowed to suggest a theory,[20] which is similar to the method of this thesis where my drawings are suggestive of the development of the theoretical part of the thesis and vice versa. Peirce thinks that abduction is "primary"[21] amongst the three forms of arguments because it lets hypotheses emerge in the first place: being a basic creative formation where we abduce when we put sensation and ideas into systems of signs, language and logic.[22] Peirce gives one example of this, which expresses the difference between what he senses – a blooming flower – and the way in which he can express the blooming flower through a representation, in this case language.

> Looking out of my window this lovely spring morning I see an azalea in full bloom. No, no! I do not see that; though that is the only way I can describe what I see. *That* is a proposition, a sentence, a fact; but what I perceive is not proposition, sentence, fact, but only an image, which I make intelligible in part by means of a statement of fact. This statement is abstract; but what I see is concrete. I perform an abduction when I so much as express in a sentence anything I see. The truth is that the whole fabric of our knowledge is one matted felt of pure hypothesis confirmed and refined by induction. Not the smallest advance can be made in knowledge beyond the stage of vacant staring, without making an abduction at every step.[23]

There is a difference between what is sensed, and how that sensation is represented and communicated through a sign. When sensations and ideas are arranged in systems of representation, or when one translates a sensation into representation, the experience of the sensed phenomenon becomes mediated through the representation and is no longer a 'pure' sensation or idea. The vessel of representation is used, which has itself a constitution that to some extent shapes what it transports. The typical semiotic relationship of three consists of the thing itself, its sign/representation, and the connection between them. To be precise, the connection between the thing that is represented and its representation is of primary importance, since it can be abductively and sensuously motivated, just as it can be deductively and logically motivated. I will cover this in more depth later with a discussion of the diagram.

The idea that abduction is a primary, formative inference that underlies all reasoning agrees with Peirce's pragmatic approach to the world "according to which the meaning of a concept is equal to its behavioural consequences in conceivable settings"[24] as explained by the theorist of science, Frederik Stjernfelt. The semiotician and writer Umberto Eco also underlines this premise in Peirce: that in his opinion, "our thoughts correspond perfectly to the external things."[25] For this reason, abduction is the gateway for something new to enter into any complex of problems: the way human reasoning is able to "interface" with the world, as it were. Thus abductive reasoning is relevant for this project in this primary sense, as it becomes a way to conceptualize how sensations and ideas undergo a transformation as they are represented, a transformation that is not neutral but that is always situated in a person and in a context between which abductive inferences can mediate, as Peirce described with his "azalea in full bloom". Here a sensation does not necessarily have a fixed reference or meaning, but rather the relation between the sensation, the representation, and that which is represented can be explored, as often happens in architectural drawing.

The paradox of abduction - Intuition and logic?

Abductive inferences lie before deductive and inductive ones, which can only begin when basic coherencies, presuppositions and premises have already been established. Abduction works in the area where coherency between sensations and concepts *is being* established in the first place – the primary abduction – and thus abductive reasoning moves in the gap between sensation and concept, and allows relations to be tentatively created between the two. Therefore abduction typically has little empirical support, if any at all, i.e. a clear point of reference may not exist, but only a guess or a suspicion that could explain a surprising fact or event. Therefore it has been questioned whether abduction is a logical form at all, and not rather a form of intuition,[26] in which case – it is claimed – abduction would cease to be a method.

With this question, Deleuze's reading of Henri Bergson's intuitive method comes to mind,[27] where Deleuze asks "[h]ow is intuition – [...] – capable of forming a method [...]?"[28] The intuitive method has already been related to an architectural context by

Peter Bertram,[29] and there are some shared approaches between Deleuze/Bergson's intuitive method and Peirce's abduction. Although I will not make a comparative analysis of the shared approaches, these theories of knowledge are important in relation to artistic research, where areas that formerly were often kept separate are brought together. The paradoxical nature of both the intuitive method and abduction corresponds to the attempt to situate art and science close to each other, and to make the friction between them productive. The intuitive method and abduction share the paradox of putting together intuition, a concept lying at the heart of sensation, with method and syllogism, concepts lying at the heart of logic.

It is not that abduction contains *either* logic *or* intuition. It contains both simultaneously, Anderson argues. To think that abductive *logic* comes first, which would block the way for *primary*, *intuitive* abduction, is to confuse "logical with temporal priority,"[30] so Anderson, who states that "[i]n Peirce's view it is possible for the hypothesis and its abductive application to occur together. Therefore, abductions may be insightful and originative and still have logical form."[31] Anderson supports this with Peirce's statement that abduction "[…] is an *act* of insight."[32] But that does not mean that abduction *is* instinct or intuition (and I will use the terms instinct and intuition interchangeably in the following). Rather abduction stands in a unique relation to instinct. Instinct allows us to guess and to follow logical forms, but we do not guess *because* we have instinct, so the philosopher Nicola Erny.[33] She states that abductions are indeed based in instinct, and instinct is to be understood as an evolutionary embodiment of insight and experience in a socio-cultural context, which makes it possible to guess in a qualified way at all. Instinct is important in processes of becoming, as Peirce points out when he talks of a primary formative abduction where sensation and representation are related in the first place, as in the example with the "azalea in bloom."

Erny argues that Peirce talks about abduction being related to instinct as a way to mark abduction as different from randomly guessing,[34] and as a way to rely on experience-based insights. Intuition becomes problematic only when we understand it as being unquestionable, independent, a sort of knowledge coming from God or from somewhere outside any context. According to Peirce's pragmatic approach to the world, he would not see abduction as detached from context, but rather as inseparable from context-based knowledge, experience, and sensation, as we will see in the next chapter. One might then say that because of intuition the guess becomes qualified and not random; due to intuition the guess is given a direction with a tendency to be right.[35] In other words, whether intuitive abduction can be a method or not comes down to whether we have a world-view of simultaneity and implication between simultaneous conditions, or one of sequence and execution. That abduction as logical form would exclude being in a relation to intuition only follows from a sequential world-view, where instinct comes first and logic follows. Conclusively, abduction cleaves out two views of the world, one of sequence and one of simultaneity. In relation to this, I agree with Anderson who argued that intuition/instinct does not venture before logic, but that logic and intuition can venture simultaneously. At least that is how I would describe how architectural drawing works: as simultaneously intuitive and logical, emerging as a negotiation between sensations, representations, and logical structures. The implication of this paradox – with intuition and logic venturing at the same time – is that abduction can operate 'outside' secure terminologies and conventions, and in that sense it is a subversive form of reasoning, always endangering conventions by measuring them up against sensed phenomena. As such it has the potential to undermine shared and secure concepts, conventions and definitions, and this same quality makes it possible for it to enable new concepts to emerge.

Abduction as world-creating device

Robbins argued that drawing can transform the 'outer world' into an architectural world that is manageable and coherent for architectural intent.[36] Bertram argues that creating a "possible world"[37] is an act of artistic, architectural creation. Umberto Eco also understood abduction as a "world-creating device".[38] Primary abduction, where sensations and ideas are translated into signs and representations, makes it possible to let something new into a reasoning process, or into the premises of a problem at all. This can, for instance, be formulated as a qualified guess or as a daring explanation. Peirce talks about endless semiosis: an endless formation of new signs and meanings continuously forming and reforming the human field of knowledge, and the philosopher Ole Fogh Kirkeby points out that abduction forms part of that process.[39] Abduction as an insecure logical form that leads to new insights, and therefore to new premises, is captured by Peirce in the following definition:

> The form of inference therefore is this:
>
> > The surprising fact, C, is observed;
> > But if A were true, C would be a matter of course.
> > Hence, there is reason to suspect that A is true.[40]

If A is actually true then we have found something new that forms part of the premises of our next inquiry, thus creating a 'new world' different from the world as it was known before the new insight.[41] This abductive process is like a feedback loop continuously changing the premises, an iterative process of emergence, where not only *a* new world emerges but where the world continuously emerges anew.[42] Eco agrees with this idea of

abduction as a world-creating device that takes part in an "evolutionistic" rather than a "rationalistic"[43] process of world creation. He is also interested in abduction as a way of reasoning that creates connections that do not yet exist; these can be new connections between old facts, or non-existing connections between facts, clues, and ideas where coherencies between real and imagined things are constructed. Concerning abduction as a world-creating device, Eco distinguishes between two sorts of abduction: one that guides the construction of general laws; and one that guides the construction of a particular explanation that fits the facts at hand. Abduction as construction or discovery of general laws as in the great scientific discoveries (Kepler etc.);[44] and abduction as constructing local, temporary coherency in situated events, as when a detective solves a criminal case. A universal abduction, which is very similar to deduction, so Eco, starts out from an observation of (surprising) facts and poses a "hypothesis of a general law."[45] A local abduction starts in the same way but "ends at the hypothesis of another particular fact which is supposed to be the cause of the former."[46] The universal abduction seeks to extract provable facts from the world and to find universal truths, whereas the local abduction seeks to create coherency in partial and temporary states-of-affairs. Eco hence distinguishes between abductive reasoning that is very close to deduction, and abductive reasoning that is closer to primary abduction and intuition. Eco displays these two directions by tracing abduction in both the *composition of* a detective novel, and in *the plot* of such a novel, which creates a fictive, coherent world and which could be a plot in the real world. Thus Eco also points out a distinction as well as a similarity between a scientific and a poetic abduction, as Peirce has called it himself.

> It cannot be said that all framing of hypothesis is mathematics. For that would not distinguish between the mathematician and the poet. But the mathematician is only interested in hypotheses for the forms of inference from them. As for the poet, although much of the interest of a romance lies in tracing out consequences, yet these consequences themselves are more interesting in point of view of the resulting situations than in the way they are deductible. Thus, the poetical interest of a mental creation is the creation itself, although as a part of this a mathematical interest may enter to a slight extent. Detective stories and the like have an unmistakable mathematical element.[47]

The construction of a scientific hypothesis, the poetic *and* logical construction of a detective story, and the way a real detective would construct relations between clues and create a plausible explanation of the course of events in a crime, have a shared component of reasoning, so Eco.[48] To create the hypothesis of a crime by creating a world that fits the facts is also to solve the crime. In the case of a scientific problem, the same sort of reasoning could be implied as both creating and solving the problem[49] and the same aspect of creation can also apply to poetic creation. Eco stakes that "the mechanism of abduction"[50] is the same, no matter whether we are dealing with the creation of universal laws or with situated and temporary coherencies; however, situated, local reasoning happens on the basis of more general socio-cultural ways of inferring, which cannot be translated to another context without alteration.

The local abduction that Eco coins with Peirce as a local, sometimes poetic, world-creating device could describe a 'productive' form of drawing reasoning too, where one drawing 'move' follows from and leads to another. Indeed the writer Emma Cooker describes drawing thus: as a productive mode of reasoning where the hypothetical *if* keeps the thought in flight, and the concluding *then* grounds it. The drawing – so Cooker – stalls the grounding *then* and thus the uncertainty and suggestiveness of the hypothesis' initial *if* keeps the drawing process open and going.[51]

Peirce, Kirkeby, Eco, Bertram and Cooker find abductive traits in both mathematic and poetic reasoning, in scientific reasoning, and in drawing reasoning, in both the creation of universal rules and in locally situated coherencies – as in a crime or a drawing. In all instances suspension of disbelief is allowed, at least for a while. Eco puts forth that, even if the mechanism of reasoning is the same, the consequences of the respective endeavours of abductive reasoning – seeking for universal rules, local coherencies or poetic qualities – are interesting for different reasons: where a poetic abduction, such as the construction of a fiction or a drawing is more interested in the quality of the consequences, of the output, then the universal abduction emphasizes the stringency of the logical method. Nonetheless, each kind of abduction contains an element of the other kind of abduction: the strictly logical abduction becomes redundant if it is cut off from the world, whereas the poetic abduction can look to logical forms if coherency or grounding is wanting. Abductive reasoning, hence, is simultaneously at work on two levels in this thesis, both as a way to situate theory and drawing practice in relation to each – remember Peirce's claim that "[a]bduction seeks a theory"[52] – and as a form of drawing reasoning which can be both logical and poetic.

FROM ABDUCTIVE TO DIAGRAMMATIC REASONING

Peirce says, "[…] in a remote way Abduction rests upon diagrammatic reasoning."[53] This is relevant for this project, because diagrammatic reasoning, especially in Stjernfelt's reading of Peirce, brings us yet a step closer to *conventional*, architectural drawing. A diagram within Peirce's semiotics and system of thinking, namely, works by both abductive *intuitive* reasoning and deductive *conventional* reasoning *together*. This idea seems fitting to architectural drawing since, in conventional, architectural drawing, there

can be both intuition and logic at play together. My diagrammatic understanding of architectural drawing is supported by the historian of ideas, Malene Busk's, and Bertram's readings of Deleuze's *diagram as motif*, who both put forth not only a productive aspect of drawing,[54] but also a methodological aspect of drawing, which concerns drawing's potential within research processes. With these understandings of the diagram as having to do with both reasoning in general, as well as in artistic processes, I propose to understand conventional, architectural drawing as a diagrammatic reasoning activity with the potential to open up its own convention. First an understanding of the diagram in Peirce is given, and then this understanding is related to conventional plan drawing.

A semiotic concept of reasoning

As briefly mentioned in the chapter on primary abduction, in Peirce's semiotics reasoning happens in a relationship of three: an object (the word object in Peirce describes the category of things and phenomena that a sign relates to, and does not mean an object in an everyday-like use of the word); the objects' sign/representation; and the relationship between the object and the sign.[55] The precise connection between the object and the sign/representation is of major importance, since the relationship can be abductive, intuitive, and sensuously motivated, just as it can be deductive and logically motivated. To say this differently: signs and their object can either stand in a clearly understandable relation to each other, or not.

A sign is not the same as that which it represents, a fact from which conventional architectural drawing gains momentum, and which becomes a powerful support to both architectural thinking and building. The drawing is not the building, but it represents it: the drawing is the sign; the building the object. But the drawing is also always in a relation to a situated maker who can choose *how* the drawing is to represent the building – more or less conventionally or in a more or less imaginary way. Diagrammatic reasoning allows for the maker to experiment with the drawing itself through drawing techniques etc., as well as to experiment with the drawing's relation to the building. This premise already begins to reveal the double nature of diagrammatic reasoning. In Danish and German the word *sign* (*tegn*/*Zeichen*) takes part in the word drawing (*tegning*/*Zeichnung*), so that here the connection that Peirce offers between signs, objects, and reasoning is, when the subject is drawing, nearby. It is important to remember that Peirce's thinking presupposes that there is a deep, basic conformity between structures of signification and structures of reality.[56] That is to say that the world as human beings experience it is itself the 'measure' of processes of signification; said differently, there is no knowledge that is not related to our experience of the material world. Thus Peirce thinks of different kinds of 'life world' phenomena as intertwined with reasoning, which again is expressed in different kinds of signs. (For a description of how Peirce distinguishes between phenomena of firstness, secondness, and thirdness, see appendix).

Phenomena:	Firstness	Secondness	Thirdness
Reasoning:	Abduction	Induction	Deduction
Signs:	Icons	Indexes	Symbols
Works by:	Instinct/Guess	Empirics	Habit/Law[57]

I will roughly outline some of the routes in Peirce's system of thought, which have to do with how phenomena and signs relate to different sorts of reasoning. Peirce groups phenomena of firstness, which have to do with thought, feeling, and sensation, with abductive reasoning and the class of signs called icons. Icons are signs that represent their objects by *likeness*, *resemblance* or *similarity*.[58] Phenomena of secondness, being physical and material, are grouped with inductive reasoning and relate to the signs called indexes. Phenomena of thirdness, which are habitual and conventional, relate to deductive reasoning and the signs called symbols. A symbol is *conventional*: it is a sign with a clear interpretation and a shared, general meaning.[59] Symbols can be words that that describe the relation between two entities, such as the word *moves*. If we say A moves B, then A and B are the objects that pointed to, and *moves* is the relation between them.[60] As signs that rely on convention and habit, symbols are the most unambiguous and secure signs used to make laws and contracts. But, for the same reason, symbols can be too general and therefore can also lead to errors in reasoning. And, despite their status as secure, symbols *do* grow, as Peirce says,[61] because symbols rely on other signs that change. Symbols grow because relations change between objects and the phenomena they describe. So even if symbols describe conventional, secure relations between object, meaning, and sign, these relations might change. It could be said that symbols grow because of both changes in the world and changes in the way humans transform knowledge into signs. One way of conceptualizing this transformation is given by Peirce's diagrammatic reasoning concept.

Induction relates to secondness and describes reasoning through indexes. A typical index is an imprint, a trace, or a physical connection that gives a sign, such as a weathercock in touch with the wind, or an old-fashioned photograph where rays of light leave a physical trace on light-sensitive paper. An index could be a proof found at a crime scene, a fingerprint or footprint, something that carries traces from a direct physical influence or force. Indexes are also related to pointing: the index finger is the finger that points. A footprint in the muddy earth indicates the person who left it there. Personal names and pronouns are also indexes due to their dimension of pointing, although a name and a

person do not “touch” in the same way that a weather cock is in touch with the wind. Names point at what they represent and therefore they are indexes. Apart from this, indexes can have a direct physical impact on the nervous system, as a scream or a knock on the door.[62] Such are the general outlines of Peirce’s characteristic of signs. But soon his signs start to take place within each other and become mutually influential: a footprint, for instance, is an index because somebody’s foot has left an imprint, but it is also an icon because the imprint looks like a foot. Old-fashioned photos are icons because they look like that which they represent, but are *also* indexes because they are generated by physical traces of rays of light on light sensitive paper.

Reasoning with icon diagrams

With this very brief overview of Peirce’s semiotic system above, I will elaborate the icon, which relates to firstness – sensation and feeling – and abduction. The surprise of the icon in Peirce is that it also contains the diagram as a subcategory. Icons are the only sign that can stand alone, and one of their main qualities is that they enable us to study something that only exists as possibility, cf. Bertram’s “possible world,” and Eco’s “world-creating device.” It makes good sense, therefore, that icons relate to abductions, since hypotheses are also ‘*if* conditions’. An icon standing alone resonates with an architectural drawing, particularly a sketch lacking references and therefore a secure meaning. Moreover it is a quality of icons to allow us to study what something would be like in this or in that case without it actually being like that; it has a proposing character, as does drawing. This makes icons appropriate tools to enable discussion, thinking, and for obtaining feedback. Peirce says,

> A pure icon can convey no positive or factual information; for it affords no assurance that there is any such thing in nature. But it is of the utmost value for enabling its interpreter to study what would be the character of such an object in case any such did exist. Geometry sufficiently illustrates that.[63]

An icon holds a possibility, an idea or singular quality that may not have a material form or even exist in any other form than *as* the very icon. Peirce calls material, iconic signs hypoicons in order to distinguish between icons as material signs and icons as pure thoughts (for instance, as a geometrical figure expresses a pure, abstract thought) or sensation (as the colour red expresses a pure sensation). There are three kinds of hypoicons: images, diagrams, and metaphors.[64] Images, diagrams, and metaphors all work by likeness, but different kinds of likeness: images work by visual/mimetic likeness; diagrams by *relational* likeness; and metaphors by analogy or association.[65] Where images have to do with visual likeness and “simple qualities”[66] – such as a pure sensation of the colour red, – diagrams have to do with operational likeness. It might be surprising that diagrams are categorized as a subcategory of the icon, since Peirce underlines diagrams as having an important role in logic and mathematics. The more conventional idea of a Percian icon is that it is an image that has a likeness with the object it represents, as a portrait does, and this might not seem to play a very big role in logic. Moreover, Peirce also emphasizes symbols and deductive reasoning as being the closest relatives to logic. But in spite of this the diagram remains an icon, relating to thought and sensation, yet playing an important role in logic. Peirce selects icons guided by conventional reading rules as deserving particular attention, for instance mathematical formulas.[67] Mathematical formulas are in the first place icons, but icons of logical and conventional relations. But conventional relations in Peirce’s system belong to symbols. The icon and the symbol, as Stjernfelt points out, move towards meeting in the diagram, which can visualize and mediate between conventional reading rules, and thought and sensation.

In *Diagrammatology,* Stjernfelt elaborates reasoning with icon diagrams. Stjernfelt argues for a strong concept of the diagram as icon, basing his conception of the icon on a “non-trivial”[68] understanding of it, and emphasizing that the icon is an operational sign, not simply a mimetic or image-like one, which is the common understanding: it is common to emphasize that icons are similar to their objects, for instance by visual resemblance, but Stjernfelt gives an “*operational* account of similarity.”[69] All icons are understood by their operational qualities, although the operational qualities of a landscape painting and an algebraic formula are quite different. To think of a landscape painting as icon because it *resembles* a real landscape is a trivial conception of icons, although not wrong. But with the operational icon conception, Stjernfelt transposes the balance and allows for the idea that both landscape painting and mathematics have an operational diagrammatic nature. Moreover both include diagrammatic reasoning on the part of the receiver who analyses the icon. When contemplating a painting it can be treated as a diagram: the relations between its parts can be considered, beholders can both navigate in it by the rules of perspective, or picture themselves walking along a path in the painting, so Stjernfelt argues.[70] If we apply any “reading rule”[71] to the icon under examination then we are operating on an icon diagram and make experiments with it. But for this reason, there is not just *one* way to understand the painting; the painting remains indeterminate with regard to how it is to be read and can be questioned continuously. That indeterminate quality is related to abduction, and characterizes icons’ productive value as a testing ground. As icon the painting can look and feel like a physical garden “more or less,”[72] not ‘either or’, which is a consequence of the conditions that icons are similar to or resemble the objects and phenomena they represent. Likeness, resemblance and similarity are elastic terms. Despite of this vague ‘more or less’ condition the icon can be a functional diagram, an exact formula, for

instance, which does not at all resemble that which it represents and explains, but shows and tells how that which it represents operates. This exactness of the diagram exists side by side with the suggestiveness of the icon in Peirce's icon diagram, and thereby becomes productive for basically all sorts of reasoning.[73] This also applies to drawing as a device for architectural reasoning. The sensuous suggestiveness that a drawing can have evokes different responses in the receiver, and this is a quality of icons.[74] And yet drawing can also communicate through completely clear, conventionalized reading rules (a quality of symbols), but, says Stjernfelt, these two signs and their ways of reasoning meet in the diagram and give it its strong reasoning potential. Here we begin to see how diagram icons share traits with conventional architectural drawings, which are image-like in character being both suggestive and undecided, while simultaneously being precise and logical with regard to how that which they describe operates, and how this is communicated through conventional drawing signs and signatures. Peirce even highlights the icon's sensuous way of reasoning with regard to an elevation. He says that by contemplating the elevation the architect can establish whether it will be beautiful and satisfying, because the sensuous effect the icon has on the architect will answer such aesthetic and poetic questions.[75] Thus Peirce describes an important iconic quality of the elevation drawing: that the icon serves the architect by rendering visible something imagined, while being different from that 'pure' imagination of thought, but also being very precise about it.

An icon without any rules may be the only way to represent an idea or sensation in the first place,[76] but Peirce emphasizes those icons to which conventional rules are attached. This is, according to Stjernfelt, a non-trivial understanding of the icon, where the icon is operational because it is accompanied by a symbol. Diagrams are icons guided by a reading rule, habit, or convention. A symbolic reading rule, habit, or convention allow us to operate on the icon in other ways than would be allowed by the icon alone.[77] This double nature – icon plus symbol – taps into both abductive and deductive reasoning. Remember that Peirce says that there is an element of mathematics in all reasoning, including poetic reasoning. But he also says that there is an element of observation in all mathematics, meaning that mathematics is not purely deductive. If it were, mathematics would not develop, or could only develop within its own system, which would limit the mathematical inquiry.[78] Abduction permits the inquiry on a given field to remain open.[79] This dual nature, which has in part already been captured in the idea of abduction as simultaneous intuition and logical form, also lies at the heart of diagrammatic reasoning in Stjernfelt's sense where icons and symbols are brought together.[80] In creative processes this holds the promise of remaining in close contact with the world, on the one hand, and questioning conventions and habits, on the other, whereby transformation of conventions and habits are enabled. In the diagram abductive intuition and qualified guesses join forces with deductive logic, conventions and habits. A pure icon can transport sensations and ideas better than instructions or explanations, whereas the power of symbols lies in communicating instructions and explanations, and in the diagram these qualities form a relationship of reciprocity and dependence.[81]

The same can be said of architectural drawing, which relies on conventions expressed as drawn symbols. In a finished working drawing the logic of the drawing corresponds closely to the logic of the building.[82] However, the drawing is also able to convey sensations, perhaps more so when a sketch, but also in the form of a finished working drawing, as seen in Sigurd Lewerenz's drawing showing the plan and façade of his church in the Swedish town of Klippan (1965-66). The material feel of brick is conveyed very well as smudged pencil strokes,[83] and even though the drawing consists of a well-known plan and elevation, the elevation seems like a spatial drawing – an oblique or isometric view – because the geometry of the building shows itself thus when it is drawn as elevation. Hence the conventional technique (elevation) together with the architecture produce an affect, which opens up the way the drawing is read.

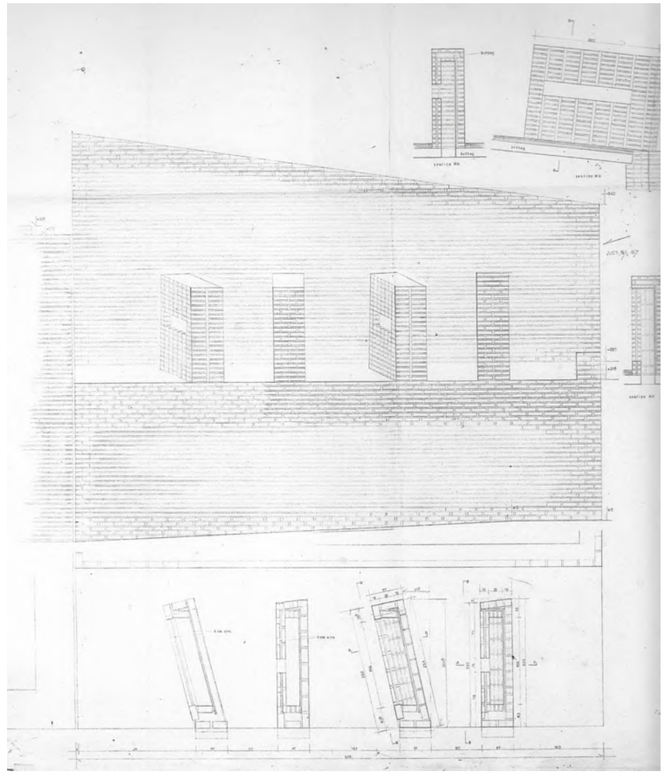
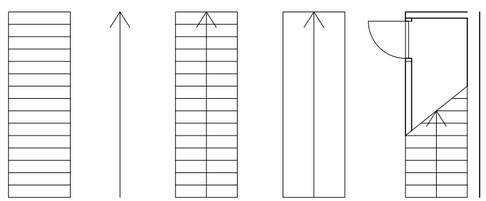


Fig. 2.
Sigurd Lewerenz, plan and elevation drawing for his church in Klippan, Sweden.

Conventional drawing reasoning

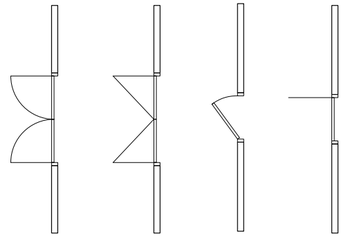
A movement has been made above from abductive to diagrammatic reasoning, and a connection suggested between these concepts of reasoning and conventional drawing. Now I will give an example of this connection in more detail, exemplified with plan drawings.

Robbins already outlined which drawing techniques can be said to be conventional: orthogonal projections such as plan, section, and elevation, and different sorts of perspective and axonometric projections. Moreover *signatures* convey a range of messages, and conventional signatures, such as a door or a stair in plan view, are diagrams because they are images carrying conventional reading rules. They are images that relate to what they describe through resemblance, but they have also acquired clear meaning and determinacy with regard to what they describe, and have become both habit and convention. Not only does the drawing of a stair fluctuate between being an image that mimes the way a stair looks when seen in plan view, and conveying a clear instruction about what is up and what is down. The stair diagram also fluctuates through a range of slightly different signatures, which, however do not affect the overall meaning of the stair diagram. The arrow-head indicates both the rise of the stair and movement, a "path of travel,"[84] but this is movement in a generalized way, not as a trace left by a person. Movement and change in height are conveyed in a generalised way that is symbolic rather than indexical or iconic. In fact, an arrow as such is an even more general diagram than the stair, because it is used in many other contexts than the architectural one. As general diagram, an arrow means that there is an affect between two entities; that something is transported or translated from x to y.[85] In the case of the stair, the arrow indicates that bodies can move both up and down, and it instructs others in the building process as to how this should be made possible. Allen has said that an architectural drawing becomes notational, that is, becomes an unambiguous, instructional medium at the exact moment where numbers and letters are added to it.[86] But in fact this happens some time before numbers and letters are added.



A stair, plan,
1: 100

In diagram signatures where one 'looks through conventions,' such as the stair, architectural drawings become notational media even without numbers and letters. It is true that text and numbers specify even more information, but the drawing still gives instructions without the text or numbers: diagrammatic reasoning is already at play. Another example is given by the door signature: like the stair's arrow, the door's swing symbolizes a range of possible movements in a generalized way, not as a trace, since a door by definition is not always in the same position but is opened or closed over and over again, rotating around an axis. As signature, this also has the diagrammatic ability to fluctuate between different graphical representations, but communicates the door's direction of opening just the same.



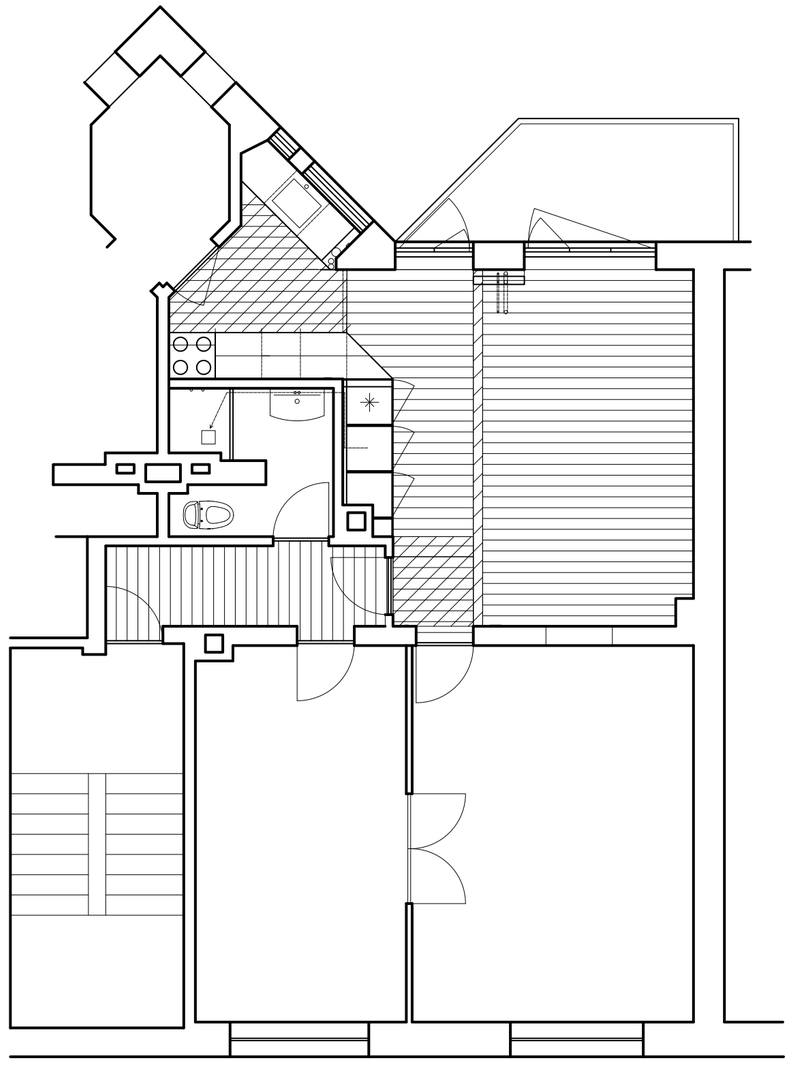
A door in plan
view, 1: 100

People who know this convention will understand what it means, and for them it conveys a clear instruction concerning a building element, and in this sense the door signature is very precise. But on the other hand, what it conveys is indeterminate: the door is, by definition, not fixed. So, peculiarly, the exactness of the door diagram is used to transport a situation which is, by definition, an indeterminate matter of choice. Indeterminacy is 'kept' in a determinate symbol and continuous change is conveyed very precisely. Similarly signatures that indicate textures are also diagrams, tending either towards the symbolic or the iconic. Take the signature for insulation, for example: it does not resemble insulation but it symbolizes it, whereas signatures for concrete or cast materials resemble a cast substance consisting of little stones etc. and therefore tend towards the icon. Conventional signatures are part of overall drawings, and these drawings too are diagrams. A plan drawing of an apartment as shown below is image-like – to the trained eye it slightly resembles that apartment – and is accompanied by many presupposed reading rules. Some signatures are mimetic, but only to the degree that

people trained in reading plans can see the likeness. One needs to be aware of the conventions, otherwise one will hardly see the likeness. For these reasons architectural plan drawing is a diagram in Stjernfelt's sense, an icon with a symbolic reading rule, more mimetic in its way of being an operational diagram than, for instance, a text, a score, or a computer script, but much more operational and potentially determinate with regard to reference than a painting. A plan drawing such as this one is also guarded by strong conventions and, in that sense alone, is symbolic. But plan drawing as such, as shared notational system, is peculiarly open too, since extremely different houses can be drawn while all following the plan convention. It is this tension between the iconic and the symbolic, between abductive and deductive reasoning, which makes conventional drawing both limiting and opening. The paradox of conventional drawing is that it works as a logical, projective framework that helps architects to orchestrate relations concerning building in a shared and rational way that corresponds to building logic, while conventional drawing also allows sensations and imaginations to play their part in the orchestration.

ARCHITECTURAL DRAWING =
DIAGRAM

ICON SYMBOL



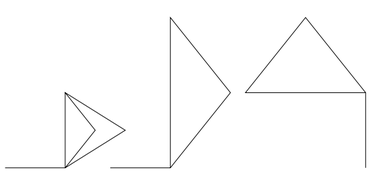
A plan of an apartment without numbers or letters.

TRANSGRESSING CONVENTIONS WITH DIAGRAMS

The dual nature of the diagram in Peirce and Stjernfelt has been explained and emphasized as playing an important role in reasoning processes, especially with regard to conventional, architectural drawing. It has been argued that, together, icons and symbols gain a productive momentum, where suggestive indeterminacy and rational precision can together become productive, and that this is valuable for both scientific and poetic reasoning. Now, in this chapter the potential of the diagram is further unfolded, not just regarding a fertile joint performance of icons and symbols, but regarding the potential to challenge conventions themselves.

Peirce and Stjernfelt emphasize that diagrams are productive in reasoning processes and that diagrams let us learn more than we already know.[88] It is a force of the diagram to give clarity in thinking by cutting into the bone of things. As Stjernfelt says "[...], the diagram represents [its object] through a skeleton-like sketch of relations …,"[89] thus underlining that diagrams orchestrate and represent *relations*; i.e. are images that make relations visible. In everyday use the word diagram could indeed mean something like a simple graphical sketch, an explanatory drawing, a list, a manual, a recipe for cooking etc., and it would not be wrong to call such things diagrams, because they are organisational helpers and external memories. But they are not necessarily the kind of diagram that challenges something existing, produces something new, or transforms habitual ideas of phenomena; they do not apply the transformative force of the diagram.

Good diagrams are those that allow the thinking of new thoughts, and the transformation of the already known: when they let us see and learn more than what is contained in the premises that constitute the diagram itself, so Peirce. Hence the diagram is more than a material token such as a drawing; it is a figure of thought (in German *Denkfigur*)[90] where the material token helps the thinking to evolve. For a diagram to be fertile and lead to new diagrams, it must perform in a way that leads to a conclusion that is greater than the sum of the parts, even though the conclusion reached might be temporary, it would still differ from the diagram that produced it. If a diagram does not yield more than it already accounts for, it is not a good diagram, so Peirce.[91] Peirce puts it thus: "A *diagram* is an *icon* or schematic image embodying the meaning of a general predicate; and from the observation of this *icon* we are supposed to construct a new general predicate."[92] But what does it mean that a diagram embodies the meaning of a *general predicate*? One of Stjernfelt's examples shows this: take a triangle; it can be written algebraically or drawn geometrically, with continuous lines. Irrespective of the type of notation, the same phenomenon, a triangle, is described, and, importantly, in each case one is still operating on a diagram.[93] The triangle diagram is indeed general but it is also operational and can lead to many new diagrams that, in more or less remote ways, have to do with the originary triangle diagram. A triangle can



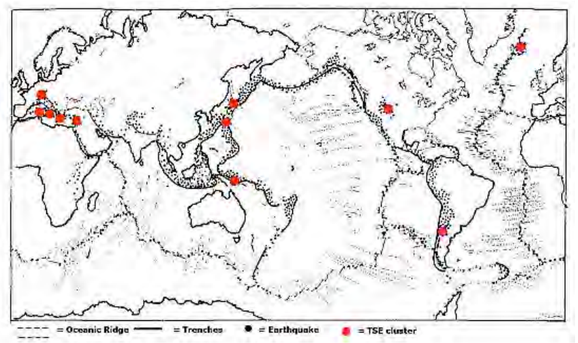
lead to other operations that involve triangles but which are not in the premises of a single triangle.[94] This means that a quite simple diagram can give rise to many different experiments and can lead to the emergence of other diagrams.[95] As a general concept, or in Peirce's words a general predicate, a triangle can take part in continuous processes of transformation that lead to more than the initial constitution of a triangle, as, for instance, when triangulation is used to make a geographical map.

The diagram as a map of rational relations

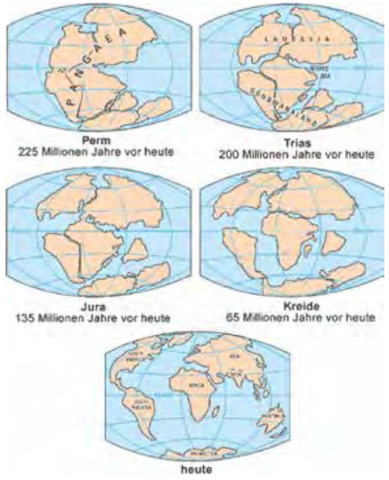
Peirce says that "new symbols arise through diagrammatic experimentation"[96] and that diagrammatic experimentation with symbols can lead to the discovery of other symbols. At the conference *Thinking with Diagrams*[97] Stjernfelt showed an example of this sort of diagrammatic reasoning, where experimentation with *general predicates,* i.e. symbols guarded by well-known conventional meaning, leads to the emergence of new general predicates. The example Stjernfelt gave is relevant in this context because it deals with diagrammatic reasoning through mapping, which is also at times an architectural endeavour. The example used was that of Alfred Wegener's discovery of the tectonic plates in 1912: how Wegener conceived of the idea that there might be such a thing as tectonic plates. The idea originated through his mapping seismic activity, notated on a world map. Wegener's mapping of it made him hypothesize that such a thing as tectonic plates existed, hidden beneath the visible surface of the earth. The effects of the plates could be read in his mapping, although the plates themselves were not visible to the human eye. His hypothesis was later proven, but that is of minor importance in this context, where the focus is on the way the map was used as icon diagram so as to come upon the hypothesis. This, Wegener's first discovery, led to an even more daring hypothesis, namely the hypothesis of the Pangaea (1929), which suggests that all land on earth was once one single coherent continent. This too was later confirmed, and Wegener's discovery of the Pangea is, according to Stjernfelt, an advanced example of diagrammatic reasoning.

The diagrammatic reasoning approach taken by Wegener included the abductive move to add something new to the premises: in this case seismic activity was plotted on to a standard world map. Surprising facts, so to speak, were plotted into a conventional mapping framework, and when Wegener tried to fit the pieces of landmasses together as if they were a puzzle, he was able to form the Pangea hypothesis. Stjernfelt indeed calls the diagram "a formal machine for Gedankenexperimente,"[98] and Wegener had for a while suspended disbelief and allowed him to make a 'Gedankenexperiment', whereby he took the 'spielraum' needed to question conventions: if the pieces were to fit together, then it could mean that the world had once been one coherent continent. This process of diagrammatic reasoning led to the establishment of a new general predicate,

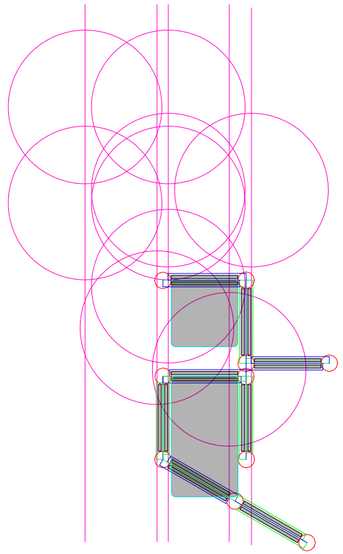
a new premise, where the Pangaea theory becomes part of new hypotheses. Eco distinguished between abductions that were made in the search for universal rules and local, temporary even poetic abductions. Wegener's abduction searched for a universal rule; his aim was not to compose an image of the world map, but he must have played with this image, this icon, and asked *what if*, in order for his hypothesis to emerge, and as such this supports Eco's claim that the reasoning that is at stake in universal and local abductions has a shared element. Stjernfelt's example of Wegener's work shows an icon – a map of the world – being at play in processes of *rational* reasoning directed towards a scientific agenda. And while for Peirce and Stjernfelt this is the most important way of using the icon diagram, Busk and Bertram with Deleuze emphasize aspects of the icon diagram that move towards more poetic, artistic reasoning processes that do not seek for universal rules but seek to make singular works of art. The same productivity, however, is characteristic of the diagram, as is its ability to break with conventions.



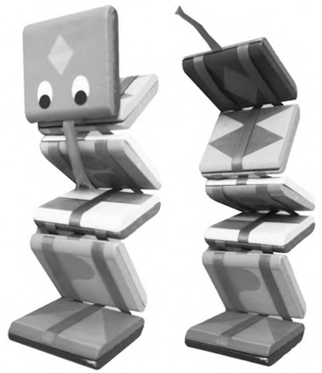
A map of seismic activity indicating the tectonic plates.



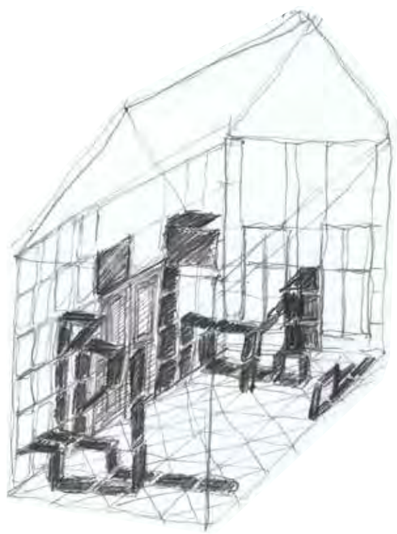
Maps showing the changing positions of landmasses from Pangaea to the present.



The toy snake drawn as set on end and seen in plan view. Besides the circles indicate the ranges of the snakes possible movements.



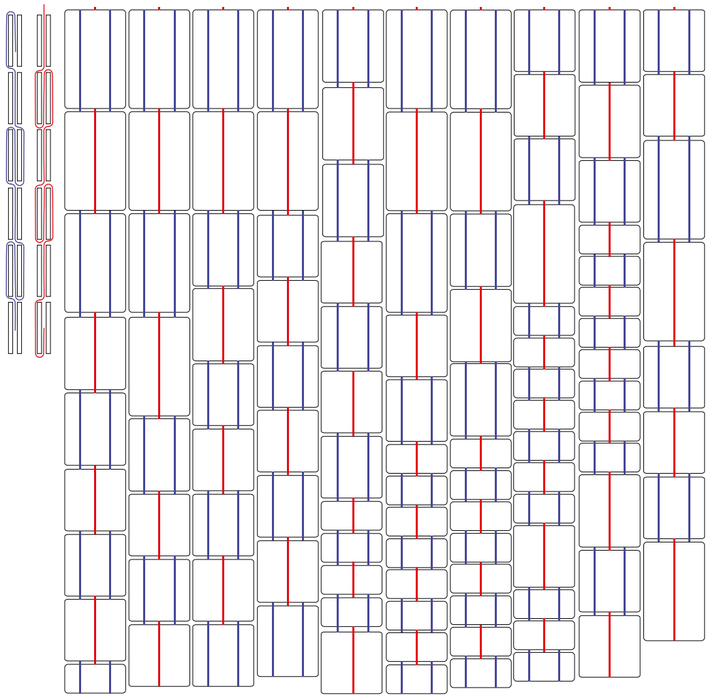
The toy snake.



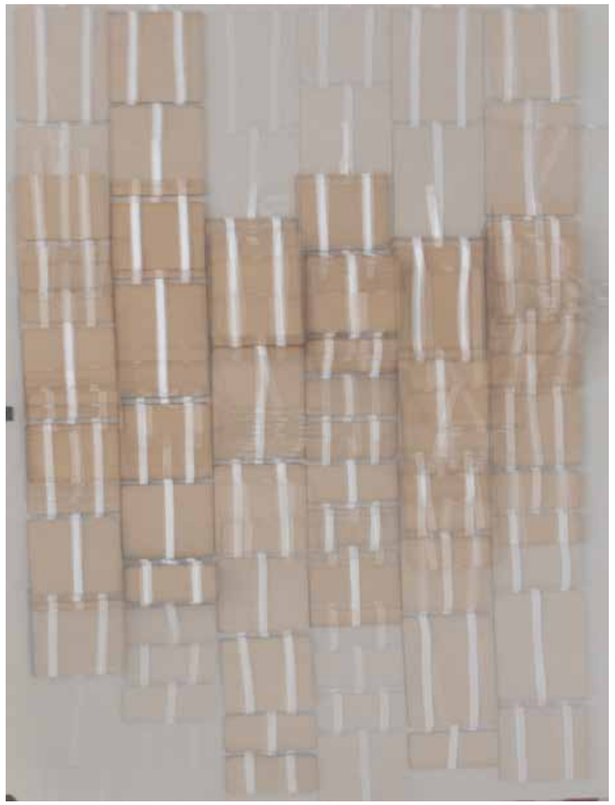
TOWARDS A DIAGRAM: A DRAWING MACHINE

This is the first place in the thesis where my drawings enter. During the process of working with two practices the same themes were not always addressed at the same time, and the process was not as linear as one might think, but rather jumping back and forth between the practices. However, as drawing and writing began to be arranged in relation to each other resonance spaces between the two practices became clearer, a typically abductive way of working where a mass of facts – the drawings and the texts – without any causal relation, were contemplated together and arranged iteratively, whereby connections between them emerged. I have placed this series of drawings here because it is about a general diagram embodied in a little toy snake, which I have then taken and treated it as if it were a more spatial diagram. Therefore this series of drawings could be seen as an example of how general diagrams can be productive of other diagrams. The toy snake embodies a general predicate, that is, a general, coherent diagram and rule-set, which is here used as a drawing machine. As opposed to Peirce and Stjernfelt's claim that a general diagram should lead to other general diagrams, the diagram of the toy snake is used much more subjectively to generate the drawings here. But Stjernfelt also calls a diagram a formal ma-chine for Gedankenexperimente, and one could say that I have used the snake's diagram as a formal drawing machine, where its rules of movement become part of imaginations about flexible, moveable spaces.

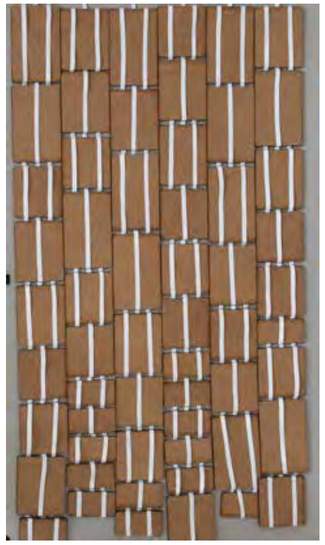
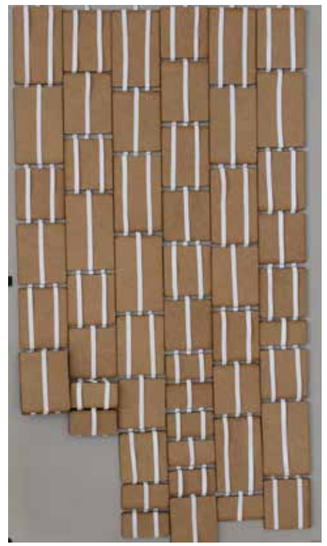
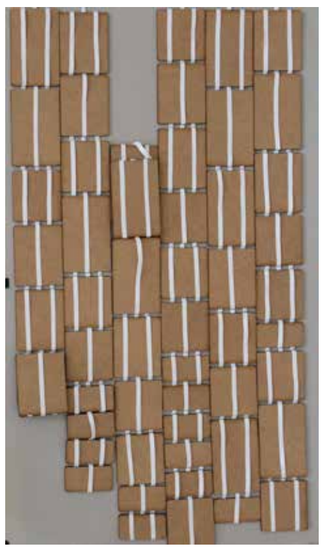
The toy snake consists of square pieces braided together, and the braiding allows for other ways of moving and folding the snake than would be possible if each square piece were connected to its neighbour with a usual hinge, which rotates around one axis with a fixed point of rotation. Moreover, this way of braiding the pieces together enables the snake to move in such a way that each piece seems to flip downwards and change place with its neighbour when one holds it in the hand and flips a piece over towards the floor. The snake is so simply made, but its movement is astonishing. The toy snake gives rise to imagination generative for the drawing process. The toy also has an acoustic aspect, since the way the wooden pieces flip downwards creates tones and rhythms similar to when one draws a stick from one end of a xylophone to the other. The snake's diagram can easily be dismantled in drawing – it is easy to draw how the cords are braided around the wooden pieces, but drawing the snake also encompasses the challenge of notating its movement. I consider these drawings to be iconic movement notations, which share some characteristics with experimental, musical notation, where the graphical space of the musical notation was cultivated in an attempt to allow for new sorts of music. I develop this idea more in the last chapter, MEDIA MUTATIONS III, where this sort of drawing, which lies somewhere between being an indeterminate sketch and an operational icon diagram, is developed more. Mean-while, the focus of these drawings is a first ramification of drawings generated by the toy snake's diagram, which was also generative of two other drawing series, TOWARDS AN ANALOGUE DIAGRAM and TOWARDS A DIGITAL DIAGRAM.



This drawing depicts how the plates of the toy are braided together with two cords, one red and one blue. On the left of the drawing we see a side view showing how the two cords are wound around and between the plates, thus enabling the movement. More strings placed next to each other make up a moveable, wooden curtain.



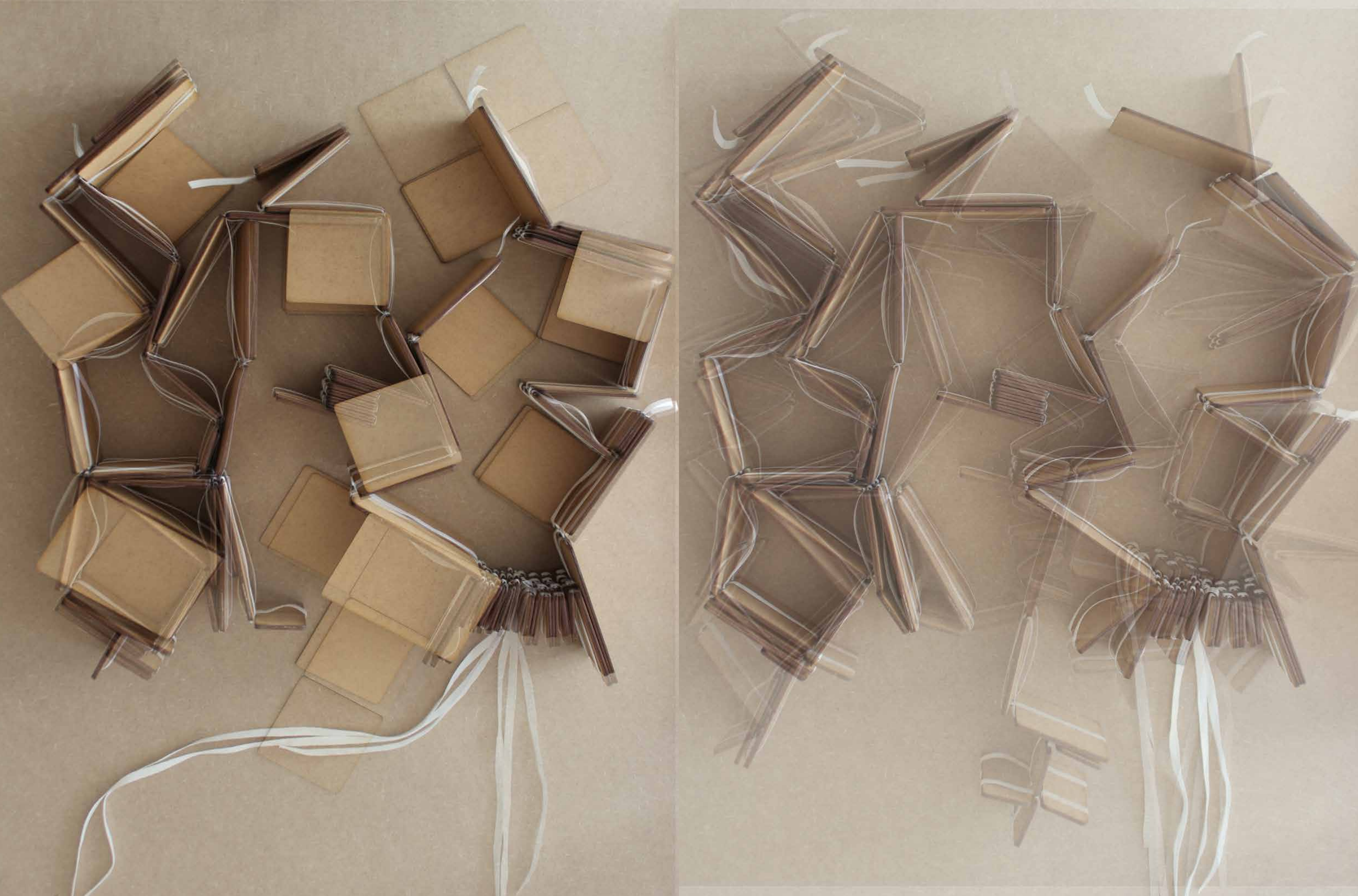
I made some models that visualize a moveable field which is flat but can become spatial as it is folded, a flexibility I tried to capture by superimposing photos of the model in different positions, as on the next pages.
Lasercut MDF, cord.

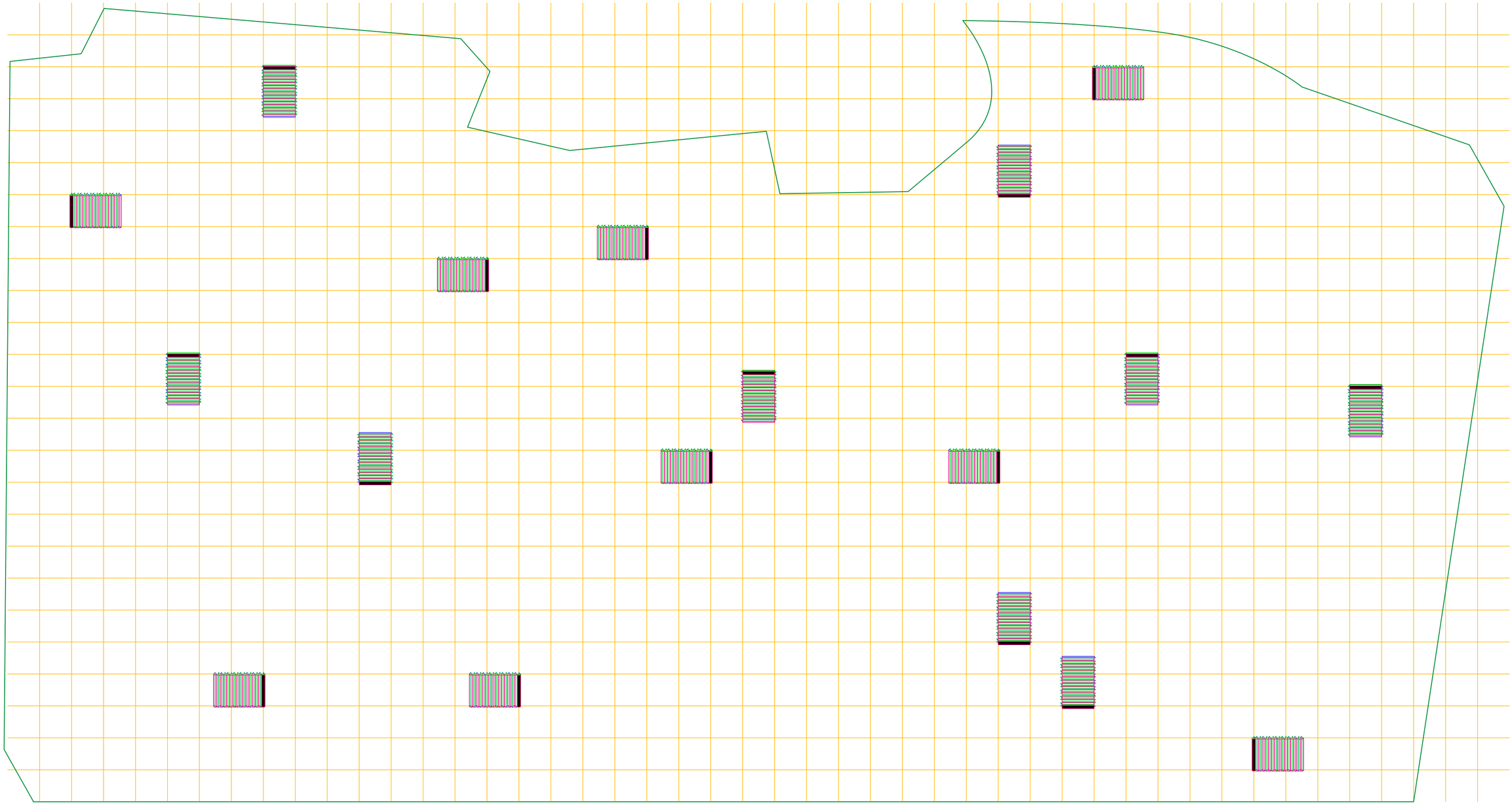






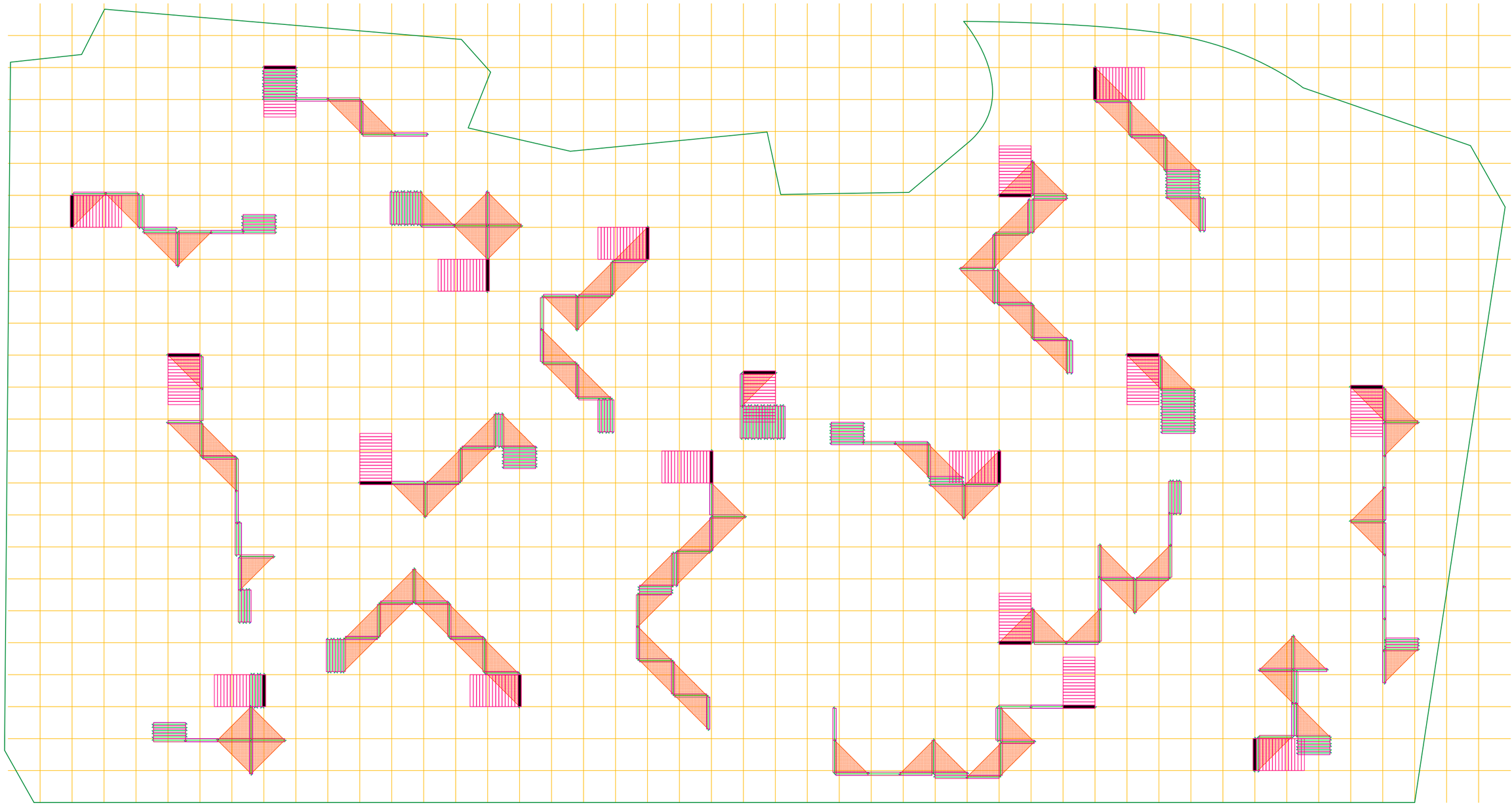




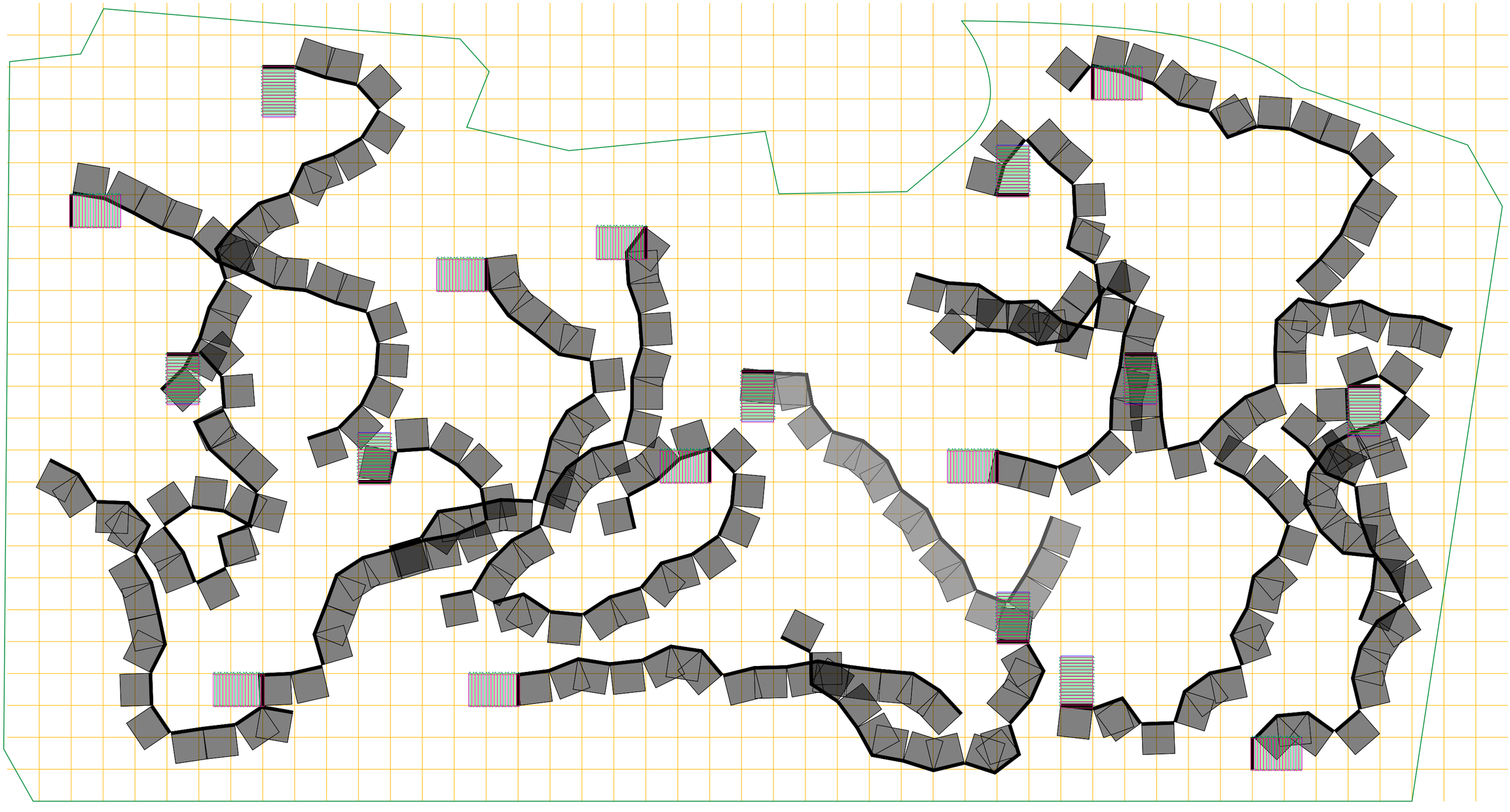





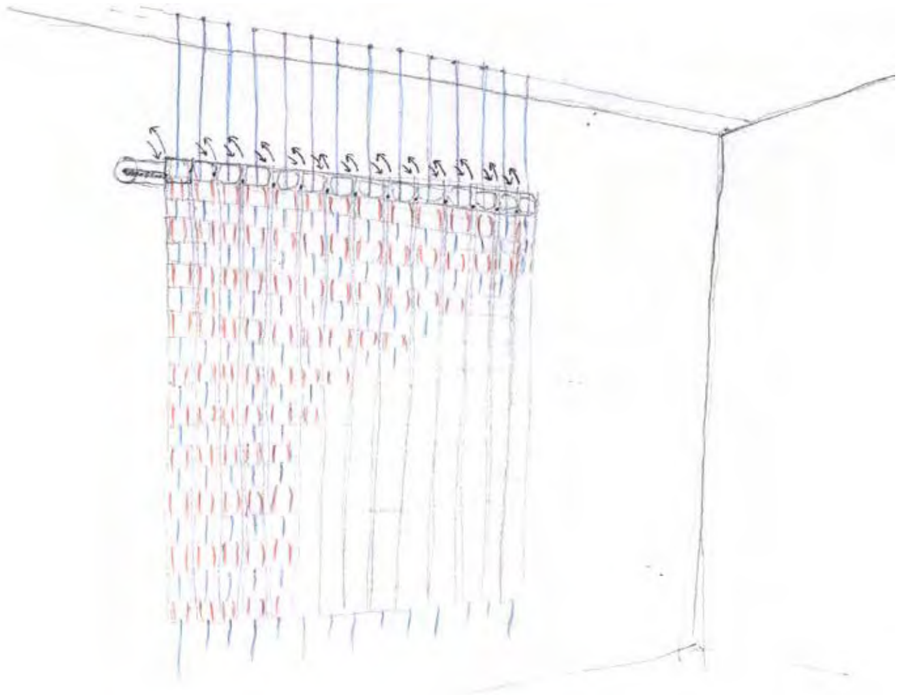
I made some plans, considering the snake diagram in approximately a 1:100 scale. Here several snakes are simply put on end and placed on a site following a grid structure. However, it soon became clear that in order to transform the snake diagram from its toy scale and logic to a building scale and logic a whole other translation would be needed. Still I think this and the following two drawings point in the direction of temporary and flexible spaces – markets, camps, etc.



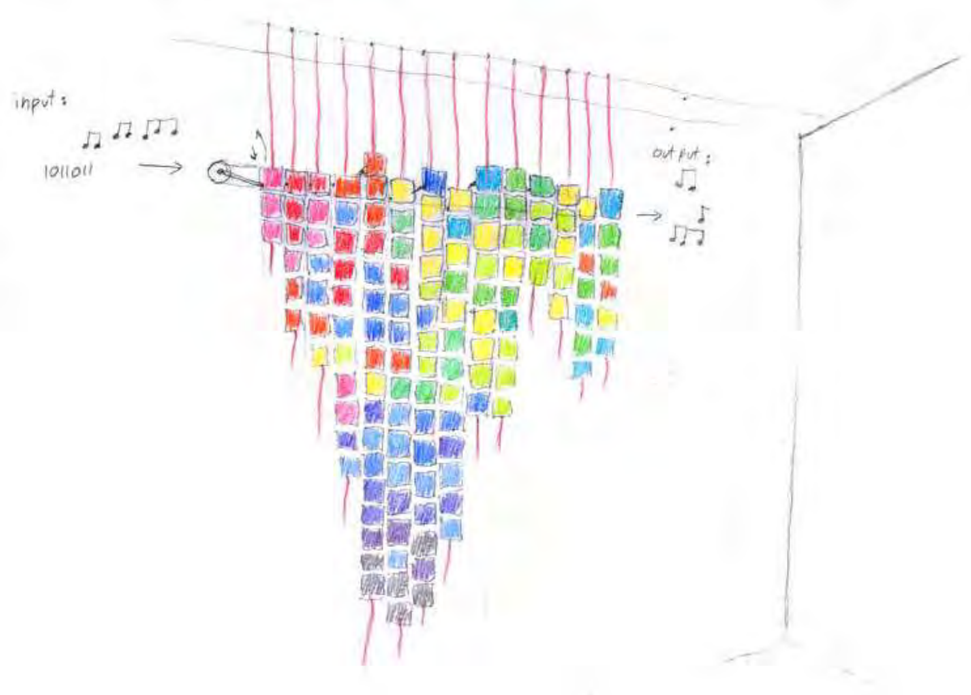
In this drawing the snakes from the previous drawing are folded out in different way, but the rule is that the unfolding only can happen by a 45 degrees rotation.



As opposed to the snakes in the previous drawing, these snakes are folded out according to random angles of rotation. The angles of the snakes were calculated randomly with *Processing*. See Drawing Appendix for more trials.



I decided that it would be more right to keep the snake diagram ‘alive’ as an actual drawing machine, a hybrid between a musical instrument and a movable, spatial structure here shown in two hand sketches. This led to this idea of the curtain-like construction hanging in a room controlled by a small motor and a computer script.



The idea is that the top piece of each string can be flipped over, setting off a chain reaction that causes every piece to flip over one by one, from top to bottom. The many strings next to each other can be made to draw different motifs and patterns depending on the input code contolling the motor that sets off the top pieces. The curtain can thus be made to draw and to play- it has the sound aspect too, since when a wooden piece flips downwards it makes a tone and a rhythm.

The diagram as a map of possible worlds

I have already mentioned that Stjernfelt related diagrammatic reasoning to painting, and emphasized that the beholder of a painting could make diagrammatic experiments with the painting and was thus contemplating a diagram. The painting allowed for diagrammatic reasoning on the part of the receiver, but, – what about the maker? Although Deleuze was not himself a painter it is exactly the diagram as a productive device for *making* a painting which he takes up in relation to the paintings of Francis Bacon. Deleuze coins the diagram of the painter as the "diagram as motif."[99] Deleuze's diagram concept is kindred with Peirce's and yet differs from it, and I include it here because it takes our understanding of the diagram further towards artistic creation than does Peirce's. Peirce and Stjernfelt emphasized the diagram as a map of rational relations, while Deleuze emphasizes the *diagram as motif* as a potentially inexhaustible map of possible worlds. Although Peirce and Deleuze differ with regards to where exactly the diagram plays its most important role,[100] Busk says that Deleuze takes the creative potential of Peirce's diagram to the extreme.[101] In Busk's reading of Peirce and Deleuze's diagrams through each other, she focuses on their creative, epistemological potential, also in art.[102] Any diagram, despite its general and machine-like character, works in a situated environment, and in art practice the diagram produces style, not because of mere intention or pure chance, but because the diagram is respectful "of the inner laws of motion in a work."[103] Where the *diagram as motif* is somewhat different from Deleuze's other diagram concept, the abstract machine,[104] in that the diagram as motif is closely concerned with the act of painting and much less general than the diagram as abstract machine, Busk nonetheless relates these two concepts of the Deleuzean diagram and also sees a machine-like trait in the painter's diagram. Deleuze describes the process of painting as being destructive, as an endeavour to break down those clichés and habits that are pre-given in the painter's mind and therefore also on the canvas,[105] a process which is not so foreign to Peirce's diagram that helps a reasoner to keep the inquiry open so that new insights can emerge, as Busk points out.[106] Stjernfelt called Peirce's diagram "a formal machine for Gedankenexperimente,"[107] and hence the machinal element, which is at stake in Deleuze, is seen as present in Peirce's diagram too. With regards to artistic diagrams – artistic 'machines,' – Busk mentions that the "Bacon machine"[108] functions because of Bacon's particular diagram, which leads to his *style*.[109] In comparison, the theorist Anthony Vidler claims that Le Corbusier's *Villa Domino* was his diagram, since it was a general principle – a 'machine' – for construction, which he instantiated in a range of different buildings that did not become identical, but are nonetheless recognizable as having been made by Corbusier.[110] These more singular diagrams – the Bacon machine and the Corbusier machine – are not merely a way for scientific reasoners to keep their inquiry open and moving forward. As Busk says:

> The diagram or abstract machine in a work of art allows the artist to experiment in 'controlled' fashion, which means that the artist has a defence against the pictorial clichés that will otherwise inevitably appear.[111]

The "cliché is as great a threat to art as […] prejudice to science"[112] Busk says; with cliché meaning habits which have frozen, become empty manner, or even limiting. Busk points out how the motif on the canvas pushes back on against the painter's diagram, his "mental and mobile map."[113] In this process clichés of the mind might appear on the canvas, but they can be destroyed again as they appear, but not before. Hence the painting as artefact with its particular material constitution and techniques yields resistance to pure thought and sensation by making them visible in a material guise. What Busk calls the artist's mental and mobile map has also been called a "figure of thought" (Denkfigur) by the artist Nicolaus Gangsterer, a term which connects to a more Peircian-sounding diagram, similar to Stjernfelt coining Peirce's diagram as a "moving picture of thought."[114] These terminologies of the diagram refer to it not as a token or a painting as such, but as a sort of filter between the painter and the painting, where the painting or diagram token is negotiated back and forth as it is being made.

The painting itself and the painter's mental map of it are different from each other, but run analogously to each other,[115] and in Deleuze's diagram as motif, the painter's diagram works through what is called "analogue language."[116] The analogue language is not to be understood as a 'proper' language, but resembles screams, colour, and other phenomena that have a direct impact on the human nervous system.[117] The analogue language orchestrates sensation and operates on the painting's surface relative to the painter's mental map.[118] Deleuze's idea of an analogue language is not only related to a direct impact on the nervous system, but also to semi-figurative painting, such as Bacon's. Analogue language is understood as different from *code* because analogue language, as opposed to code, cannot be translated.[119] Deleuze distinguishes between figurative painting and abstract painting (Mondrian is Deleuze's example), and claims that abstract painting works by *digital code*. In fact, Deleuze suggests that in abstract painting the diagram has been replaced by code, which is in essence digital. The code is cut off from sensation, "it has pure hands, but it has no hands,"[120] which means that code does not have a nervous system susceptible to sensation.[121] Whereas it could be claimed that diagrams can indeed be digital (as Nelson Goodman does, as we shall see in the chapter *MEDIA MUTATIONS III*), the important point is that the analogue language cannot be translated, while a discursive language or a code can. Bacon's analogue language is specific and singular for him in his context, and yet Deleuze sees Bacon's way of painting by analogue language as a diagrammatic activity in which Bacon fights the clichés in his own mental map, which will invade the canvas unless they meet

resistance.[122] The finished painting is *not* the painter's singular diagram (his mental map or figure of thought), but the diagram allows for new openings, since the painter forces open his own mind through the act of painting, and this is indirectly shown in the painting itself.

Peirce and Deleuze's concepts of the diagram that span from diagrams as general predicates to situated, mental maps, present the diagram not so much as a physical thing, but as a relation or a map of relations, between a maker and something made, which can lead to new works and ideas. The diagram is a filter between physical things – tokens and paintings – and the mind, and because it enables relations to be seen and orchestrated, clichés can be destroyed and conventions questioned. And in this sense diagrams have their play *in between,* in the sphere of implications between the maker and the made, in a reciprocal process of thinking and making.

Imaginative moments

It has been argued that the diagram is a helpful device for breaking down conventions and clichés in both scientific and artistic processes. With Peirce's diagram extended towards art, and with Deleuze's *diagram as motif*, we have a paradoxical situation where the diagram on the one hand lets us destroy clichés and habits – and the habitual and conventional is the symbolic in Peirce – in order for openings to occur and so as to keep the inquiry open. But, on the other hand, diagrams also orchestrate habits and conventions, for instance in the conventional diagrams of architectural drawing: plan, section, and elevation etc. As such, Peirce and Deleuze's diagrams read through each other both depend heavily on the conventions and clichés from which they are launched, while also having the ability to question conventions and clichés.

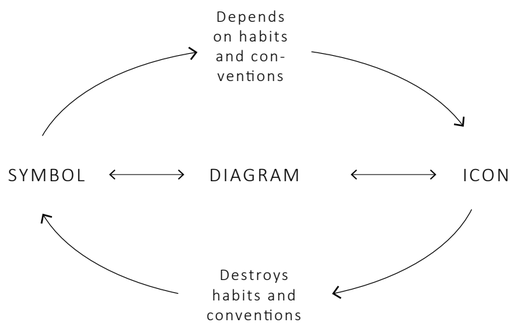
If we take an orthogonal, multi-view drawing, tripartite with plans, elevations and sections together – then how do we point out the conventional diagram within it? I have already analysed this above with focus on the use of signatures in plan drawings. Where signatures are relatively straightforward to understand as icons with symbolic reading rules, orthogonal projection as such is 'more invisible'. Orthogonal projection reveals itself indirectly in the way conventional drawings made, a topic I shall return to several times in the following chapters, specifically following Robin Evans.[123] Orthogonal projection is, on the one hand, a shared, calculative framework that architects see and work through. On the other hand, this framework only shows itself indirectly in the drawings made. Apart from being a geometrical construct it could also be understood as an epistemic environment within which thoughts that may not yet have been thought through but that have epistemic potential can be handled, as is argued in the next chapter. Thinking and clarifying half-thought thoughts is typically also called sketching when the subject is architecture. Although sketching as a way of drawing offers more freedom than making a working drawing would do, sketching is not necessarily completely free from conventions. It is very common to sketch in plan, section or elevation, and hence these conventions are a way to handle sketches in a controlled and measurable fashion although the result of the sketching may yet be unknown. In this case, conventional diagrams provide a way of being precise about uncertainty, through which architects can grasp ideas and sensations at an early stage and seek to transform them into architecture. The conventional orthogonal diagram comes into play located between the reasoner and the drawing as a shared, invisible filter which, to some extent, forms everything drawn with it in its own picture. And yet any drawing also carries singular traces of its maker and its situation. Hence both a shared, conventional, symbolic diagram and more singular diagrams are at play together. This dynamics between the icon and the symbol has already been touched upon above; the diagram of conventional drawing is paradoxically double by being iconic *and* symbolic, sensuously motivated *and* springing from a shared, known framework, both structuring *and* opening.[124] This tension between clichés or conventions and the destruction or transformation of them is valuable for the diagram's ability to ramify into new diagrams. This might seem to describe an equilibrium, but is rather the attempt to describe a transformation. This transformation, so Busk's reading of Peirce, comes from the so-called "imaginative moment"[125] of the diagram. This is a breaking point, a dangerous as well as fertile moment, which holds the promise of the birth of something new, but also poses a danger. It is the moment where the diagram's relations are so much *like* the relations of the phenomenon represented that "the diagram is for us the very thing,"[126] as Peirce says. This is important, because the diagram here breaks down the boundary between the representation and the represented. The phenomenon is possibly similar to the moment when a drawing becomes a world in itself with its own dynamics and its own logical and sensuous moves, where the reasoner forgets that there is a difference between the drawing and the drawn. Busk says:

> The special 'imaginative' moment of the diagram in Peirce, when the object and subject are disconnected and the transformative syntax of the diagram begins to operate independently as its own reality and not as a representation of prior charts of reality, is an effective way of getting round the blocks created by cliché – creating the potential for starting to thinking new thoughts.[127]

Busk understands the imaginative moment not as the moment where a good idea emerges out of nowhere, but rather the moment where the material under investigation becomes *alive*, where it becomes productive.

> […] the diagram map can gain its own life in which it (so to speak) 'starts to think' – to produce systems, assemblages and relations which are not tied to a predefined or recognisable domain but are mobile, abstract and material at the same time.[128]

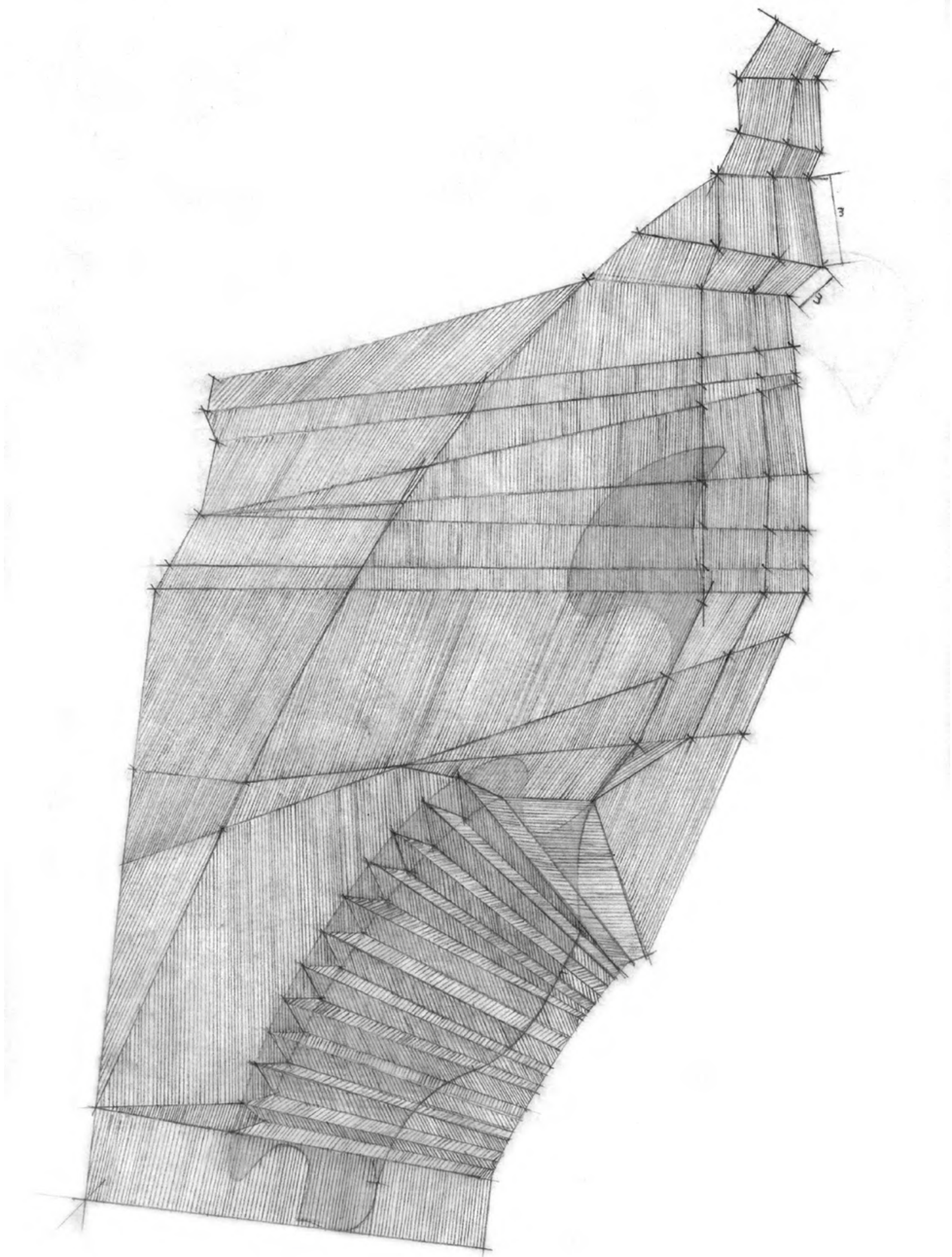
This moment of autonomy, where the diagram becomes a reality of its own, is a way to establish an alternative reality that can question existing reality. But there is a danger, namely, to get caught up in the imaginative moment, in an alternative, imaginary reality.[129] Hence the promise of transforming conventions comes together with the danger of getting lost in the redundancy of pure production or in too much imagination. So the tension of the diagrammatic reasoning which relies on clichés and conventions while also destroying and opening them up holds both the danger of getting lost in sheer production and the promise of transforming the world into other worlds.



TOWARDS AN ANALOGUE DIAGRAM: MEMORY DRAWINGS

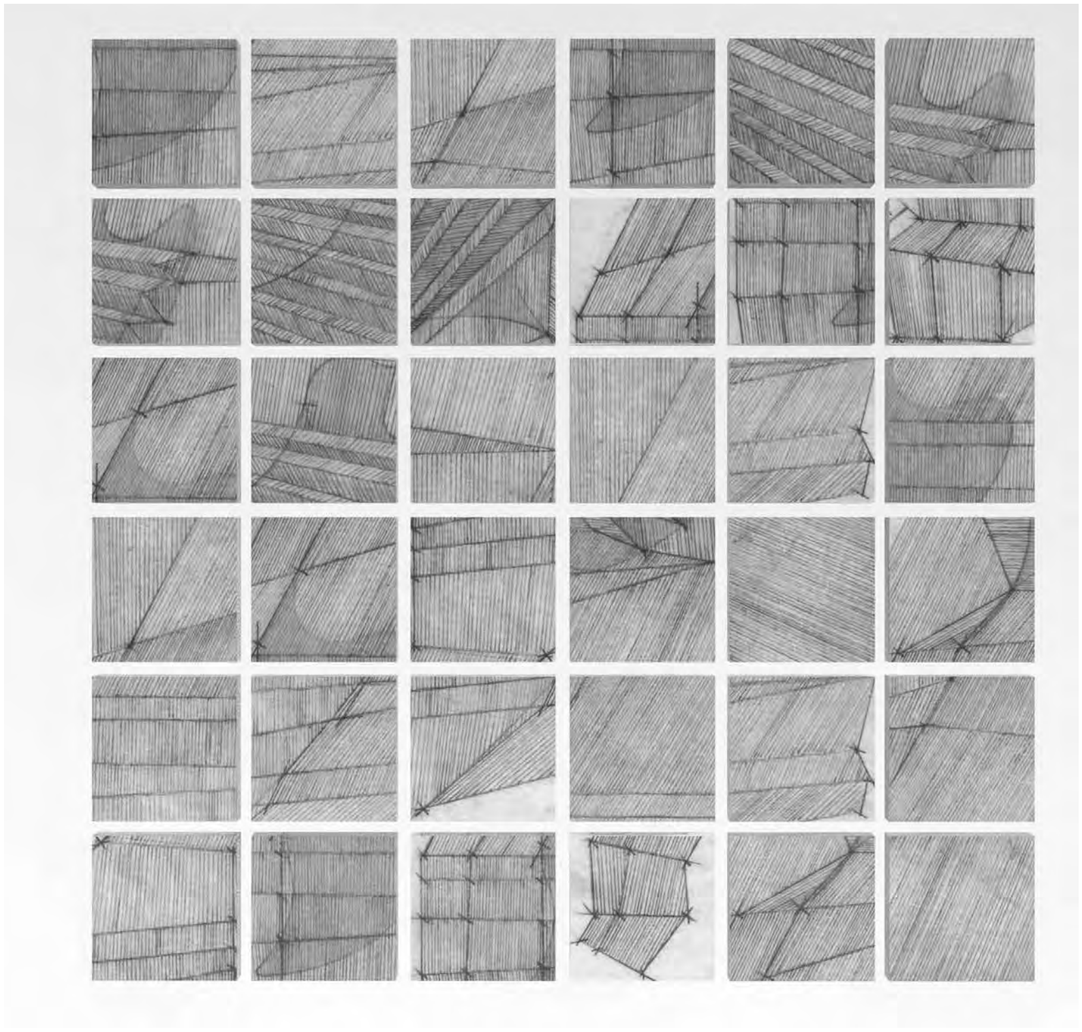
This drawing series is placed here close to Deleuze's *diagram as motif* with its analogue language. Although only few of these drawings are hand drawn, which is how one typically understands the term analogue, it is attempted that a hand drawn 'feeling' is kept throughout the series although the computer was used to make most of the drawings. But the series is also analogue, because the changes that happen from one drawing to the next are happening due to my subjective moves and not generated by a digital code. When painting becomes digial, so Deleuze, we are no longer dealing with painting as motivic and diagrammatic, howver, I discuss later how diagrams can be both analogue and digital, but for now Deleuze's understanding of painting is left unquestioned and taken in the meaning of being a sensuously motivated, destructive act aiming at destroying pictorial clichés. Apart from this series tending towards analogue drawing, I do see is as closely related to the drawings presented just before called *Towards a Diagram*. But whereas *Towards a Diagram* was about a more general diagram which was displaced and then used to generate drawings, this series of drawings is about a more analogue diagram. And yet the drawing series are somewhat akin because of the interest in toys, games and playing. They are also familiar in that they both have square game-pieces that can be moved around in different ways. Where as the general diagram of the snake was displaced into another context, the analogue diagram in this series is directed towards destroying the rules of the game called *Memory*. On the one hand, *Memory* is a drawing machine (similar to the snake), which has a completely rational and generative structure. *Memory* draws, because square pieces with different pictures on one side are laid out on a table in a grid-like structure and then the players flip the pieces, taking turns, searching for matching motifs. Therefore the game leads to a new drawing every time a player has her turn.

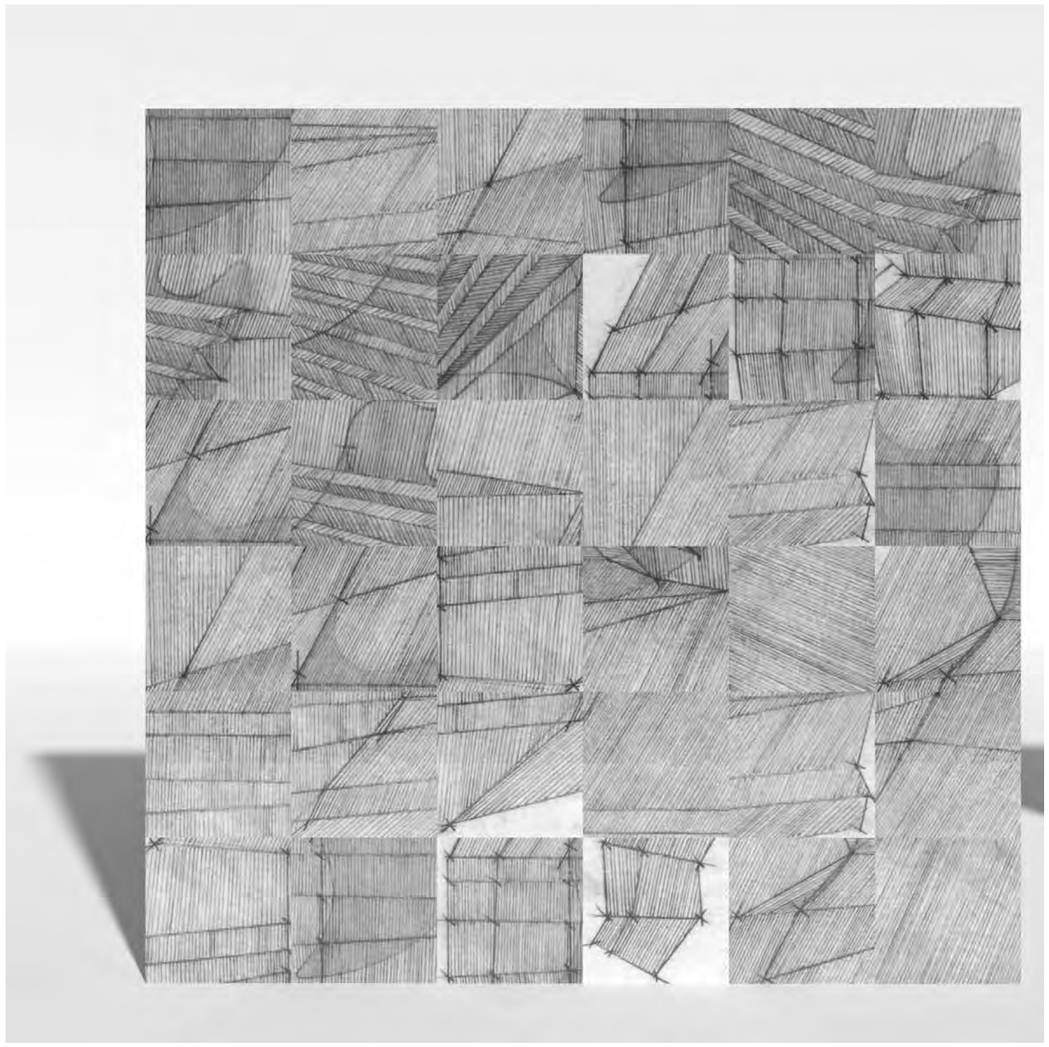
Approaching the *Memory* game as an engine for composing drawings, the focus of the game shifts, and it is not about winning or losing, but about making a drawing that changes every time a player has his turn. Deleuze has called such games non-sense games, and he says that they are only games that one can play in art and thought.[130] Such games ramify, rather than coming to a closure. They have a lot of movement, but cannot lead to a winner or a loser. The previous drawing series took a completely coherent rule-set from the toy snake and displaced them towards space, but followed the rules of movement given by the particular way of braiding. These drawings are more transformative of the rules, and when meaning is lacking the drawing can become contemplative and epistemic both receiver and maker have to invent the reading rules themselves.



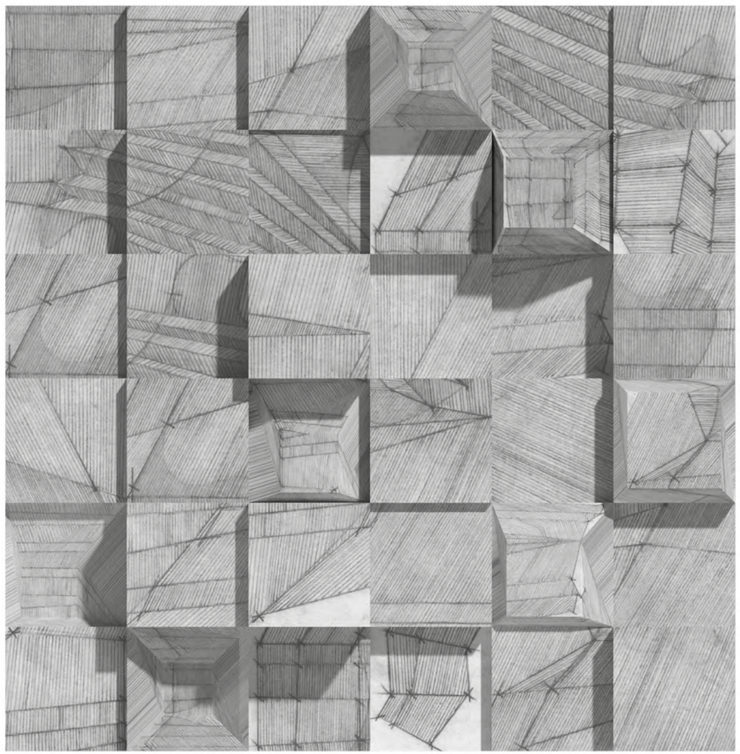
The series starts with this hand drawing.

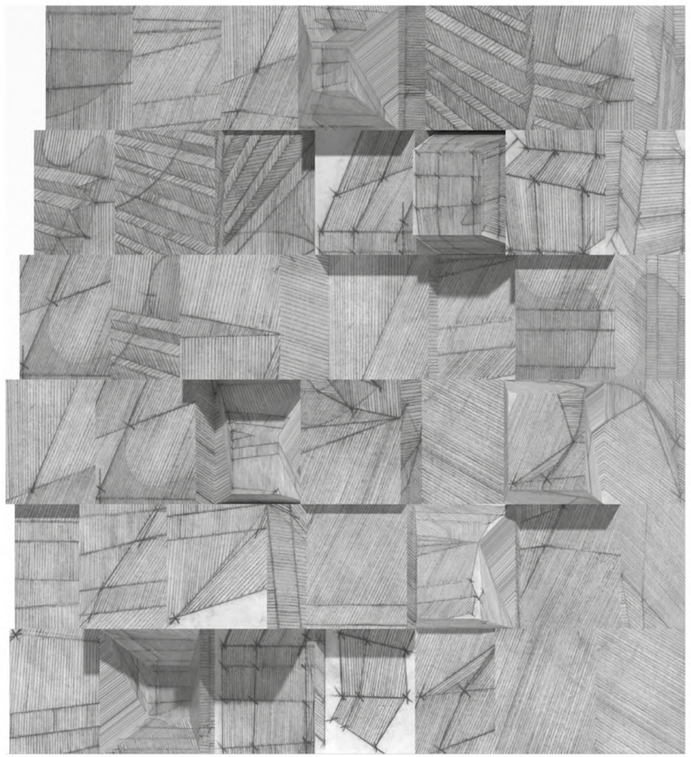
The hand drawing was cut up in *Memory* game pieces.

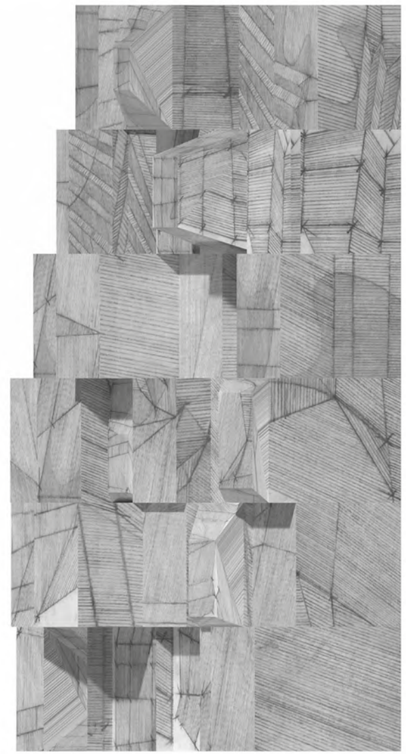


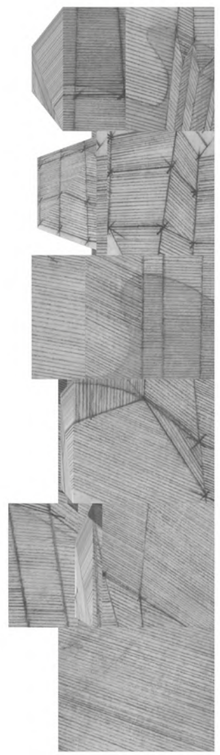


Then I started playing the game in the sense that I made different formal manipulations with the game pieces, such as here, where they are used as texture and rendered as 3D structure.

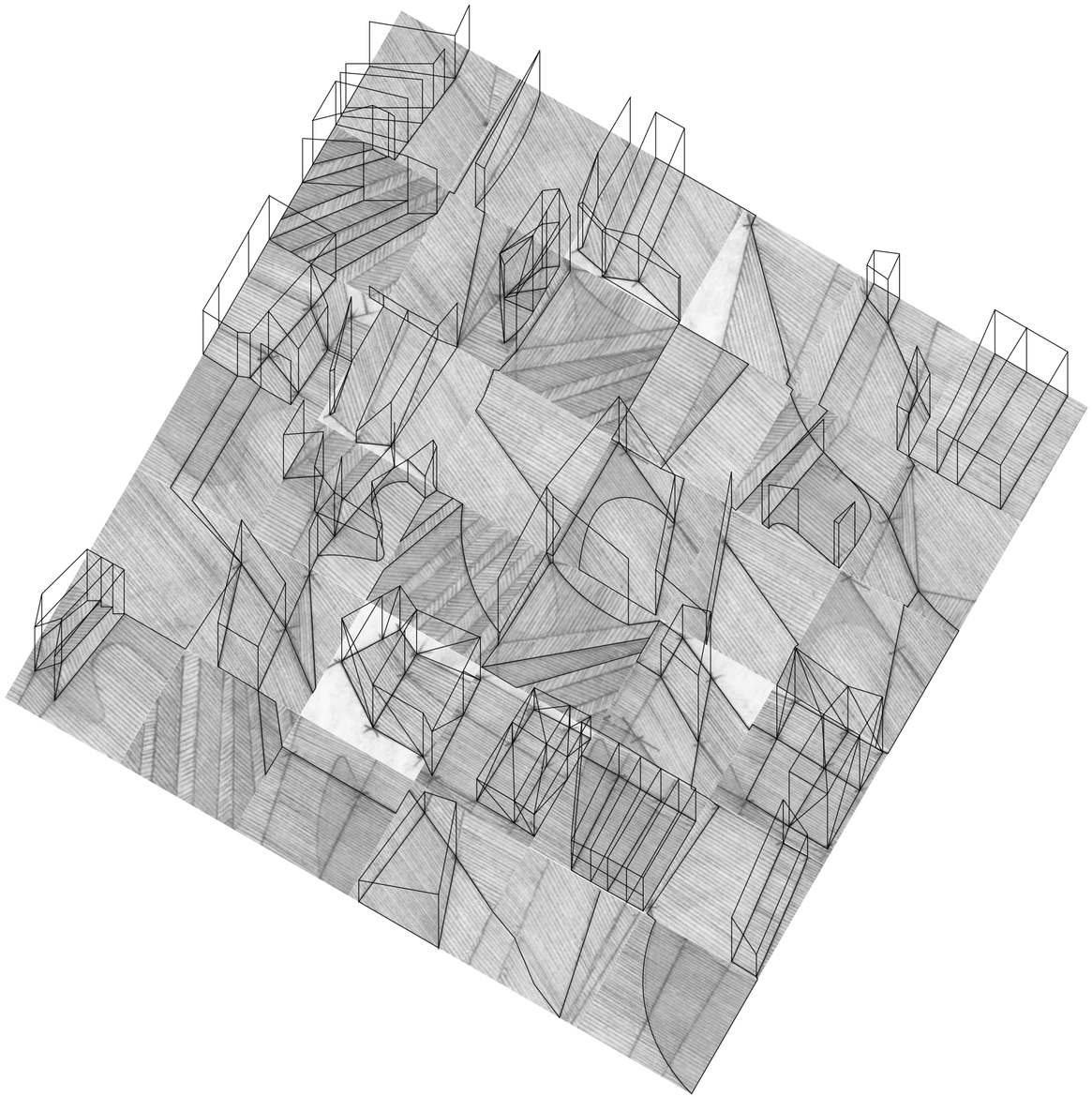




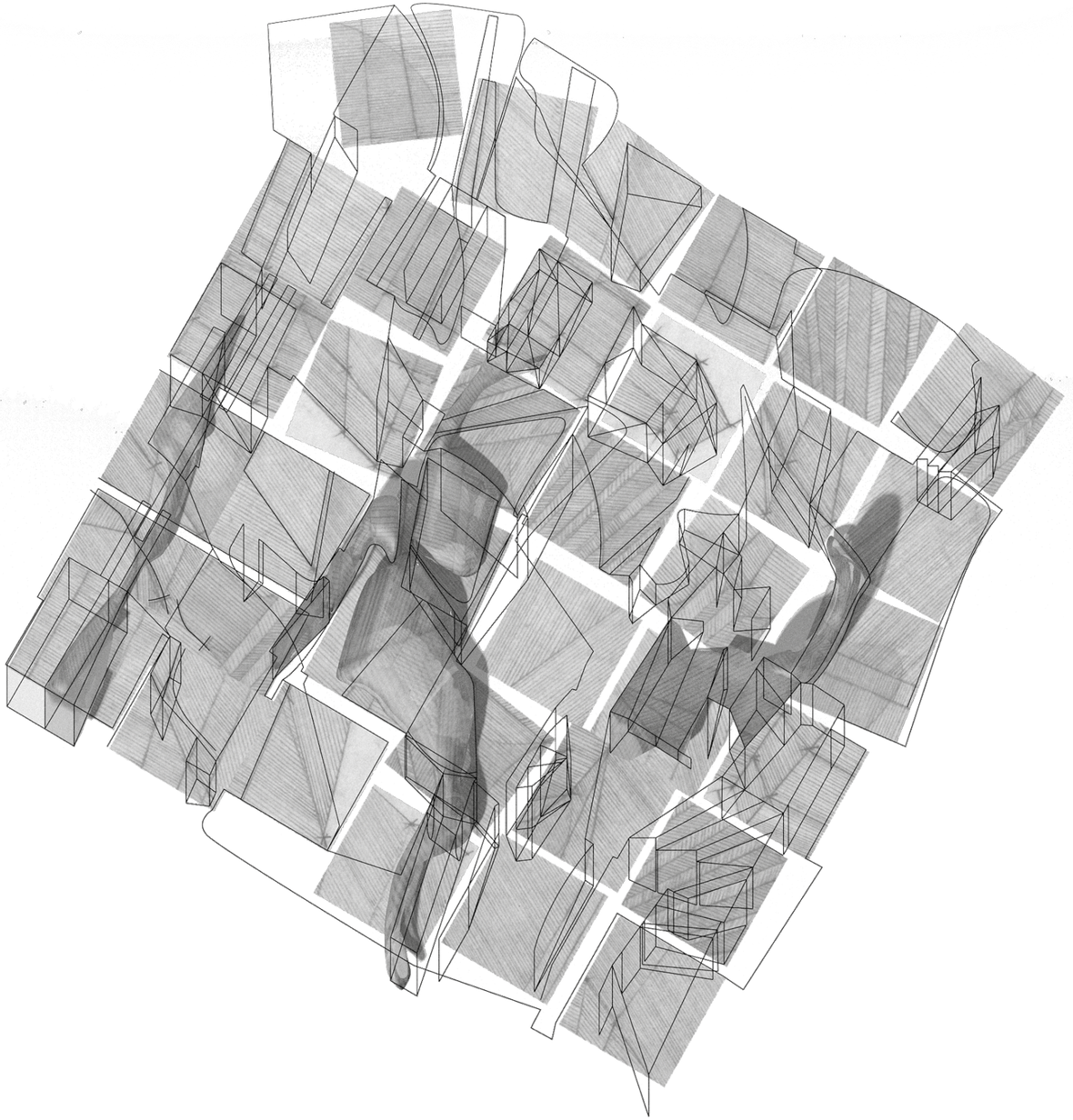


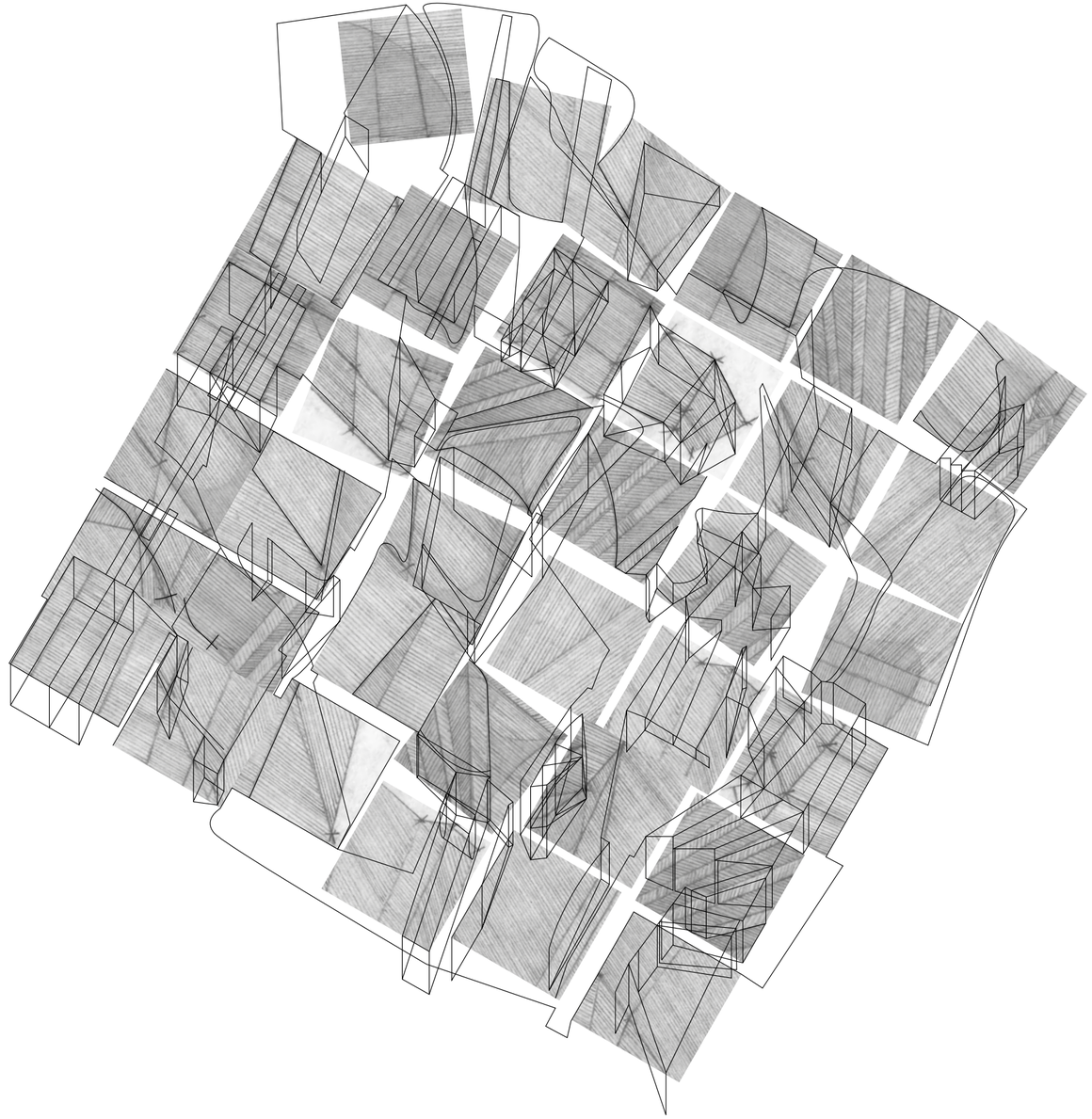


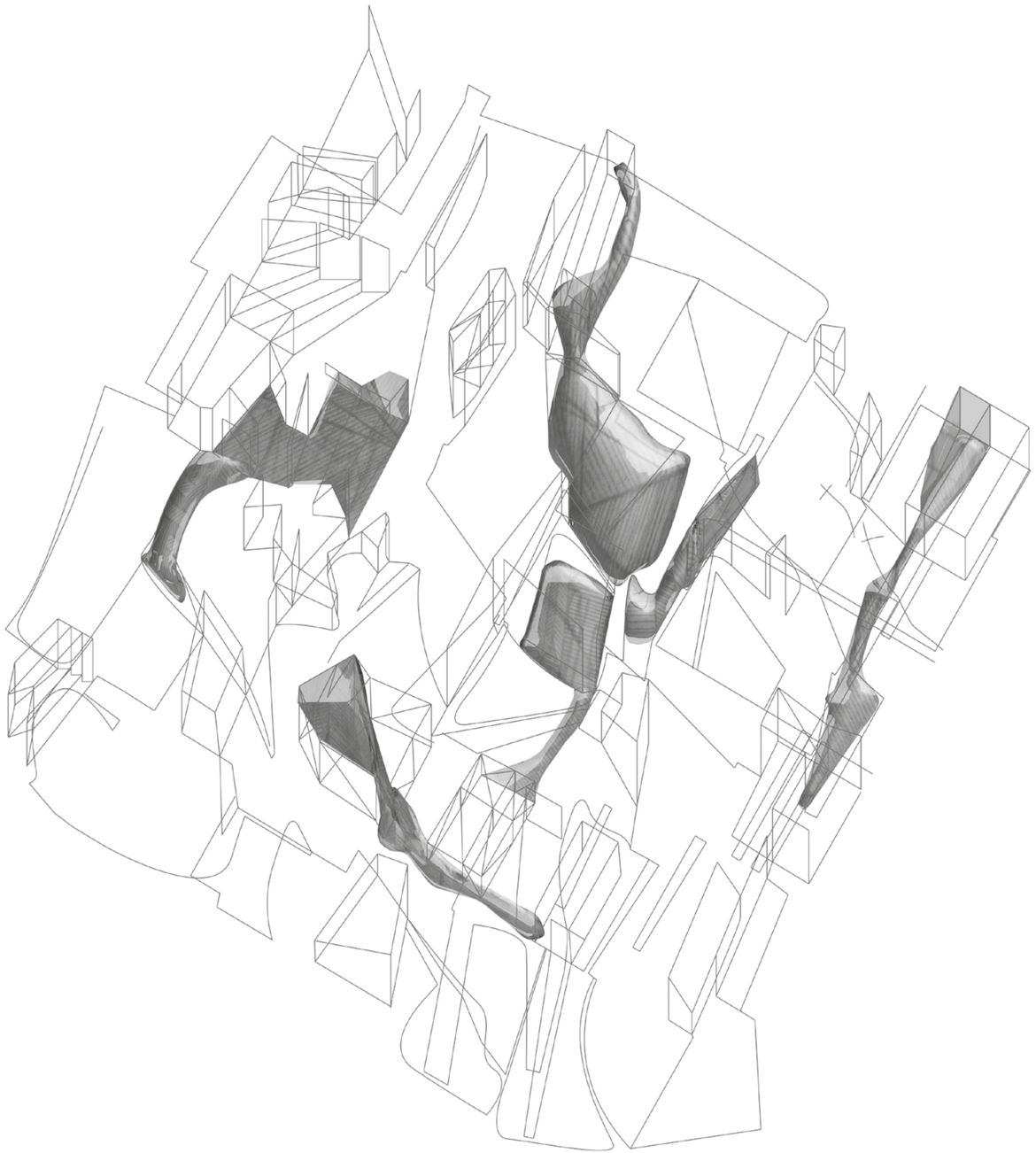
Playing the game, more manipulations. View of the model. To the left we see the model in front view, and then it the view is rotated, and we end by seeing the model in side view.



Playing the game.







[1] Douglas R. Anderson, "The Evolution of Peirce's Concept of Abduction," *Transactions of the Charles S. Peirce Society* 22, no. 2 (Spring, 1986): 150. Anderson refers to Fann, *Peirce's Theory of Abduction* (The Hague: Martinus Nijhoff, 1970): 31.
[2] Charles S. Peirce, *Charles S. Peirce: Semiotik og Pragmatisme*, ed. Anne Marie Dinesen and Frederik Stjernfelt, trans. Lars Andersen (Denmark: Gyldendal, 1994), 20-21, 155, 160, 173.
See also, Peirce, *Collected Papers vol. VII,* ed. Arthur W. Burks, 137.
[3] Peirce, *Semiotik*, 167.
[4] c.f. Anderson, "Evolution."
[5] Sami Paavola, "Peircean abduction: instinct, or inference?," *Semiotica,* 153-1/4 (2005): 131-54.
[6] "For Peirce, it seems absurd to argue that Kepler, Newton, Einstein, and others were simply lucky. […]. Think of what trillions and trillions of hypotheses might be made of which one only one is true; and yet after two or three – or at the very most a dozen guesses, the physicist hits pretty nearly on the correct hypothesis. By chance he would not have been likely to do so in the whole time that has elapsed since the world was solidified." Anderson, "Evolution," 152-3.
[7] "It must be remembered that abduction, although it is very little hampered by logical rules, nevertheless is logical inference, asserting its conclusion only problematically or conjecturally it is true, but nevertheless having a perfectly definite logical form."
Charles S. Peirce, *Pragmatism as a Principle and Method of Right Thinking: The 1903 Harvard* Lectures on Pragmatism*,* ed. Patricia Ann Turrisi, (New York, Albany: State University of New York Press, 1997), 245.
[8] For instance Karl Popper. Cf. Anderson, "Evolution," 152. Andersen refers to Karl Popper, "The logic of Discovery" (New York: Harper and Row, 1968), 31, where Popper says "The initial stage, the act of conceiving or inventing a theory, seems to me neither to call for logical analysis nor to be susceptible of it."
[9] "Any novice in logic may well be surprised at my calling a guess an inference. It is equally easy to define inference so as to exclude or include abduction. But all the objects of logical study have to be classified; and it is found that there is no other good class in which to put abduction but that of inferences. Many logicians, however, leave it unclassified, a sort of logical supernumerary, as if its importance were too small to entitle it to any regular place. They evidently forget that neither deduction nor induction can ever add the smallest item to the data of perception; and, as we have already noticed, mere percepts do not constitute any knowledge applicable to any practical or theoretical use. All that makes knowledge applicable comes to us *viâ* abduction."
Peirce, "The Proper Treatment of Hypotheses (a Preliminary Chapter, Toward an Examination of Hume's Argument against Miracles, in its Logic and in its History)" (1901), *Historical Perspectives of Peirce's Logic of Science: A History of Science*, vol. II, ed. Carolyn Eisele, (Berlin, New York, Amsterdam: Mouton, 1985), 899. Peirce's emphasis.
[10] Charles. S. Peirce, "Deduction, Induction and Hypothesis," (1878), *Chance, Love and Logic*: *Philosophical Essays*, ed. Morris R. Cohen (USA: University of Nebraska Press, 1998), 134.
[11] Karl Popper's famous claim of falsification, which is inspired by Peirce, aims to avoid exactly this sort of empiric generalization.
[12] Allen, *Practice*, XV.
[13] Thomas A. Seboek, "One, Two, Three spells U B E R T Y," in *Dupin, Holmes, Peirce: The Sign of Three*, ed. Umberco Eco and Thomas A. Sebeok (USA: Indiana University Press, 1983), 1.
[14] Ibid.
[15] Ole Fogh Kirkeby, "Abduktion," in *Videnskabsteori og metodelære,* ed. Heine Andersen (Copenhagen: Samfundslitteratur, 1990), 123-4.
[16] Peirce, *Pragmatism as a Principle*, ed. Turrisi, 250.
[17] Ibid., 245.

[18] "A mass of facts is before us. We go through them. We examine them. We find them a confused snarl, an impenetrable jungle. We are unable to hold them in our minds. We endeavor to set them down upon paper; but they seem so multiplex intricate that we can neither satisfy ourselves that what we have set down represents the facts, nor can we get any clear idea of what it is that we have set down. But suddenly, while we are poring over our digest of the facts and are endeavoring to set them into order, it occurs to us that if we were to assume something to be true that we do not know to be true, these facts would arrange themselves luminously. That is *abduction*." Anderson refers to Peirce, "Evolution," 147. The quote is a deleted passage from the Harvard Lectures on Pragmatism, Lecture VII. The deleted passage is published in *Pragmatism as a Principle*, ed. Turrisi, 282. Peirce's emphasis.
[19] Anderson, "Evolution," 149.
[20] Peirce, *Collected Papers vol. VII*, ed. Burks, 137.
[21] "I now proceed to consider what principles should guide us in abduction, or the process of choosing a hypothesis. Underlying all such principles there is a fundamental and primary abduction, a hypothesis which we must embrace at the outset, however destitute of evidentiary support it may be." Peirce, *Collected Papers vol. VII*, ed. Burks, 137.
[22] Nicola Erny, „Kreativität und Methode. Ein Vergleich zwischen Charles S. Peirces Begriff der Abduktion und der Methodenkonzeption von Giambattista Vico," *Zeitschrift für philosophische Forschung* 53, H. 1 (Jan - Mar, 1999): 52.
[23] Peirce, *Historical Perspectives of Peirce's Logic of Science: A History of Science*, vol. II, ed. Carolyn Eisele, (Berlin, New York, Amsterdam: Mouton, 1985), 899-900, Peirce's emphasis.
[24] Frederik Stjernfelt, *Diagrammatology – An Investigation on the Borderlines of Phenomenology, Ontology, and Semiotics* (Dordrecht, Heidelberg, London, New York: Springer, first softcover printing, 2011), 115.
[25] Umberto Eco, "Horns, Hooves and Insteps," in *Dupin, Holmes, Peirce, The Sign of Three* ed. Umberto Eco and Thomas Soeboek, (USA: Indiana University Press, 1983), 217. Eco refers to Benedict Spinoza's dictum: "*Ordo et connexio idearum idem est ac ordo et connexion rerum*" [The order and connection of the thought is identical to with the order and connection of the things].." translation from Latin retrieved from:
(http://owtp.org/2013/01/top-renaissance-philosophy-quotes/) (accessed 18.02.2015).
[26] The Peirce scolar Sami Paavola questions this and argues that it is better to distinguish between abductive inferences as logical forms, and abductive instinct as perceptual judgement. He does not exclude that abduction has to do with both instinct and inference, but insists upon a distinction between these two sorts of reasoning, albeit both are abductive. The Peirce scolars Nicola Erny and Douglas R. Anderson, however, argue that abduction is a logical form as well as an inference without any clear-cut demarcation. See Sami Paavola, "Percian Abduction: Instinct or Inference," *Semiotica* 153, no. 1 (2005): 131-54.
[27] Gilles Deleuze, *Bergsonism*, trans. Hugh Tomlinson and Barbara Habberiam, (New York: Zone Books, 1988).
[28] Ibid. 14.
[29] Peter Bertram, *Intuitiv Metode*, (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009).
[30] Anderson, "Evolution," 157.
[31] Erny, "Kreativität", 64. Erny refers to Anderson.
[32] Anderson, "Evolution," 156, quotes Peirce: "The abductive suggestion comes to us like a flash. It is an act of *insight*, although of extremely fallible insight. It is true that the different elements of the hypothesis were in our minds before; but it is the idea of putting together what we had never before dreamed of putting together which flashes the new suggestion before our contemplation." Peirce's emphasis, "Harvard Lectures on Pragmatism: Lecture VII," Turrisi, ed. 242.
[33] Erny, "Kreativität," 65.
[34] Ibid., 62.
[35] Anderson, "Evolution," 160-61.

[36] Robbins, *Why*, 38.
[37] Bertram, *Frembringelse*, 220-23. Similarly, Stan Allen says, with regard to the diagram as a vessel for reasoning: "A diagram is a description of potential relationships among elements; not only an abstract model of the way things behave in the world, but a map of possible worlds." Allen, *Practice*, p. 51
[38] Eco, "Horns," 214.
[39] Kirkeby, "Abduktion," 140.
[40] Peirce, *Pragmatism as a Principle*, ed. Turrisi, 245.
[41] Kirkeby, "Abduktion," 140.
[42] Ibid.
[43] Eco, "Horns," 218.
[44] "For example, at a certain stage of Kepler's eternal exemplar of scientific reasoning, he found that the observed longitudes of Mars, which he had long tried in vain to get fitted with an orbit, were (within the possible limits of error of the observations) such as they would be if Mars moved in an ellipse. The facts were thus, in so far, a likeness of those of motion in an elliptic orbit. Kepler did not conclude from this that the orbit really was an ellipse; but it did incline him to that idea so much as to decide him to undertake to ascertain whether virtual predictions about the latitudes and parallaxes based on this hypothesis would be verified or not. This probational adoption of the hypothesis was an Abduction. An Abduction is Originary in respect to being the only kind of argument which starts a new idea."
The quote is retrieved from the online Peirce Dictionary ed. Mats Bergman and Sami Paavola:
http://www.helsinki.fi/science/commens/dictionary.html look up: abduction, "Minute Logic: Chapter I," (1902).
[45] Eco, "Horns," 204.
[46] Ibid., 204.
[47] Stjernfelt quotes Peirce, *Diagrammatology*, 84. The quote can also be found in Peirce, "On Quantity," *The New Elements of Mathematics by Ch. S. Peirce (Vol. IV),* ed. Carolyn Eisele, (The Hague, Paris: Mouton, 1976), 268.
[48] Eco, "Horns," 204.
[49]Cf. Deleuze, *Bergsonism* and Bertram, *Intuitiv Metode*.
[50] Eco, "Horns," 215.
[51] Emma Cooker does this in relation to the artist, Nikolaus Gansterer's drawings in "Distancing the If and Then," in *Drawing a Hypothesis – Figures of Thought*, ed. Nikolaus Gansterer (Wien, New York: Springer Verlag, 2011), 97-108.
[52] "Abduction seeks a theory."Peirce, *Collected Papers vol. VII*, ed. Burks, 137.
[53] Peirce, "PAP," *New Elements vol. IV,* ed. Eisele, 320.
[54] This might be where a building practice would find diagrams in architecture the most effective. Cf. Mark Garcia, ed., *The Diagrams of Architecture (*West Sussex, United Kingdom, John Wiley & Sons Ltd, 2010).
[55] See appendix on Peirce's way of classifying phenomena as respectively phenomena of *firstness, secondness, and thirdness*.
[56] Eco, "Horns," 217.
[57] Scheme derived from Peirce, *Semiotik*, 143-44.
[58] Ibid., 100–1, 118-21.
[59] Ibid., 129.
[60] Ibid., 131-2.
[61] Ibid., 134.
[62] Ibid., 120-4.
[63] The quote is retrieved from the online Peirce Dictionary ed. Mats Bergman and Sami Paavola:
http://www.helsinki.fi/science/commens/dictionary.html look up: icon, "Logical Tracts. No. 2. On Existential Graphs, Euler's Diagrams, and Logical Algebra," (1903). (accessed 14.12.2014).
[64] Peirce, *Semiotik*, 118.

[65] "Hypoicons may be roughly divided according to the mode of Firstness of which they partake. Those which partake of simple qualities, or First Firstnesses, are *images*; those which represent the relations, mainly dyadic, or so regarded, of the parts of one thing by analogous relations in their own parts, are *diagrams*; those which represent the representative character of a representamen by representing a parallelism in something else, are *metaphors.*" The quote is retrieved from the online Peirce Dictionary ed. Mats Bergman and Sami Paavola:
http://www.helsinki.fi/science/commens/dictionary.html look up: hypoicon, "Syllabus: Syllabus of a course of Lectures at the Lowell Institute beginning 1903, Nov. 23. On Some Topics of Logic," (1903).
[66] Ibid.
[67] Peirce, *Semiotik*, 119.
[68] Stjernfelt, *Diagrammatology*, 90.-1
[69] Ibid., 90. Stjernfelt's emphasis.
[70] "As soon as an icon is contemplated as a whole consisting of interrelated parts whose relations are subject to experimental change, we are operating on a diagram." Ibid., 92.
[71] Ibid., 97.
[72] "[…], I must call your attention to the differences there are in the manner in which different representations stand for their objects. In the first place there are likenesses or copies - such as *statues, pictures, emblems, hieroglyphics,* and the like. Such representations stand for their objects only so far as they have an actual resemblance to them - that is agree with them in some characters. The peculiarity of such representations is that they do not determine their objects - they stand for anything more or less; for they stand for whatever they resemble and they resemble everything more or less."
Peirce, *Writings of Peirce, 1857-1866*, ed. Kloesel, Fisch et al., 467.
[73] "diagrammatic reasoning is the only really fertile reasoning." Peirce, "PAP," *The Monist*, (Oct 1906): 542. Retrieved from jstor's early Journal Content, jstor.org, (accessed 27.1.2016).
[74] Peirce, *Semiotik*, 133.
[75] Ibid., 120
[76] Ibid., 118
[77] Ibid., 97-105.
[78] Ibid., xiii.
[79] "Do not block the way of inquiry" Peirce says. Malene Busk refers to this in "The Diagrams of Peirce and Deleuze," in *Cartography, Morphology, Topology*, ed. Cort Ross Dinesen (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009), 170-3.
[80] Stjernfelt, *Diagrammatology*, xiii.
[81] Ibid., 78.
[82] Cf. Evans discusses how drawing and building follow two distinct logics, and how these logics can be in "near perfect accord" as in Renaissance buildings and perspective drawing, for instance, or can be lacking in accord as in Scharoun's Berliner Philharmonie, where conventional drawing techniques were not supportive of the spaces that Scharoun imagined. Scharoun thus used models and tweaked conventional drawing techniques in order to accommodate his ideas. Evans, *Cast*, 119, 221.
[83] *The Working Drawing*, 45.
[84] Francis D. K. Ching, *Architectural Graphics,* (New Jersey: John Wiley and Sons, 5th ed., 2009), 53.
[85] Per Aage Brandt, *Det Menneskeligt Virkelige*, 88.
[86] "Drawings become notations precisely at the moment in which numerical and textual information is added to the exclusively visual." Allen, *Practice*, 46.
[87] Stjernfelt, *Diagrammatology*, 99.
[88] Ibid., 49-88.
[89] Ibid., 90.
[90] Gansterer, *Drawing a Hypothesis*, 22, 154-73.
[91] Busk, "The Diagrams of," 170-73.

[92] Peirce, *The Essential Peirce vol. 2 (1893-1913)*, ed. the Peirce Edition Project, (Bloomingdale and Indianapolis: Indiana University Press, 1998), 303. Peirce's emphasis.
[93] Stjernfelt, *Diagrammatology*, x, xii.
[94] Ibid., xiii.
[95] Ibid.
[96] Ibid., 115.
[97] Stjernfelt at the conference *Thinking with Diagrams* at Freie Universität, Berlin, spring 2011 http://www.geisteswissenschaften.fu-berlin.de/v/schriftbildlichkeit/veranstaltungen/oeffentlich/tagungen/thinking_with_diagrams (accessed 13.02.2015)
[98] Stjernfelt, *Diagrammatology*, 99.
[99] Gilles Deleuze, *Francis Bacon – The Logic of Sensation*, trans. Daniel W. Smith, (Minnesota: The Minnesota University Press, 2005), 93.
[100] Busk, "The Diagrams," 171.
[101] Ibid., 173.
[102] "The diagram is real to the extent that it participates as a condition of reality in the birth of connections that are still unreal, such as a picturesque or musical composition, a scientific system of functions, references and experiments, or dynamic self-reproductive economic exchange relationships." Ibid., 172.
[103] Ibid., 171.
[104] Gilles Deleuze and Felix Guattari, *A Thousand Plateaus - Capitalism and Schizophrenia,* trans. Brian Massumi, (London: Continuum, 2004), 155-59.
[105] Busk, "The Diagrams of," 172.
[106] Ibid., 170.
[107] Stjernfelt, *Diagrammatology*, 99.
[108] Busk, "The Diagrams of," 172.
[109] Ibid., 171.
[110] Anthony Vidler, "Hvad er egentlig et diagram?," trans. Nils Lyngsø, (Copenhagen: Kunstakademiets Arkitektskole, 2007). Originally published as „What is a Diagram Anyway?", in *Peter Eisenman. Faints*, ed. Luca Molinari and Silvia Cassará (Milano, 2006), 520-29.
[111] Busk, "The Diagrams of," 172.
[112] Ibid., 171.
[113] Ibid., 170.
[114] Stjernfelt, *Diagrammatology,* 89.
[115] Bertram, "The Useful Icon," unpublished.
[116] Deleuze, *Francis Bacon*, 93.
[117] Ibid., 88, 98.
[118] Bertram, "The Useful Icon," unpublished.
[119] Deleuze, *Francis Bacon*, 98.
[120] Ibid., 84.
[121] Ibid, 88.
[122] Ibid., 81.
[123] For instance, Evans, *Cast*, 118.
[124] Busk, "The Diagrams of," 172.
[125] Ibid.
[126] "I call a sign which stands for something merely because it resembles it, an *icon*. Icons are so completely substituted for their objects as hardly to be distinguished from them. Such are the diagrams of geometry. A diagram, indeed, so far as it has a general signification, is not a pure icon; but in the middle part of our reasonings we forget that abstractness in great measure, and the diagram is for us the very thing. So in contemplating a painting, there is a moment when we lose the consciousness that it is not the thing, the distinction between the real and the copy disappear, and it is for the moment a pure dream, - not any particular existence, and yet not general. At that moment we are contemplating an *icon*." Peirce's emphases.
Peirce, *Writings of Charles S. Peirce, 1884 - 1886, vol. V*, ed. Kloesel, Fisch et al., 163.
[127] Busk, "The Diagrams of," 172-73.
[128] Ibid., 171.
[129] Ibid., 168.
[130] Gilles Deleuze, *The Logic of Sense*, trans. Mark Lester with Charles Stivale, (London and New York: Continuum, 2004), 69.

DRAWING REASONING III: DRAWINGS AND MAPPINGS AS EPISTEMIC ARTEFACTS

Introduction to the chapter

The discussion now moves from diagrammatic reasoning as a generative mode of thinking in both artistic and scientific practice, to how reasoning can be generated in a process of exchange with artefacts or bounded in artefacts. This taps into the discussion about how and to what extent an art artefact can be said to embody research or "speak for itself,"[1] as Christopher Frayling, for instance, critically thematised in the well-known paper, "Research in Art and Design."[2] In the case of architectural drawing the question of the degree to which a drawing can speak for itself is especially poignant, since a conventional drawing can indeed speak for itself, at times more precisely than discursive language. On the other hand, in tapping into art and architectural practice, the conventional drawing can also be indeterminate, giving no clear signs about how it is to be read. Conventional drawing and also mapping, which is another common architectural practice,[3] balance this tight-rope walk between being an artefact that can be scientific at times, indeed technical, and also being an artistic expression. In the following chapter drawing and mapping are conceptualized as artefacts that bind reasoning in more or less determinate ways, where the conventions provide a strong framework for their being read in clear ways, but where – due to their diagrammatic character – the conventions themselves can also be negotiated. Hans-Jörg Rheinberger's idea of epistemic artefacts seems very relevant when continuing the thread from diagrammatic reasoning towards how reasoning is sedimented in or emerges from artefacts. Where the diagram as figure of thought is at play between the reasoner and the material token in both Peirce and Deleuze's understandings of the diagram, then Rheinberger's idea of epistemic artefacts extends their accentuation of the 'in-between' space in which the diagram can operate, and includes techniques and technical things as part of the in-between space. Rheinberger's ideas are rooted in his experiences as a researcher in cellular biology, and observations that reasoning in natural scientific experiments can be bounded in epistemic artefacts that are made with the help of technical equipment and notational forms. He argues that the equipment used and the representational ways of working unavoidably leave traces on the epistemic artefacts, in fact to such an extent that they cannot really be separated – an idea quite similar to Evans' arguments that the drawing relatively strongly, and yet indirectly, co-forms the building. Rheinberger's ideas on epistemic artefacts have already been related to the architectural design process, for instance by the German architect and philosopher,

Sabine Ammon,[4] and more specifically to architectural drawing and mapping by the German architect and philosopher Jan Bovelet.[5] I extend Bovelet's way of conceptualizing drawing in architecture as an epistemic practice, both with the help of Stjernfelt's diagrammatic reasoning and the art historian Gottfried Boehm's concept *iconic difference.* Moreover it is discussed how Western mapping conventions came into existence in the first place with the theory of the anthropologist David Turnbull. Turnbull accounts for how a shared Western techno-scientific knowledge space was grounded in close relation to many social movements, where the conventions for making geographical maps and measuring land were constructed in the first place. Moreover, Turnbull argues that in the Western knowledge tradition the creation of a map is similar to the creation of a theory. This is important in this thesis where an attempt is made to bring together a typical scientific format, a PhD, with a reasoning format from architecture – drawing – which can be both artistic and completely rational, and tending towards a scientific mapping practice. Moreover, my drawings are also closely related to theoretical concepts, and therefore Turnbull's outlining of the kinship between theories and maps creates a resonance space for my drawings.

EPISTEMIC ARTEFACTS

Thinking the non-thinkable

Taken in a narrow sense, the word episteme describes secure knowledge in established science;[6] but taken in a broader sense, it means recognition or realisation (in German: Erkentniss, in Danish: erkendelse). It is this broader sense that is referred to here with Hans-Jörg Rheinberger's concept of epistemic artefacts. Episteme is often opposed to techne, which, taken in a narrow sense, means art.[7] But techne also means craft and technique for crafting, and the word technology is a ramification of it. These etymological roots hint to us that art and science – techne and episteme in a narrow sense – are thought of as different domains, but that, in the broader sense of the words, they share the fact that both use *techniques* and *technology* in order to *realise* something. In this chapter the relation between technical and epistemic artefacts is analysed and set in relation to architectural drawing and mapping. In addition it is argued here that architectural drawing – especially sketching – is an epistemic practice, but that also finished drawings can be epistemic in the sense that they no longer follow known conventions, and therefore can lead to further openings and knowledge generation.

> [E]pistemicity is one of the privileged modes by which we humans enter into a particular relationship with the material world around us. This relationship is precisely of a kind in which the act of calling, or construction for that matter, is delegated to parts of the material world itself. An epistemic relation is thus a relation, […], between two kinds of objects, namely technical objects and epistemic objects. Technical objects are, so to speak, the sedimented products of former epistemic activity.[8]

The words belong to the German biologist and theorist of knowledge Hans-Jörg Rheinberger. He argues that systems for making natural scientific experiments are epistemic environments that facilitate the emergence of the new.[9] Experimental systems in the natural sciences, so Rheinberger, are themselves concrete places where new scientific knowledge emerges *in* the material under investigation.[10] What emerges in these experimental systems can only be captured due to the way these systems have been thought out as able to receive the new. The experimental systems are therefore, paradoxically, structures that human beings have thought out to facilitate the emergence of that which has not yet been thought or observed.[11]

At first this might seem to be a 'hen and egg' problematic where it is impossible to determine what came first, the system of thought or the thought that the system is supposed to capture. And this question remains open: does the system determine what can be captured, or does the 'object' or artefact that can be captured determine the system? However, the important issue is to understand what happens *between* the system and the as yet unknown event, if it appears, that will lead to the new. Rheinberger describes this relationship between the system and the event or artefact that is handled by the system as interactions between *epistemic* and *technical* objects that condition and depend on each other to a degree where they cannot be separated. Epistemic objects are therefore *embodied* with the way in which they have been handled technically, and within their formation by the very procedure they have been through (cf. Evans' argument about how projective drawing *generates* building to the same extent that it transports technical ideas about buildings). As vague appearances in the experimental system, epistemic objects/artefacts (Rheinberger uses the words interchangeably himself) cannot be separated from the experimental system itself, nor from concepts and explanations in discursive language, names etc., that can describe the appearances. But to describe an epistemic object is not simply to label it,[12] but rather an epistemic object "embodies – but in a way that can be experimentally handled – what one does not yet exactly know."[13] So the epistemic artefact is an appearance, event or material thing that can be observed in an experimental system, although it is not known discursively what the appearance is or what it means. This is about how something unknown, indeterminate and uncertain can be handled in precise ways, a recurrent theme of the thesis.

Technical objects, on the other hand, "are the instruments, apparatus, and other devices enabling and at the same time bounding and confining the assessment of the epistemic things under investigation."[14] Epistemic objects are shaped by technical objects, which are already well defined and known, and make it possible to make visible that which is as yet unknown, to measure it and so on. It is in the nature of epistemic artefacts that they cannot be pointed to directly, but only indirectly in the experimental system or through different sorts of visualisations, which also rely on notational systems. If one could point directly to an epistemic artefact, it would be known and have lost its epistemic value about which more can be learned. This idea, I think, also resonates strongly with the role of an architectural sketch, which can be drawn within the conventional drawing system before one really knows what it is. The same goes for a diagram: if a diagram could be named or conceptualized clearly it could become a convention or a technical object, but before that it is an epistemic diagram – being helpful for keeping structure and clarity throughout contemplation, but not yet clear. An epistemic object can become a technical object only when it gains "identity and determination,"[15] so Rheinberger. When an epistemic object is transformed to a technical object the relation that the epistemic object describes towards the concept is no longer unclear or indeterminate, but the opposite. In a transformation from epistemic to technical artefact, the epistemic artefact loses its indeterminacy and becomes determined. Hence in Rheinberger's account a scientific experiment in which 'the new' can appear is a controlled and yet open space, unmistakably conditioned by the technical means with which the material under investigation is handled. This is of course far from understanding knowledge produced in scientific experiments as objective, separated from a given situation, or neutral. Rather it points out a close connection between a constructed space for thinking, where knowledge is produced by the way it is technically handled as a reality of its own. Rheinberger even calls the space *between* the knower (in his case the biologist) and the knowledge produced a *trace-generating knowledge environment* in which epistemic objects are handled.[16] Conventional drawing too is trace generating both because traces are left on paper and because as projective framework drawing leaves traces on buildings.

In the experimental system an epistemic object is in a situation of mediation at all times, and this conditions it, just as the epistemic objects affect the experimental system in return.[17] Hence, when an experimental system is chosen, this choice sets some limits as to what kind of epistemic artefact can be handled or even expected to show itself within it. This resonates with the arguments given in the state of the arts chapter: that every architect compiles her own working medium, consisting of techniques and notational forms in congruence with the idea of architecture that the architect has. A compilation of an architectural medium, however, might not be known or planned in advance, but with experience a knowledge base is gathered as to which techniques and notational forms can achieve which purposes. Rheinberger talks of a "technological momentum,"[18] which is the dynamics between the environment prepared and the artefact being handled. The preparation always leaves a trace on the epistemic object as it is handled, and therefore Rheinberger thinks that *visualisation* is essentially an epistemic problem.[19] That is, the epistemic problem is visualized in and through its experimental settings, and the settings are already *prepared*.[20] The preparation informs the starting point: that which is already known, and also informs the expectations. Preparation already relates to expectations, although it lacks, by definition, security as to whether or what will appear. An experiment is *prepared* on well-known terms, and yet it is open enough to allow for something unexpected to occur, similar to a good diagram which will let us go further with a reasoning process and learn more, and not just by following pre-planned rules but by throwing these into question. The system or environment determines the scope of the experiment, its "spielraum."[21] An epistemic environment co-shapes what emerges within it through a range of different mediated visualisation techniques, "enhancements," "dilations," and "compressions."[22] These representational modes make things visible, but also, through being partial, maintain the onward movement of the inquiry. Moreover the partial visualisations themselves become starting points for other inquiries, so Rheinberger.[23] The indeterminacy of visualised, epistemic artefacts then becomes a productive quality, leading to partial closures and new openings. In the endeavour to make epistemic artefacts visible, experimental systems work with technical equipment, enhancement techniques and preparations which follow representational logics of their own.

> Two things, however, are characteristic of all preparations as visual forms of objects of knowledge. On the one hand, they participate, in one form or another, in the very materiality of the object under investigation. They *are* the research objects, insofar as they are not only brought into a measurable form, but also into a visible, heightened form, thus into *ecstasis*, if you like. On the other hand, they are developed in close resonance with particular instruments. They are, in a way, solidified in-betweens, objects that owe their existence to the medial spaces created by the instrument-driven experiment. And they come and go with the technology to which they are tied.[24]

This pointing out of the 'invisible' in-between media space, where an epistemic artefact can solidify, is an important point in this thesis, since my own drawings could be regarded as 'solidifying' a thinking process in the drawing material. (I argued in *DRAWING REASONING I* that drawing, even if it is more directed towards theory than building, can be thought of as a material practice where the material consists of pen, paper, geometrical tools, computers, surfaces, lines, points, projective systems,

calculations and more or less explicit ideas of architecture.) Any drawing as a solidified and maybe only half-thought thought is s *sketch*, – it captures some thoughts and leads to others – and no matter in which state of determination a drawing is, it is always produced from a pre-selected preparation. Evans has put it this way:

> Architectural drawing affects what might be called the architect's field of visibility. It makes it possible to see some things more clearly by suppressing other things: something gained, something lost. Its power to represent is always partial, always more or less abstract. It never gives, nor can it give, a total picture of a project, so in consequence it tends to provide a range of subject-matter that is made visible in the drawing as opposed to all the other possible subject-matter that is left out of the drawing or is not so apparent from it. … […] we have to understand architectural drawing as something that defines the thing it transmits. It is not a neutral vehicle transporting conceptions into objects, but a medium that carries and distributes information in a particular mode. It does not necessarily dominate but always interacts with what it represents.[25]

Symbolic, architectural drawing as epistemic practice

As said, Jan Bovelet has related Rheinberger's idea of epistemicy to architectural drawing by suggesting that drawing is an epistemic practice in architecture.[26] Bovelet approaches drawing as a *symbol system* that has "its own specific space of knowledge."[27] He argues that as a "non-textual form of making visible"[28] drawing makes up an autonomous form of knowledge production in architecture, from an epistemic point of view. He also argues that drawing in architecture is generative, operational, and always depends on "some sort of non-conceptual reasoning."[29] But, he adds, "[i]n order to play their role in the generation of knowledge, drawings also must follow rules that can be described in terms of symbol theory."[30] Bovelet takes symbol theory to mean *diagrammatic reasoning* in the sense given by German philosopher Sybille Krämer,[31] which is grounded in text, grammar, and clear symbolic meaning. Bovelet thus links his argument regarding drawing as a knowledge space in its own right to a symbolic understanding of knowledge production, which means that knowledge is propositional, and only those things that can be explained have unambiguous meaning. He also relates the symbolic understanding of diagrammatic reasoning in drawing to Nelson Goodman's notational theory, which I will discuss later. Bovelet does put forth that it is necessary to distinguish between the *operational* modes of texts and drawings. A drawing, Bovelet says, can only exist as a propositional argument or work as a text if it can be wrong and falsifiable; and a drawing can only be wrong if the receiver knows how to understand the drawing.[32]

Measuring the knowledge space of drawing against a symbolic, propositional, falsifiable understanding of knowledge, however, seems to limit Bovelet's initial idea that drawing in architecture is a specific knowledge space in its own right. If drawing is measured against a symbolic knowledge space then only a limited range of drawings can be considered to convey knowledge, such as finished working drawings, and even they – as we heard in the state of the art chapter – are usually laced with aesthetics. On the other hand, epistemic activity lies before knowledge, so Rheinberger, and an epistemic artefact binds and helps to generate knowledge. But I wonder why Bovelet takes a symbolic definition of knowledge in order to then measure drawing's knowledge space against it. In doing this, it becomes true that only some aspects of drawing will qualify as *knowledge*, whereas other aspects become 'merely' epistemic, lying before genuine knowledge. But should we not hold on to Bovelet's initial idea, that drawing in architecture can be considered to be a specific, architectural way of knowing and of getting to know things you work with, and could this *drawing knowledge* not be granted a little more autonomy as knowledge space? Could drawing's knowledge space not be considered to include diagrammatic reasoning in another sense than the symbolic sense of Krämer? With Stjernfelt's iconic diagram drawing might be considered as a knowledge space in its own right on terms that do not only come from outside of drawing; terms which drawing should live up to but which in fact only some aspects of drawing can live up to. If this were the case drawing's iconic knowledge space, which works well with indeterminacy, might be better recognized.

With Stjernfelt's idea of the diagram enabling a meeting between icons and symbols in reasoning process, taking away the icon would be equivalent to taking away an important part of the knowledge space of architectural drawing; or similar to ruling out abduction in a reasoning process. For this reason I prefer to conceptualize drawing as a knowledge space of the icon. This then leans towards Stjernfelts' diagrammatic reasoning as to how it could be considered to be a format of reasoning and knowing in its own right, forming a continuum between reasoning with sketches and working drawings.

Iconic, architectural drawing as epistemic practice

Bovelet concludes that "drawings are situated in between the conceptual and pictorial making visible processes,"[33] a point that I agree with based on the diagram as a figure of thought that can operate in between thoughts and material artefacts. But he does not unfold further on what the *pictorial* qualities of drawing consist of. The pictorial qualities of drawing, however, could be understood as architectural drawing's image-like and iconic qualities, and the art historian Gottfried Boehm's concept of "iconic difference"[34] might be helpful in this connection. The iconic difference is a quality of images that has to do with images in general being indeterminate with regard to how they are to be

read.[35] While images might be legible through resemblance, as is the icon in Peirce, they also work with difference and non-similarity. An image can vibrate between being recognizable and not being recognizable, and thereby it also vibrates between referring to the world 'outside' the image and making up a world itself to which it refers. Boehm sees this as a sort of *logic* belonging only to images: their own mode of working.

> By the 'logic of images,' we mean a manner of generating meaning that is particular to the images themselves and that can be derived only from them. So we are working with the premise that images add something important to our language, our concept and our knowledge that can only be experienced through these images.[36]

Thus Boehm argues that the logic of images is different from the logic of language and text, and although logic might not seem like the right word to use, Peirce's abductive and diagrammatic reasoning are also forms of logic with dynamics that are not only intertwined with the logic of language, but also with influences and sensations from the world as such, from objects and, not least, images. According to Boehm, images make sense through iconic difference, which is an indeterminate and sensuous way of reasoning. Boehm thinks that indeterminacy is characteristic of images, and that indeterminacy is fundamentally generative. He describes drawings, not necessarily architectural ones, but nonetheless relevant here, as all having to do with beginnings and open ends.[37] Iconic difference in drawings can "intonate"[38] the relation between figure and field in different ways. In the initial stage a drawing is open and lacks meaning, and by lacking meaning is indeterminate making this lack positive in this situation; the lack becomes a potential from which imagination can spring and new drawings be generated. This is expressed by Boehm as *tracing traces* and *leaving traces*; scenting something in the drawing and following the scent:

> Die Spur ist erstens nicht Schrift eines Sinns, noch weniger Double einer Realität, die sich in ihr abdrückt, sondern eine Fährte, die verfolgt sein will, deren mögliche Regel allererst zu entdecken ist.[39]

To see the drawing as a scenting and tracing activity that may or may not hide a rule, is similar to an abductive inference as described by Eco, lying between knowing and not knowing who left the footprint in the muddy earth at a crime scene, and why. A trace is the presence of an absence,[40] and thus Boehm combines icon and *index* (in Peirce) with indeterminacy in drawing as a scenting activity, which lies before any certainty or legality. This potentiality of a productive lack endows drawing with a specific difference from language, according to Boehm, and a drawing can thus be without concept but not for that reason without sense – instead it has a logic specific to images, and is a way of knowing in its own right.

Via Boehm the so-called logic of images that accompanies the pictorial qualities of drawing has been specified somewhat further. However, there is no guarantee that any epistemic object, any indeterminate logic, can be dismantled and show forth a rule, although this would be the aim for reasoning within the natural sciences. This could also be the aim for architectural practice, but it does not have to be. If an architectural epistemic artefact, such as an initial sketch, becomes known and is dismantled it can become a technical drawing. For example, if the sketch is developed and becomes a completely defined technical description, or perhaps the conventional framework – the epistemic environment consisting of well-known systems or technical things – becomes re-invented anew. A technical invention could make new ways of building possible, but it is not necessarily the aim to use an architectural design process to dismantle an epistemic object, as long as the epistemic artefact is productive and helps a reasoner to come up with new ideas and new projects. It could even be that an epistemic artefact is more generative and animate if it remains 'dressed' and indeterminate.

Let us look at an example given by Boehm, where he addresses how a conventional drawing technique was once an epistemic object and then become a technical object. Here a technical object was not drawn or invented, but the drawing technique itself was, namely perspective projection. Perspective and orthogonal projection interact with each other since an orthogonal plan can be used to construct a perspective, and a perspective can be 'constructed backwards' into plan; and since both sorts of projection can be made measurable with the same standards for measuring. Concerning the question as to how images can be scientific instruments, Boehm refers to Rheinberger and points out that perspective construction has a double capacity that has been useful to both art and science.

The rules of perspective were initially neither commonly known nor clearly defined, but they soon became and also remained so. Hence, perspective as such was to begin with an epistemic artefact. Nowadays, when perspective construction is so well-known, it is no longer epistemic, but has become technical – it has become completely known and, as a way of visualizing, it can work in combination with different technical equipment. We shall soon see in more detail that the same process of transformation from epistemic to technical artefact occurred in the case of orthogonal projection, so the Danish art historian Rikke Lyngsø Christensen. Perspective representation has been used to accommodate both technical and artistic imagery, and as a conventional technical artefact between the viewer and the viewed, perspective acts by both representing ("vorstellender") and fabricating ("herstellender").[41] Boehm calls this a "rationalization of perception" enabling processes otherwise connected to the human senses to move

into the mechanical realm, and eventually leading to the development of photography, modern image technology and drawing software. The fact that, as a technical object, perspective is used to create both scientific and artistic images makes it possible to both handle and make visible things that would otherwise not be visible.

To sum up: Rheinberger's account of epistemic artefacts, as phenomena that can be observed in natural scientific experimental settings, but which fall outside of what is already known was the point of departure. Indeed an artefact's being 'unknown' and 'new' is the very reason that it is epistemic. The researcher who investigates an epistemic artefact is not fully certain what the artefact under observation is or means, but can – because of the prepared experimental setting and systems – make experiments with the epistemic artefact. In this way the scientific experiment is a shared, calculative framework, similar to a map or an architectural drawing, in which the as yet unknown can be handled. This does not mean to say that an experiment in the natural sciences is the same as drawing a building, but to point out that similar situations of being mediated, of using technical equipment and notational systems are at stake and co-forming here. There is something shared in this procedure that aims at producing knowledge and design objects, respectively, a sort of pre-knowledge generation which may lead to knowledge or in the case of architecture clearer definition and which carries traces of an environment, and of an expectation of what will be found. An epistemic artefact can thus be contemplated, tested etc. and at some point it may become clear what the epistemic artefact is or what it means. At that point it is no longer an epistemic artefact because it has become known; so the epistemic artefact shifts 'status' and becomes a technical artefact.

As symbol, conventional drawing can take part in the production and communication of what is typically thought of as knowledge, but, I argue, the knowledge space belonging to a drawing is characterized not only by a symbolic, conventional idea of knowledge, but by drawing being an image as well as an icon and a sketch. To support this, I argued with Boehm that a knowledge space exists that is specific to images and drawings; it is a logic or maybe even a knowledge space significant to drawing, which is not textual and discursive but which could not work without indeterminacy and becoming. Moreover, through being epistemic and not yet technical, such an object also carries similarities to a sketch drawing that is not a finished, technical working drawing. Sketching is considered to be an epistemic activity here, because it is about finding out more about something that is not yet quite known to the architect; about visualizing a half-thought thought. Moreover, sketching often happens in a prepared setting in the sense that drawing techniques such as plan, section, and elevation function as the experimental setting, the calculative framework that can be used to share and give measure to the not yet known. Looking at and handling a sketch through conventional forms of projection does not make drawing into a scientific experiment, but nonetheless enables the drawing, in its role as medium and as an enabling calculative framework, to receive vague material appearances and events; through the medium this indeterminacy can be transformed into a conventionalized knowledge space.

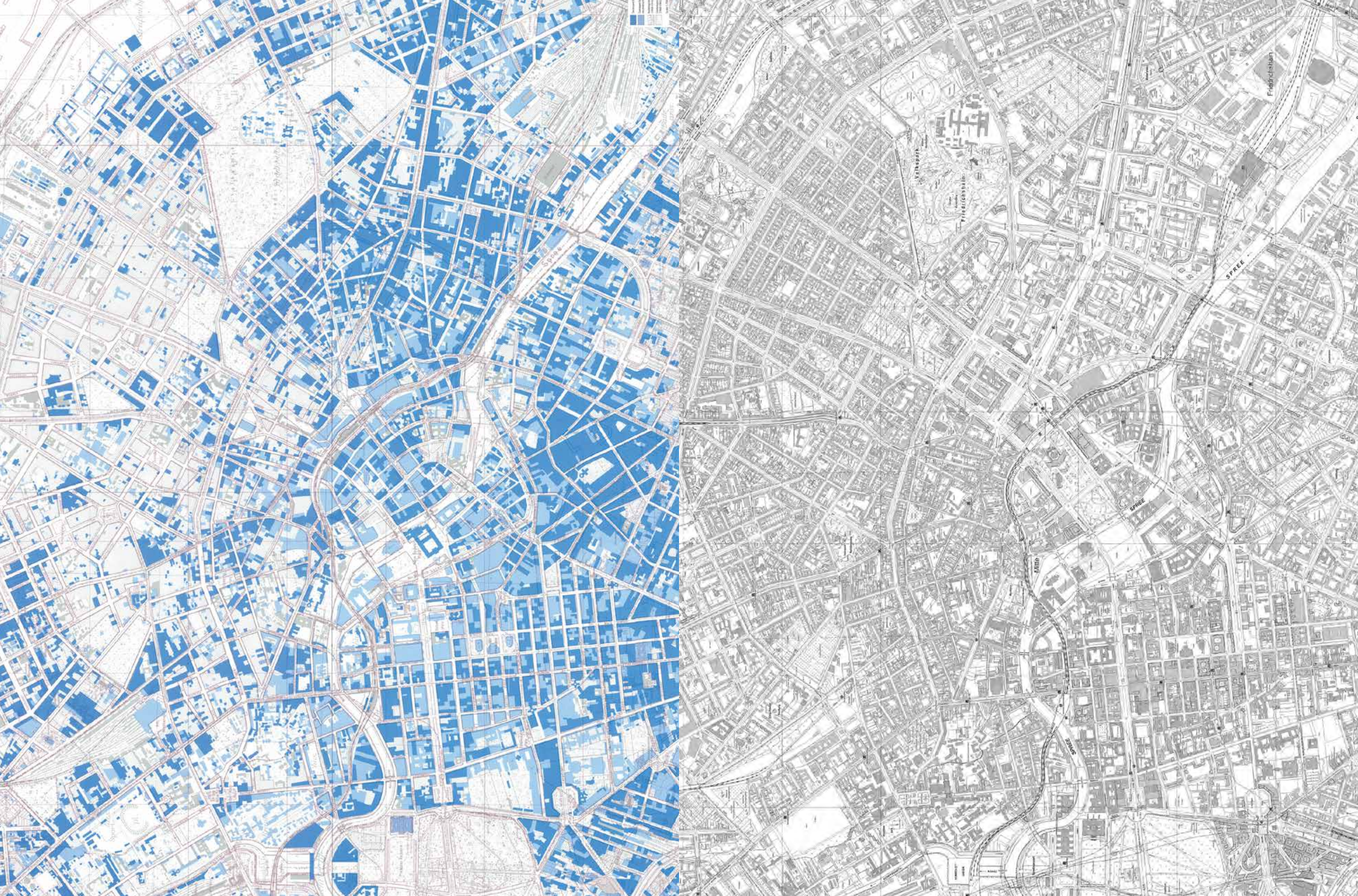
Fig. 3
Albrecht Dürer, *Man drawing a Lute,* 1525.

BERLIN HYPOTHESES

Peirce compares using a diagram for reasoning with using a map in a military campaign, and argues that diagrams and maps share the ability to give an overview of relations, be it of ground conditions or of imaginary things and experiments.[42] An overview makes it easier to make the right decision, just as it might show hidden connections, as in Wegener's *Pangaea* hypothesis. This series of maps discuss drawing a hypothesis. The series shows drawings ranging from those that respond to a hypothesis clearly formulated in language, to those that no longer follow conventional reading rules but still are finished and have an internal consistency; make up their own world with an own 'logic'. Moreover the maps are artefacts that transmit reasoning. A typical design process would start with sketching and move towards technical drawing. It would start with dealing with a high level of indeterminacy and move towards determination. In these maps the trajectory of movement is reversed. The first maps are completely determinate and can clearly be read and understood as discursive, conventional knowledge spaces – indeed this is a scientific way of using mapping. As such, the first maps affirm a hypothesis posed in language. The last maps of the series are the least determinate ones and in that sense the most sketch-like. Even though they are finished and conclude the series, they hold an epistemic potential for new maps to be made. The starting point for the drawings is given by two maps of Berlin, one from 1945, where building damage caused by the Second World War is recorded, and one from 2010 showing the city of Berlin in general with streets and buildings etc. The hypothesis was: did the many parks and playgrounds in Berlin emerge due to war damage? The answer given by the map was, yes, the majority did. This is a hypothesis that can be tested by comparing the map from 1945 with the one from 2010 and seeing what has changed in the interim time. If the aim is to answer the hypothesis, as it is in the first of my maps – in green and yellow – the abductive process where the hypothesis was *invented* has already taken place in language. Posing the hypothesis was an abduction, a qualified guess, but making the map in order to confirm the hypothesis was a deductive manoeuvre, uncovering already existing facts in order to confirm or dismiss the hypothesis.

Next pages:
Left: Map of Berlin in 1945, recording of building damage.
Dark blue: totally destroyed buildings
Light blue: partially destroyed buildings
White/grey: undamaged buildings

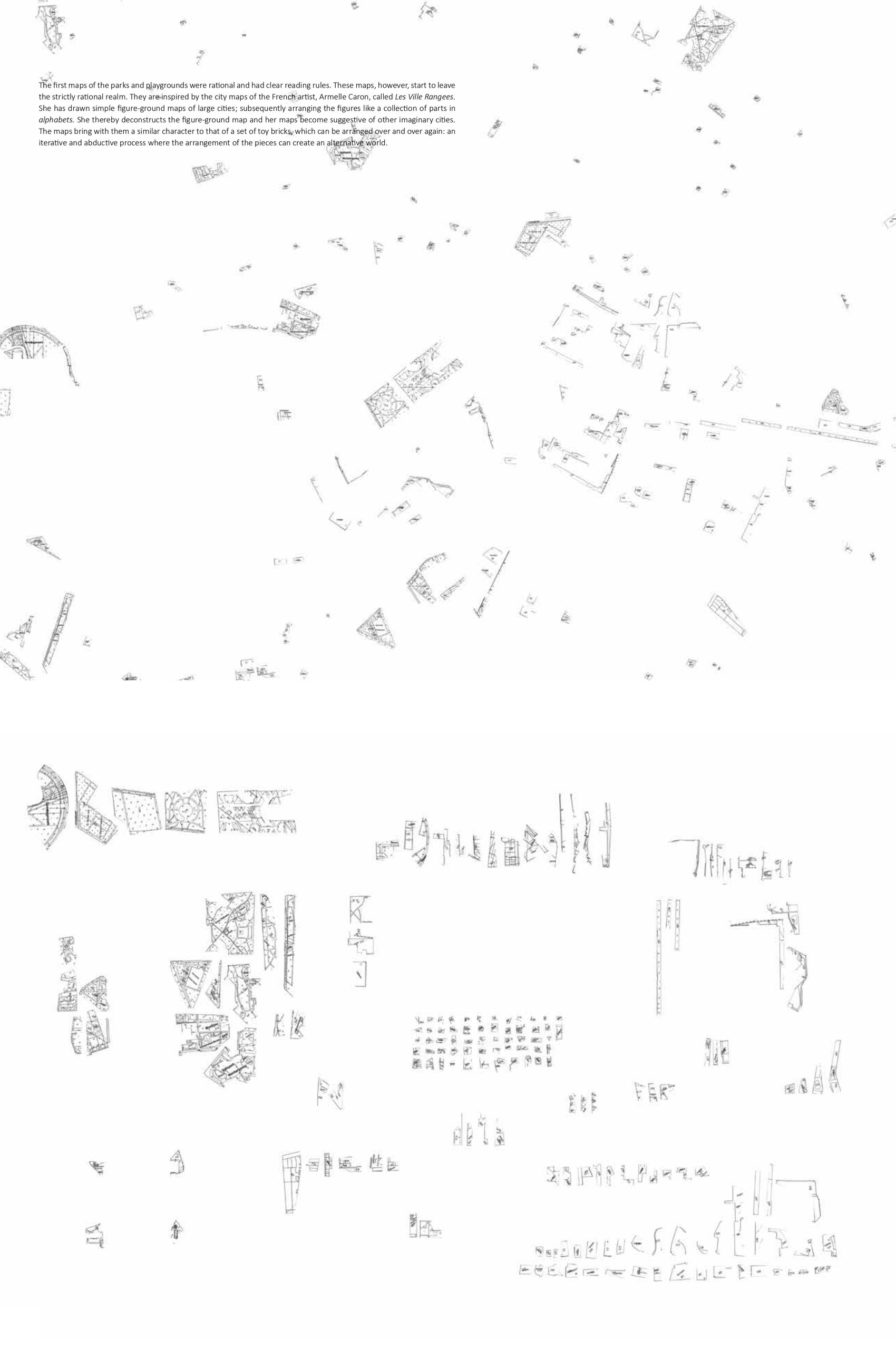
Right: Map of Berlin in 2010


Spree
Volkspark
Friedrichshain
Friedrichshain
SPREE
Mitte
SPREE

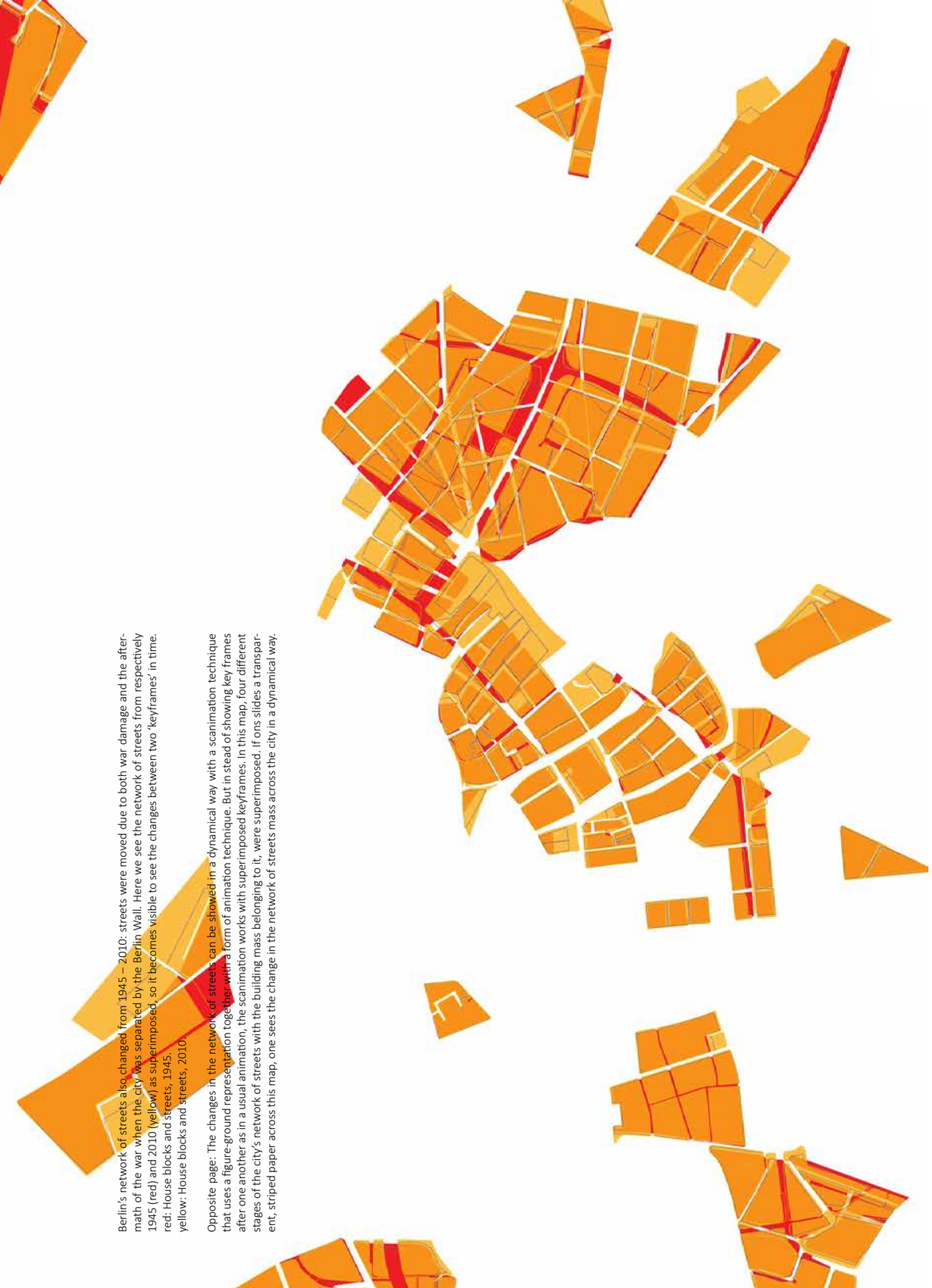
This map shows all green areas and playgrounds of Berlin in 2010. The yellow and turquoise sites are green areas and playgrounds, which clearly emerged due to buildings destroyed during WW2. The dark green sites did not emerge due to building damage. It is an ironic fact that what is a positive condition for the city today was caused by a disaster. The map answers the hypothesis that the many playgrounds and green spaces of the city emerged due to war damage.

The map only shows the playgrounds (turquoise) and green spaces (yellow) originating from war damage.

The first maps of the parks and playgrounds were rational and had clear reading rules. These maps, however, start to leave the strictly rational realm. They are inspired by the city maps of the French artist, Armelle Caron, called *Les Ville Rangees*. She has drawn simple figure-ground maps of large cities; subsequently arranging the figures like a collection of parts in *alphabets.* She thereby deconstructs the figure-ground map and her maps become suggestive of other imaginary cities. The maps bring with them a similar character to that of a set of toy bricks, which can be arranged over and over again: an iterative and abductive process where the arrangement of the pieces can create an alternative world.

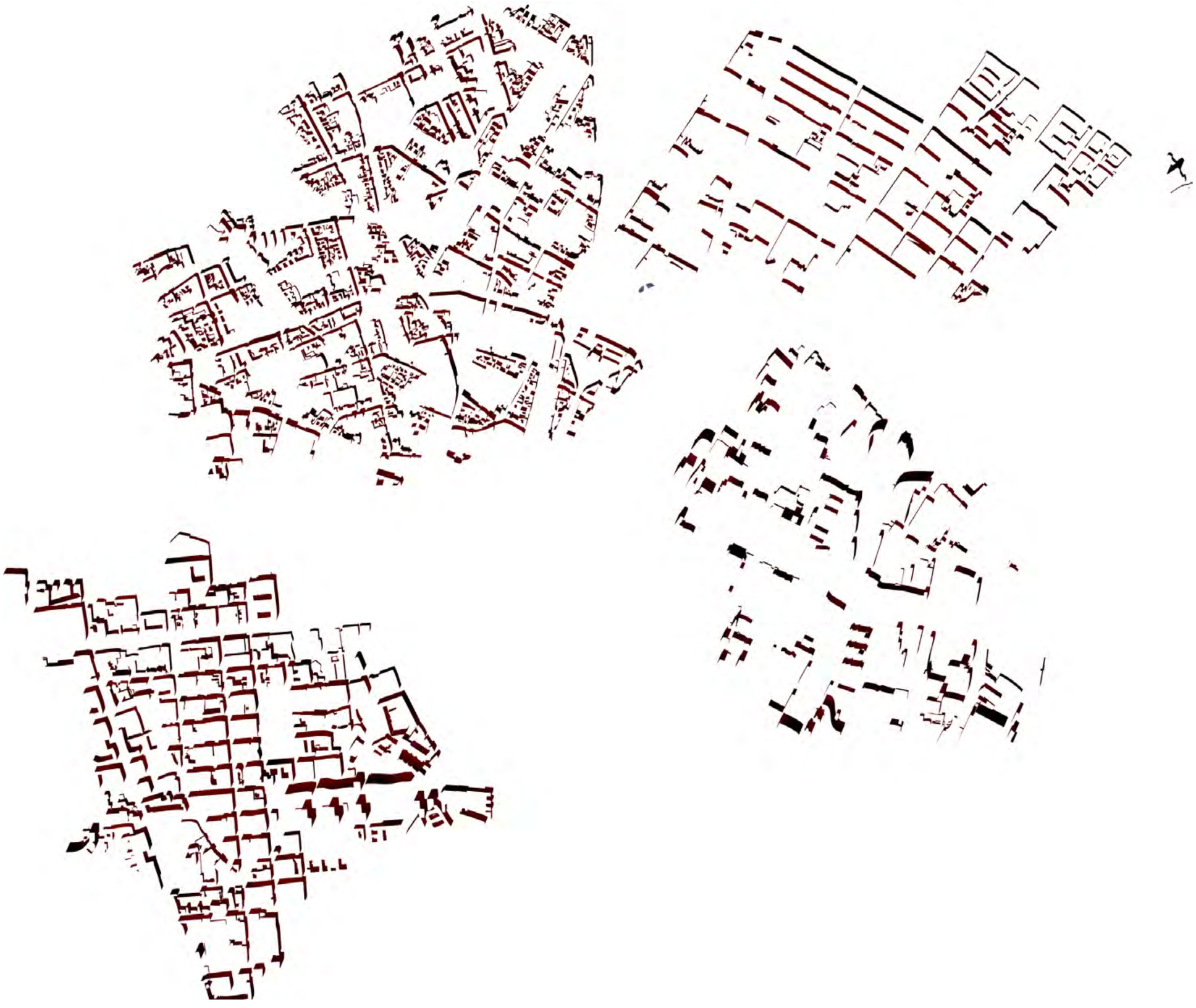


Alphabets



Berlin's network of streets also changed from 1945 – 2010: streets were moved due to both war damage and the aftermath of the war when the city was separated by the Berlin Wall. Here we see the network of streets from respectively 1945 (red) and 2010 (yellow) as superimposed, so it becomes visible to see the changes between two 'keyframes' in time.
red: House blocks and streets, 1945.
yellow: House blocks and streets, 2010.

Opposite page: The changes in the network of streets can be showed in a dynamical way with a scanimation technique that uses a figure-ground representation together with a form of animation technique. But in stead of showing key frames after one another as in a usual animation, the scanimation works with superimposed keyframes. In this map, four different stages of the city's network of streets with the building mass belonging to it, were superimposed. If ons slides a transparent, striped paper across this map, one sees the change in the network of streets mass across the city in a dynamical way.



A shadow map

The on the previous pages show building heights using shadows: mapping the shadow of a building is an indirect way of showing its height as because the rays of the sun cast shadows of the building in parallel projection. The broadest 'shadow-strokes' identify a tall building. In this shadow map I have extracted a number of urban patterns that are revealed indirectly through their shadows. For instance, the area to the upper left shows the oldest part of the city, namely the part developed from the original city core and the two former islands that founded Berlin on either side of the river Spree. The area to the lower left showing the north-south axes of Friedrichstrasse and Wilhelmstrasse was planned during the 17th century. Despite building damages the original network of streets largely survives in this area. The area to the upper right shows a workers' residential area with a traditional 19th century tenement structure. The area to the bottom right is characterized by tall point houses built in the post-war period of the 1950s, 60s and 70s. There have been considerable changes to the network of streets in this area.

The final maps on the following pages are line drawings and renderings in plan and oblique view. They do not answer a hypothesis but have inherited forms and figures from the earlier maps, and the orthogonal projection we look at the urban tissue through establishes a connection back to the city - the orthogonal projection allows us to read the drawings as plans, although the drawings do not give any of the conventional signs one would expect a plan drawing to give. They can be seen as drawn hypotheses, but they differ in kind from the first maps in this series, which answered a hypothesis formulated in language about the emergence of green areas and playgrounds in Berlin due to war damage. These last maps on the following pages no longer answer the initial hypothesis in any way, but have left convention and, I think, become epistemic artefacts, suggestive of other cities. This map series thus stretches from rational to sensuous mapping, from mapping quantitative to qualitative information, from icons with clear reading rules and ending up with as icons with vague or no reading rules.

The last maps may be described with the words of the art historian Emma Cooker, who has described how a drawn hypothesis starts with a hypothetical *if,* but at some point lets go of the "gravitational pull" of the *then* which follows. Cooker thinks of drawing as a generative mode of drawing as a line of opening '*ifs*', which can be grounded by a following 'then'. The *if* opens up an indeterminate possibility that keeps the process generative, while the *then* grounds the drawing. If there are only *ifs*, the drawing is at risk of collapsing under its own indeterminacy, whereas too many *thens* block the process:

> Comprehension remains suspended between one mode of thinking (as *if*) and the beginning of another (*then*). Suspension delays the logic of cause and effect, creating hesitation between stimulus and response. Stalling disturbs rhythm and unsettles familiar patterns by creating the space of a missed beat, an affective gap or form of creative attention in which to consider things differently to what they already are. […]. Propelled by the invitation of the drawn hypothesis, thinking momentarily escapes the pull of gravitational logic, for drawing not only complicates the production of the consequential *then*, but also encourages the generation of further *ifs*. If is like the wind, an auspicious force whose energy keeps the arrow air-bound, buoyant. Yet, too many ifs and the arrow's flight collapses impotently under the weight of its own potential or against the pressure of unruly turbulence, its hypothetical properties lost within the realm of pure fantasy. The drawing of a hypothesis is thus performed as a trajectory that harnesses the tensions of competing forces, maintained as an ever-active line oscillating between what may well have been imagined, but which could be perceived to be anchored within the real.[43]

[1] Christopher Frayling, „Research in Art and Design," *Royal College of Art Research Papers* 1, no. 1, (1993/4): 5.
[2] Ibid.
[3] i.e. James Corner, „The Agency of Mapping," in *Mappings*, ed. Dennis Cosgrove, (London, England: Reaktion Books Ltd, 1999).
[4] Sabine Ammon, „Wie Architektur entsteht. Entwerfen als epistemische Praxis," in *Wissenschaft Entwerfen*, ed. Sabine Ammon and Eva Maria Froschauer, (München: Wilhelm Fink, 2013), 337-61.
[5] Jan Bovelet, "Drawing as Epistemic Practice in Architectural Design," *Footprint – Delft School of Design Journal* 4, no. 2 (autumn 2010): 75-84.
[6] Steen Nepper Larsen and Inge Kryger Pedersen, ed., *Sociologisk leksikon*, (Copenhagen: Hans Reizels Forlag, 2011), 144.
[7] Ibid., 703-6.
[8] Hans-Jörg Rheinberger, "Epistemic Objects/Technical objects," 27. The article was originally published by the Max Planck Institute for the History of Science in Berlin as part of the Research Colloquium "Epistemic Objects" at the Technical University Berlin on May 16-17, 2008, 26. I have retrieved the article from http://www.theanxiousprop.org/pdf/AXP_Case2_07-2010.pdf (accessed 5.12.2014).
[9] Hans-Jörg Rheinberger, "Making Visible. Visualisations in the Sciences – and in Exhibitions?," in *Preprint 399, The Exhibition as Product and Generator of Scholarship*, ed. Susanne Lehmann-Brauns, Christian Sichau and Helmuth Trischler (published online by Max Planck Institute for the History of Science, 2010), 9-23. https://www.mpiwg-berlin.mpg.de/Preprints/P399.PDF (accessed 6.1.2015).
[10] "The whole thrust of the argument lies in the assumption that the primary way of symbol-making in the realm of scientific activity is itself a material process and not a linguistic one to begin with. The epistemic semiosis is one between traces generated in the experiment and invisible entities that are related to them in one way or another – and not between names and things."
Rheinberger, „Epistemic Objects," 26-27.
[11] "Experimentalsysteme sind die Orte, an denen sich in den empirischen Wissenschaften das Neue ereignet. Und das meine ich jetzt ganz konkret: Das neue ereignet sich weniger in den Köpfen der Wissenschaftler – wo es allerdings letztlich ankommen muss – als vielmehr im Experimentalsystem selbst, […]. Experimentalsysteme sind also äußerst trickreiche Anlagen; man muss sie als Orte der Emergenz ansehen, als Strukturen, die wir uns ausgedacht haben, um Nicht-Ausdenkbares einzufangen." Hans-Jörg Rheinberger, "Man weiss nicht genau, was man nicht weiss – Über die Kunst, das Unbekannten zu erforschen", in *Neue Züricher Zeitung* 5.5.2007.
http://www.nzz.ch/aktuell/startseite/articleELG88-1.354487 (accessed 28.01.2016)
[12] Rheinberger, "Epistemic Objects," 26.
[13] Ibid., 21.
[14] Ibid.
[15] Ibid., 23.
[16] Rheinberger, "Making Visible," 9.
[17] Ibid.
[18] Ibid.
[19] Ibid., 19.
[20] Ibid., 16.
[21] "In der Biologie beginnt mithin jede Untersuchung mit der Wahl eines Systems. Von dieser Wahl hängt der Spielraum ab, in dem sich der Experimentierende bewegen kann, der Charakter der Fragen, die er stellen kann, und sehr oft sogar auch die Art der Antworten, die er geben kann." Rheinberger, „Man weiss nicht genau."
[22] Rheinberger talks about these various sorts of representations throughout "Making Visible."

[23] "As models, epistemic things participate in the game of switching media. The model, as a rule, displays a different form of materiality than the thing it is taken to stand for. And as models, epistemic things thrive from the tension created by the fact that they always leave something to be asked. In German: *Sie lassen etwas zu wünschen übrig*." "Epistemic Objects," 26. See also Rheinberger, "Making Visible,"13.
[24] Rheinberger, "Making Visible," 17.
[25] Evans, "The Developed Surface," in *Translations*, 199.
[26] Bovelet, "Drawing as Epistemic Practice."
[27] Ibid., 75.
[28] Ibid.
[29] Ibid., 77.
[30] Ibid.
[31] Ibid., 78.
[32] Ibid.
[33] Ibid., 80.
[34] Boehm develops the concept in several texts, for instance, "Ikonische Differenz," in *Rheinsprung 11 – Zeitschrift für Bildkritik*, (Basel: Eikones2011): 170-76.
[35] Boehm, "Indeterminacy – on the Logic of the Image," in *Dynamics and Performativity of Imagination – The Image between the Visible and the Invisible*, ed. B. Huppauf and C. Wulf (New York and London: Routledge, 2009), 220.
[36] Ibid., 226.
[37] Gottfried Boehm, „Spur und Gespür, Zur Archäologie der Zeichnung," in *Öffnungen - zur Theorie und Geschichte der Zeichnung,* ed. Fiedrich Teja Bach and Wolfram Pichler (München :Wilhelm Fink, 2009), 43.
[38] Ibid., 46.
[39] Ibid., 49. "The trace is, first of all, not the script of a meaning, but even less is it the double of the reality that it expresses; rather it is a trail that wishes to be followed, whose possible rules are yet to be discovered." Translated by Sarah Rivière.
[40] Ibid. 48.
[41] "Man kann die Zentralperspektive deshalb den ersten Versuch nennen, die anschauliche Welt insgesamt als ein System vorstellender und herstellender Repräsentation zu entwerfen. Hier sollte sich Anschlüsse für die Praxis der Wissenschaften ergeben, die ihrerseits damit zu tun haben, „Repräsentationsräume für Dinge" zu schaffen, „die andernfalls nicht als epistemische Dinge zu handhaben wären." Boehm quotes Rheinberger, *Räume des Wissens*, ed. Hans-Jörg Rheinberger, Michael Hagner and Bettina Wahrig-Schmidt, (Berlin: Akademie Verlag, 1997), 272. Gottfried Boehm, "Zwischen Auge und Hand – Bilder als Instrumente der Erkenntnis," in *Wie Bilder Sinn Erzeugen – Die Macht des Zeigens*, 3rd ed. (Berlin University Press, 2010), 106-7.
[42] Peirce, "PAP," 492-3.
[43] Cooker, *Drawing a Hypothesis*, 102-4.

MEDIA MUTATIONS I: HOW CONVENTIONS COME INTO BEING

Introduction to the chapter

The emphasis of this thesis will now shift from methodological issues to those related to drawing and the design process. However, these domains – methodology, drawing, and design process – do extend into each other as well as all having to do with what has been called *drawing reasoning* in the previous sections. Drawing reasoning has been presented as being diagrammatic – both logical and intuitive, both potentially scientific and artistic.

The next chapters cover *media mutations*: for instance, technical *mutations* happening in the same in-between space where the diagrammatic reasoning is at play. To recap the introduction, I refer to a medium is the *intermediary*, a vessel *in-between*,[1] and this resonates with the space of the diagram as also being able to act in-between spaces. The space of architectural media is a diagrammatic space, I argue, and, although technical media are changing, I put forth that the media space is still diagrammatic, and in that sense the change in the media is not as fundamental one might think.[2] The word *mutation* is taken from biology where it describes evolutionary changes in the genetic constitution of an organism. Mutations can have either negative, positive, or zero consequences for the affected organism, and a mutation can make an organism either more suited to life in changed surroundings, or can lead to that the organism dying out. A mutation can also be "a new form of something that has changed".[3] I emphasize the latter, still seeing conventional drawing as a very strong convention, a shared figure of thought but in a changed form: a conventional diagram in changed technical and notational surroundings, so to speak. Different aspects of the drawing mutate, and some aspects become even more outspoken (for instance the notational determination of translation from drawing to building – or what Carpo called notational identicality between drawing and building – can be heightened), while other aspects retreat.

In this first *media mutations* chapter it is described how some of the conventions around architectural drawing came into being. This is achieved using the anthropologist David Turnbull's account of how the conventions for measuring land and storing this knowledge in maps emerged, and how there was a high level of indeterminacy in those processes. They could be considered as being epistemic. However, as the processes converged towards shared frameworks and conventions for mapping knowledge, they became an increasingly stable practice in Western thinking. These situations resemble the situation concerning architectural media today, where the field of media use is in movement, as is the field of artistic research. However, we cannot know if these fields

converge towards more stability. Turnbull traces what might be called a collective epistemic movement around the emergence of shared mapping standards, a sort of collective sketching process where knowledge spaces were transformed from being epistemic artefacts to being technical artefacts that worked towards a certain purpose. Social construction and technical construction became mutually productive, being non-neutral and highly situated. Rikke Lyngsø Christensen describes a further example of a similar process directly concerning conventional architectural drawing, giving an account of how orthogonal drawing emerged – plan, section, and elevation – and how this became a shared design practice and knowledge space during the Italian Renaissance. She argues that the conventional drawing as a shared framework for communication – or as diagram, as I have called it earlier on – emerged from a joint sketching process.

MAPS AND KNOWLEDGE

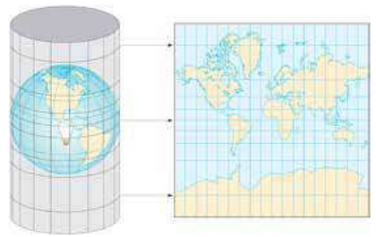
In the text *Tricksters and Cartographers: Maps, Science and the State in the Making of a Modern Scientific Knowledge Space*[4] Turnbull argues that the emergence of Western cartography is intertwined with the emergence of Western techno-scientific thinking. Scientific theories, so Turnbull, are map-like in character, because they represent relations and connections between phenomena in a completely clear way and must have internal coherency.[5]

> […], the map/science relationship is not simply metaphoric. Through the process of knowledge assemblage we have created a naturalised space amenable to being mapped; we now equate scientific knowledge with maps. […]. An instance of the ways in which the processes of science and mapping are jointly embedded is the concept of 'discovery' and 'exploration'. Territorial discovery and scientific discovery are both conflated with, and mediated by maps […].[6]

We have heard Rheinberger make a similar point about discoveries in the natural sciences being visualised *as* maps, diagrams, and models, which themselves – as epistemic artefacts – form part of new scientific theories and inquiries. Turnbull also sees a link between the aim of mapping and science, both being practices of exploration and discovery navigating in a shared "calculative framework."[7] In particular, Gerardus Mercator's mapping projection from 1569 enabled a coherent mapping space, so Turnbull. Mercator's map, probably the most commonly distributed map in the Western world, is made in cylindrical projection, which roughly means that the spherical globe is projected onto a cylinder and then folded out. Mercator's projection made it possible for European sailors to navigate on the world seas, because it was laid out with north-bound bearings in congruence with compasses. Between them, a Mercator map and a compass make it possible to adjust a ship's position in relation to a pre-planned goal, with the overview given by the map. The sailor can hold track of his own local position while maintaining an overview as to which parts of the map still need exploration.

> This projection provided a grid and the possibility of representing loxodromes, that is courses of a constant bearing, as a straight line. […] When perspective, geometry, and the grid of latitude and longitude were combined, it was possible to calculate accurately the location of any spot on earth. It was this calculative framework, this space within which to assemblage knowledge that, according to some historians of the Renaissance and the scientific revolution, […], provided the essential precondition for the possibility of modern science.[8]

Thus a form of predictability was achieved, enabling exploration without getting lost, a trait which Rheinberger also described in relation to experiments in the natural sciences, where controlled experimental environments can handle the emergence of the new, and can handle indeterminate things in experimentally controlled ways. Moreover, the various projection forms through which maps are made, co-form what is being looked at, similar to the way an epistemic artefact is formed by its context and cannot be understood in isolation from it. What is more, this embarks upon a notion of mapping having a dual nature, being both a concrete artefact and an abstract knowledge space, which, like a diagram, can be a structure of thought that can *receive* and *handle* the as yet unknown in the creation of new maps and new knowledge. For Mercator's map – in a shared trait with conventional drawing – is a highly operational *image*, an icon diagram. But Mercator's world map only gives one partial image of the world, as the cartographers Denis Wood, Ward L. Kaiser and Bob Abramms point out. For Mercator's projection and the map was invented in close correspondence with a certain purpose,[9] and only shows the world in the view given by this purpose (whether it was the purpose of the map to enable a European invasion of large parts of the world involves a wide-ranging discussion that I will omit here, but one purpose was indeed to enable sailors to navigate). Mercator's projection not only lead to images of geographical conditions (advantageous to the Europeans, since Europe is represented as being larger in relation to the equatorial countries) in a shareable, mathematical framework, it was also a technical instrument that enabled navigation. The relation between going on a journey of discovery and a knowledge space which enables discovery is literally bounded in the Mercator map artefact, and indeed subsequently dominated other knowledge spaces.[10]



Mercator world map

In order to give resistance to the exploitation which was made possible in close connection to the particular Western knowledge space, Turnbull encourages questioning, and his own approach is to unravel its becoming. Turnbull discovers that the shared standards for measuring to which cartography and science refer, came out of a "messy motley,"[11] that is, a rather chaotic assembling of local, partial knowledge spaces and maps, which were adjusted to each other over centuries through social negotiations and cross-border agreements. Several attempts to make a "master map"[12] were made starting in the 16th century in Spain and Portugal. During the 17th century large steps were made in development in this area, but it was not until the end of the 18th century that, finally, French and English observatories in Paris and Greenwich negotiated a synchronisation.

> The English and French astronomers disagreed by a matter of 11 seconds of longitude and 15 seconds of latitude which, on the ground, amounts up to roughly 500 metres. Such technical questions are not, of course, *sui generis*, but are coproduced with the instruments and practices that make possible both their formulation and their solution. Concomitant with that process is the creation of the kind of homogeneous and unified space in which science's universalised form of knowledge become possible through linking of local knowledge spaces.[13]

The two observatories reached an agreement in 1787 based on triangulation, allowing French and English measurement standards to be synchronized. The two countries had agreed upon the "linear distance between the meridians of Paris and Greenwich,"[14] and this agreement, Turnbull says, "would set in motion the process whereby the whole of the Earth's territory could be mapped as one."[15] Where this meant as a critique of maps as an overarching, homogenizing, calculative framework, suppressing of other knowledge spaces, the collective epistemic process that led to the creation of this calculative framework is relevant, since it reminds us that conventions are *made*. There is resemblance here to the current state of affairs in architecture, where media practices are being constructed, locally and subjectively, in close relation to architects' practices. Despite the fact that a "master map" was eventually agreed upon – the Mercator, so Turnbull – a map in which all knowledge following the rules of this knowledge space could be assembled, there are still minor local differences and inconsistencies in the way time and space are measured across the world.[16] Turnbull finds it important to see and show these inconsistencies, just as it is important to show that there are alternative knowledge spaces.[17] Inconsistencies in maps offer a point of resistance, so Turnbull, because unravelling inconsistencies can push back on constructed coherency, which might suppress other knowledge spaces.[18] Hence Turnbull's account of the historical emergence of convention is not only a parable for conventional drawing being a media practice in change, but also for artistic research, which introduces inconsistencies – in the form of art works and other methodologies – into academic and scientific practice. However, in the case of architectural drawing as a 'calculative framework' for mapping knowledge, Turnbull's account shares a domain with Western scientific thinking, because architectural drawings rely on the same shared calculative frameworks for measuring space, as well as time, just as maps do.

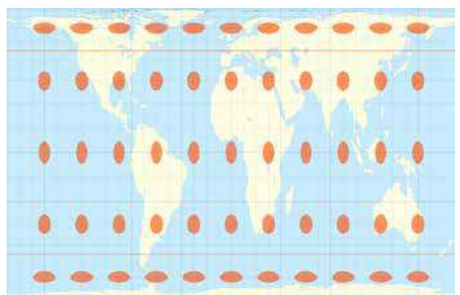
World maps and projection

Let us try to compare a couple of world maps in order to catch a glimpse of the invisible projections that are used to make world maps and to co-shape the images of the world that they project.[19] World maps make the co-shaping performed by a projection particularly visible, since their purpose is to show the whole world at once,[20] being the extreme case of mapping. All world maps are flattened images of the earth, a spherical globe, which cannot be flattened and unfolded into a two-dimensional plane without distortion.[21] Depending on which type of projection the cartographer chooses, the image of the world becomes different.[22] The Mercator map is the most commonly distributed map in the Western world,
and as I said, it is made with cylindrical projection, roughly meaning that the globe is projected onto a cylinder and then folded out. Sailors could draw their route in straight lines on the map and each straight line would have a north bound compass bearing, however, this would not be the shortest route, since the earth is actually spherical and any shortest route follows a great circle.[23] The only place a Mercator world map follows a great circle is around the Equator, and here the projection is not distorted. The Mercator map is conformal, meaning that each feature such as continent and country, retains is correct form, but in order to achieve this the actual areas of the landmasses are not shown in true relation. Wood, Kaiser and Abramms compare this property of Mercator's map to a face where each feature (eyes, nose, mouth...) has the right shape, but the eyes are proportionally three times larger than the chin.[24] On a Mercator map, Europe, the Northern part of Asia, and Northern America are much larger than they really are when compared to the equatorial countries. Greenland looks twice as large as Australia, when in fact Australia is actually three times larger than Greenland. Thus the Mercator world map gives a distorted image of the world, if we do not compensate by knowing how the projection works. In maps of smaller parts of the world the distortion of the Mercator projection is less significant, because the unfolding of a curved sector of the earth's surface is less extreme than the unfolding of a whole sphere as in the world map. As Wood, Kaiser and Abramms say, a projection for mapping is invented in correspondence with a certain purpose,[25] and Mercator's projection worked according to the purpose to not only present an image of the world, but to do so in a mathematical

framework that could be shared, which was also a technical instrument that enabled navigation.

The Gall-Peters equal-area projection has another purpose and correspondingly it shows another image of the world, where landmasses are depicted in actual size, while giving up conformity of shape. The world has been hung up to dry, as Wood, Kaiser and Abramms say, but now we see the real relationship of size between Greenland and Australia, just as the Poles are not blown out of proportion. Thus the map becomes less complimentary to Europe. Buckminster Fuller's *Dymaxion* map gives yet another image, namely of a flexible world. There are several editions of the *Dymaxion* map,[26] a 1946 cubo-octahedron (using squares and triangles in combination), and a 1954 icosahedron edition (using only triangles). Fuller's simple stroke of genius was to project the globe onto a polyhedron which was already sphere-like and which would lend itself to development,[27] that is, unfolding without distorting the image already projected onto it. The distortion of both landforms and land sizes therefore remains relatively small. There is no distortion along the edges of any of the folds of the polyhedron, only between the flat surface of a polyhedron face and the sphere,

and this distortion is distributed equally on each piece increasing towards the middle of each piece. Thus distortion is divided equally around the globe, and another purpose – a kaleidoscopic image of the world, where the image of the world changes depending on where one sees it from – is embedded in the projection. This idea was a part of Fuller's holistic ideas of a 100 % sustainable world for everybody (enabled by technology).[28] In this series of maps from Life-Magazine in 1946 the world is folded out in relation to different strategies of warfare and fantasies of gaining world control – note that this was just after the Second World War. The "Jap Empire" map shows how the Japanese would strategically wish to try and control the sea and coastlines, whereas the "Heartland" map is related to the German strategy for controlling the central, coherent landmasses of Eurasia. The icosahedron edition of the *Dymaxion* map from 1954 had the same properties as the one from 1946, but was furthermore supposed to serve as the game board in Fuller's *World Peace Game,* which is basically about creating a better world by playing out scenarios and negotiations concerning power relations, flows of money, goods, etc.. In both editions of the *Dymaxion* map we do find the same kind of calculative framework, which Turnbull criticised for being characteristic of a suppressive Western knowledge space, but on many levels the *Dymaxion* map seeks a principle of



Gall-Peters equal area world map.

equality and is intended to raise awareness of the many points of view towards the world. The purpose of the map which is embedded in its projection is simply different to that of Mercator. As a game board in the *World Peace Game*, the *Dymaxion* map functions as a concrete artefact and mental image that aims to support people in gaining a better understanding of the situation of other countries through their playing the role of that country. Despite the different intentions of these three world maps, they all play by the rules of a Western knowledge space, a mathematical, coherent framework for mapping. But what we can see by comparing different images produced by the world by different mapping projections is that the invisible projection has co-formed its object – the world – and that the image of the world cannot be seen as separated from the projection and its purpose.

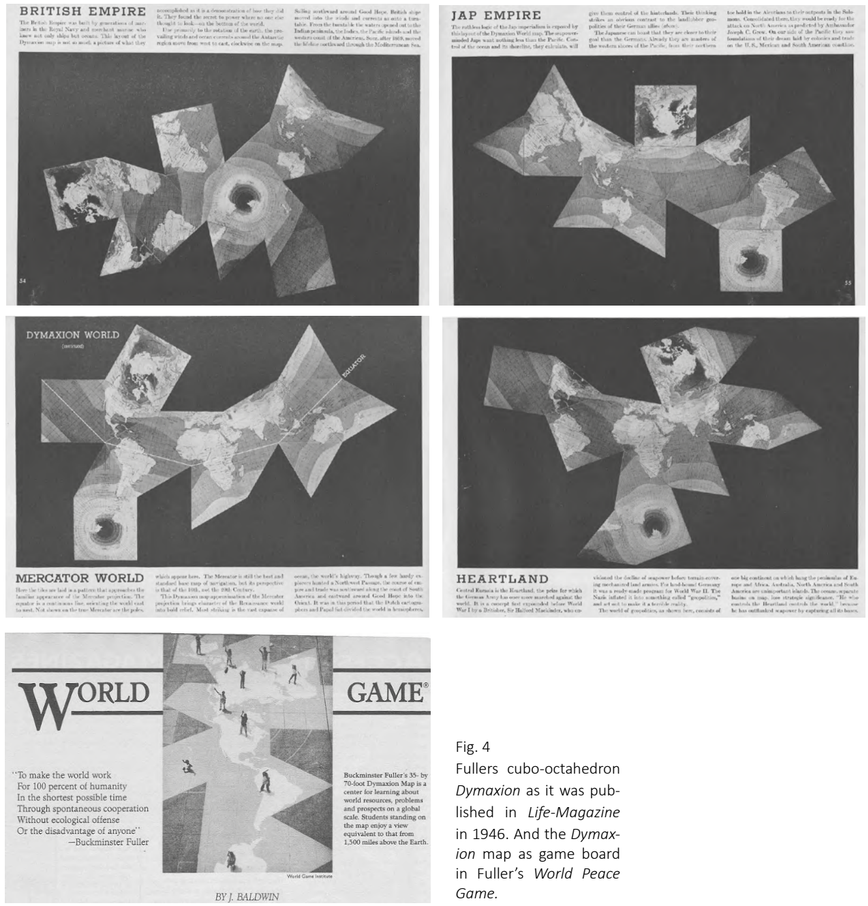


Fig. 4
Fullers cubo-octahedron *Dymaxion* as it was published in *Life-Magazine* in 1946. And the *Dymaxion* map as game board in Fuller's *World Peace Game*.

THE LEAP SECOND

I have placed a series of world maps here, in relation to Turnbull's theory. My world map series came out of a fascination with an inconsistency in the conventions of measurement, an inconsistency which goes by the name *the leap second*. I made the maps before having read Turnbull's theory, but his invitation to find inconsistencies in maps and unravel them in order to make map constructions more transparent had then already been investigated here. *A leap second* is more of a placeholder than it is a measuring unit. The unit has been made in order to handle indeterminacy in the metric system that is used to measure both space and time.[29] This unit serves as a 'buffer' in order to avoid the earth's own rotation getting out of sync with the measuring system of human-made time, which it otherwise will since the earth is the only 'clock' which 'keeps time' exactly. Although the leap second is in no way a secret, I first discovered it when starting to work with a world map of time zones, and it disclosed that even that which cannot be measured can be handled in the measuring system, simply because it has been conceptualized and given a place. The leap second is a placeholder that can receive a yet unknown 'amount of time'. Hence it has become a metaphor for this series of drawings descriptive of a sort of time lapse, a wormhole in the system from where my 'mutant' maps can escape.

The starting point was a world map of time zones, which represents the relationship between time and space in the metric system in perfect synchronisation.[30] This perfect synchronisation can also be retrieved in the way any location on earth can be described in a mixture of time and space units: degrees, minutes, and seconds. Take Berlin, lying on the latitude 52 degrees, 31 minutes, and 0 seconds West (52°31´0´´W), and the longitude of 13 degrees, 24 minutes, and 0 seconds East (13°24´0´´E).[31] Human-made clock time is counted with 24 whole numbers, 24 hours making up a day and a night, and these 24 hours are set out in a graticule – a calculative framework – across the world map and always displaced by one unit along the longitude, thus gradually adapting to geographical locations. Time and space are thus synchronized in this world map of time zone, where a graticule that counts to 24 is placed on top of an image of the world in some sort of projection, and this image provides orientation for the reader, who can read a geographical place on the earth in relation to the measuring system for time (an icon with a symbolic reading rule). Hence what Turnbull called a calculative framework is, in this map, a graticule that has been adapted to a projected, flattened image of the unfolded earth. Where the map shows the prevailing, human-made time standard, there are also alternative ways to measure time locally with hourglasses and sundials, which were used before the time became standardized and conventionalized, a process that started in about 1876 in Great Britain.[32] In 1884 the standard time system that we still use was agreed upon internationally, and the globe was divided into 24 time zones each counting 24 hours, as shown in the initial map. 24 time zones with 24 hours 'stretched' out across the globe is basically the description of a proportion, which can be shown graphically in longitudes and latitudes adapted to the image of the world. The standardization of time became necessary as the British railway gained reach,[33] and shared timetables were needed across countries to enable people to rely on trains' arrival and departure times throughout the British Empire.[34]

There was, hence, a practical need and a purpose behind the shared time standard, where the Greenwich meridian and observatory became the reference points. This time standard still in use today is called *Greenwich Mean Time*, *Universal Time* or simply *UT*.[35] UT refers to a scale called *UTC (Universal Time Coordinated)*, which again follows the *UT1*, the earth's own rotation:

> One can think of UT1 as being a time determined by the rotation of the earth, over which we have no control, whereas UTC is a human invention. It is relatively easy to manufacture highly precise clocks that keep UTC, while the only 'clock' keeping UT1 precisely is the earth itself. Nevertheless, it is desirable that our civil time scale not to be very different from the Earth's time, so, by international agreement, UTC is not permitted to differ from UT1 more than 0,9 second. When it appears that the difference between the two kinds of time may approach this limit, a one-second change called a leap second is introduced into UTC. This occurs on average about once every year to a year and a half.[36]

This means that the measuring system invented by humans takes indeterminacy into account and a certain elasticity is already built into the measuring system just because it has a placeholder, the leap second. The time standard can continuously be synchronized to the earth's actual movement, since by convention it is allowed to sometimes add a leap second to the system's counting. Therefore, the notion of the leap second is a wormhole, an indeterminate unit in the watertight scenario of seamless coherence and predictability between space, time, and earth movement. The leap second is a measure for the unmeasurable, which can then be handled anyway. It describes a discrepancy in the relationship between the earth's flow of time and our counting of it, a difference between a phenomena and an ideal representation of it. The leap second describes the difference between what can and cannot be counted, it is a pure diagram since it just orchestrates the relation between the earth and us counting, and orchestrating relations is what diagrams can do.

Dissection

In the first drawings the different layers of the world map of time zones were taken apart, metaphorically separating the projective system used to describe space from the counting system used to describe time. Then I introduced another time system, so-called @-time, a time standard made by Swatch, the Swiss watch company, which was conceived for counting time on the Internet.[37] The idea of @-time is that since the Internet as a 'virtual place' does not have a geography in the same way that the earth does,[38] there is no need for geographical time zones. Universal Time is adapted to the earth's geographical form and movement, which is practical because nightfall and daybreak in different locations across the world are taken into consideration. But @-time does not consider geography. Although both Universal Time and @-time are just scales, Universal Time is set up in a cyclic scheme that corresponds to the gradient transition between day and night in different geographical locations. Universal Time prioritizes that 8 o'clock in the evening is always evening throughout the world, and not always 8 o'clock at the same time in Sydney and New York as @-time does. @-time is in a way completely linear, not adjusted to nightfall and daybreak, but to progressive counting. No matter where you are geographically it is always 740@s at the

same time despite nightfall and daybreak. @-time thus subjugates space to counting time in an extreme way, but nonetheless, even @-time links to earth's own pace of rotation and has its reference point on the Greenwich meridian too. This means that when it is 12 o'clock Greenwich Mean Time in Greenwich it is 500@s all over the world. Without any point of reference @-time would be redundant and meaningless to human beings, simply counting in relation to nothing.

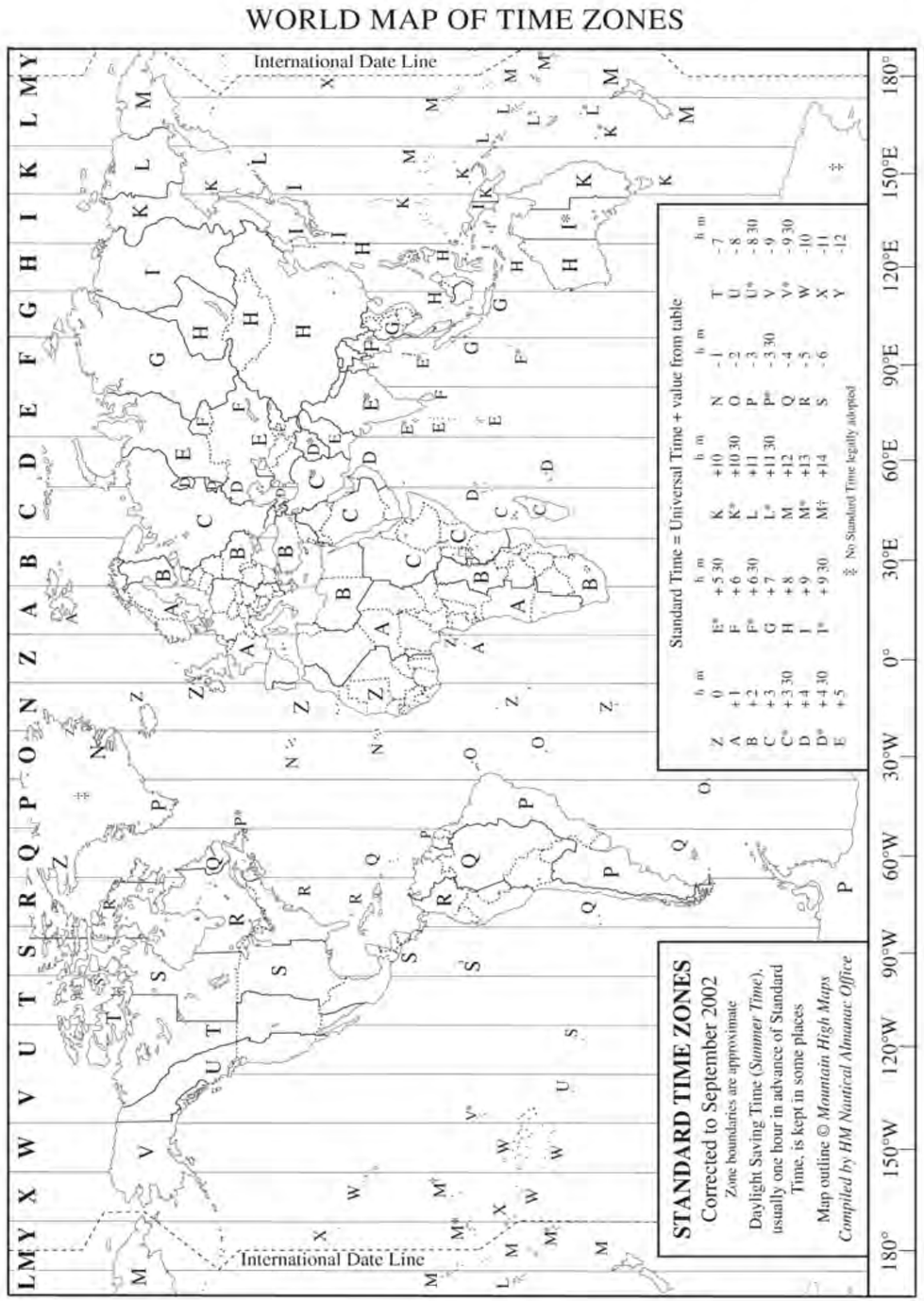
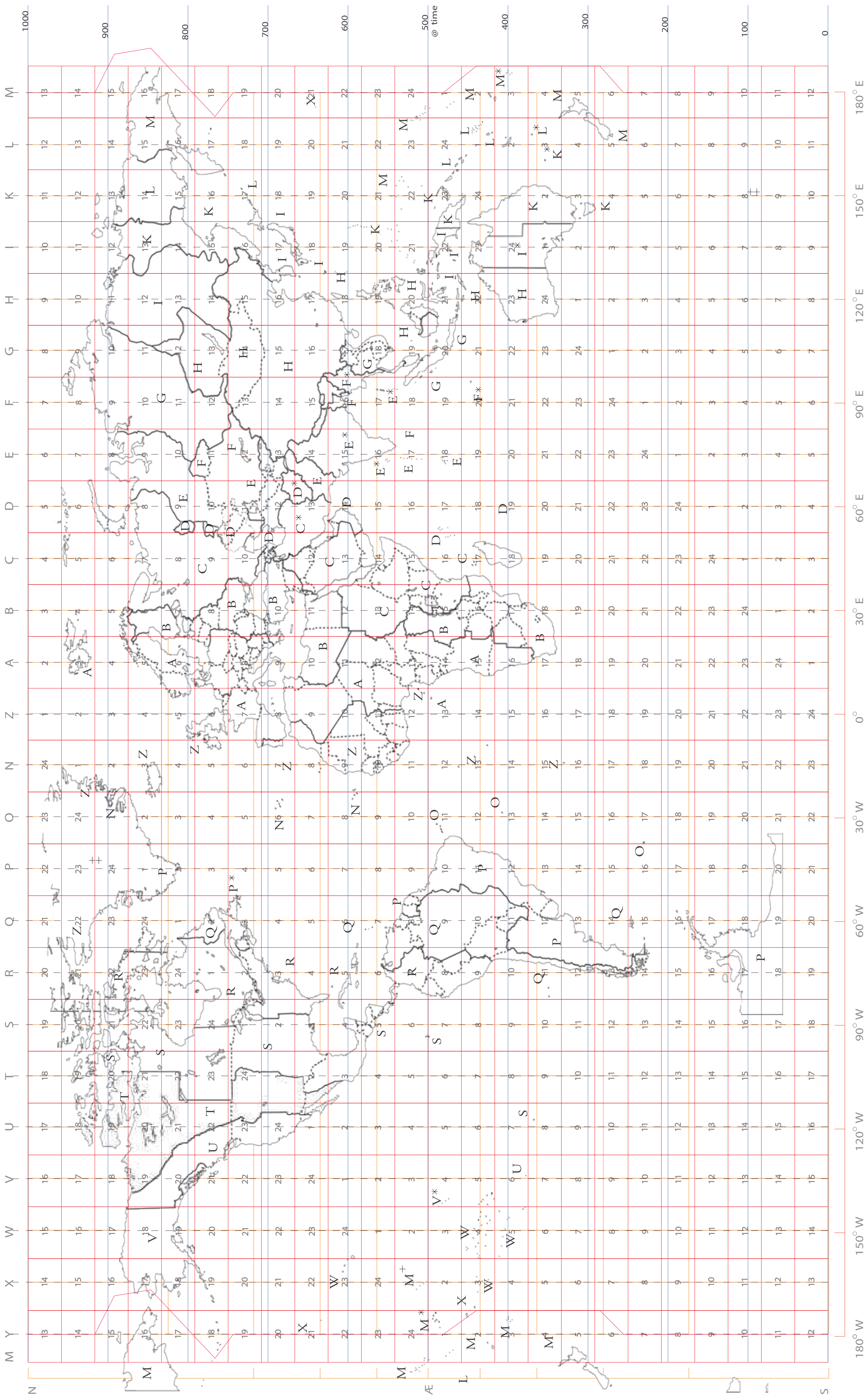
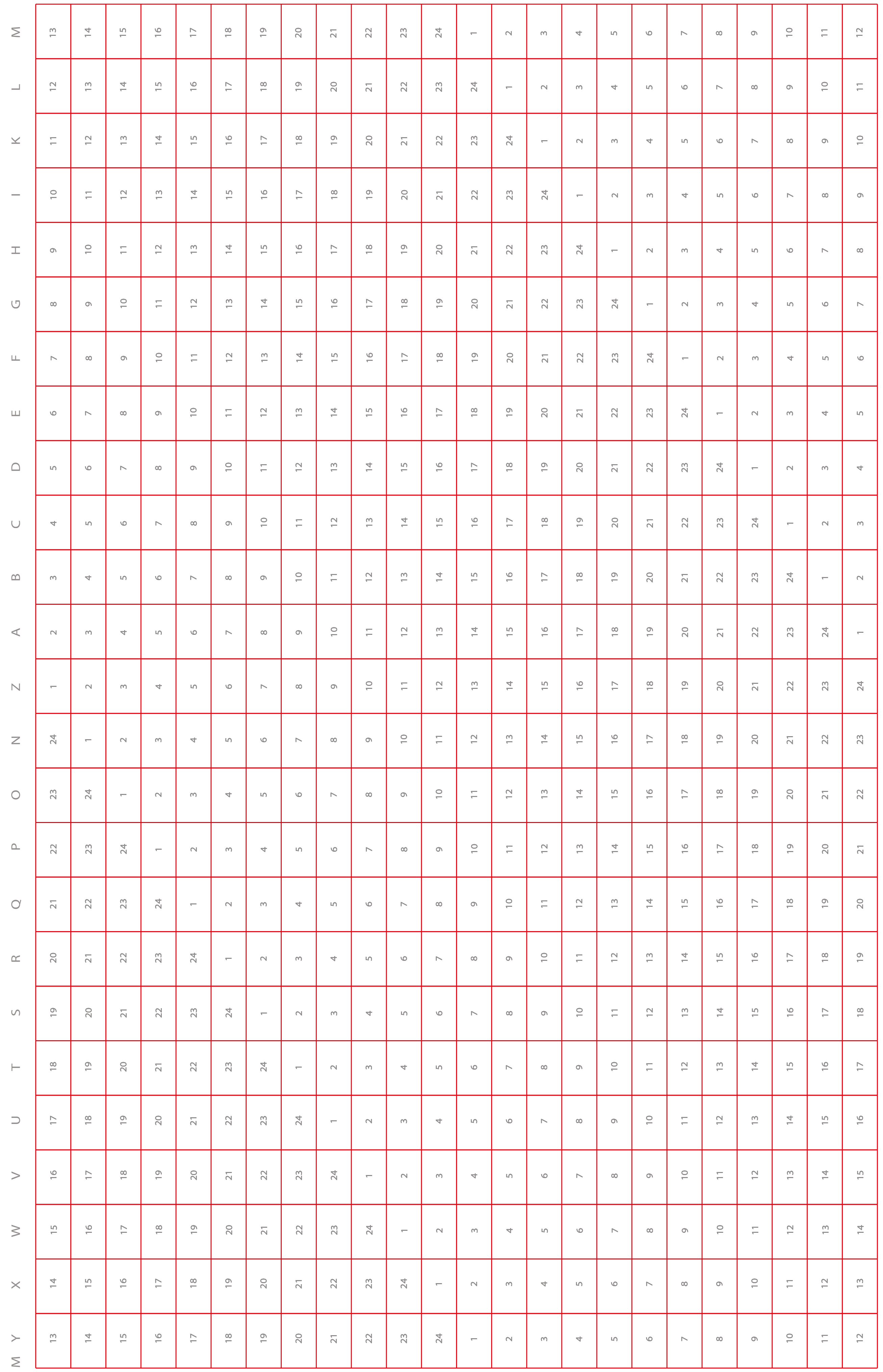


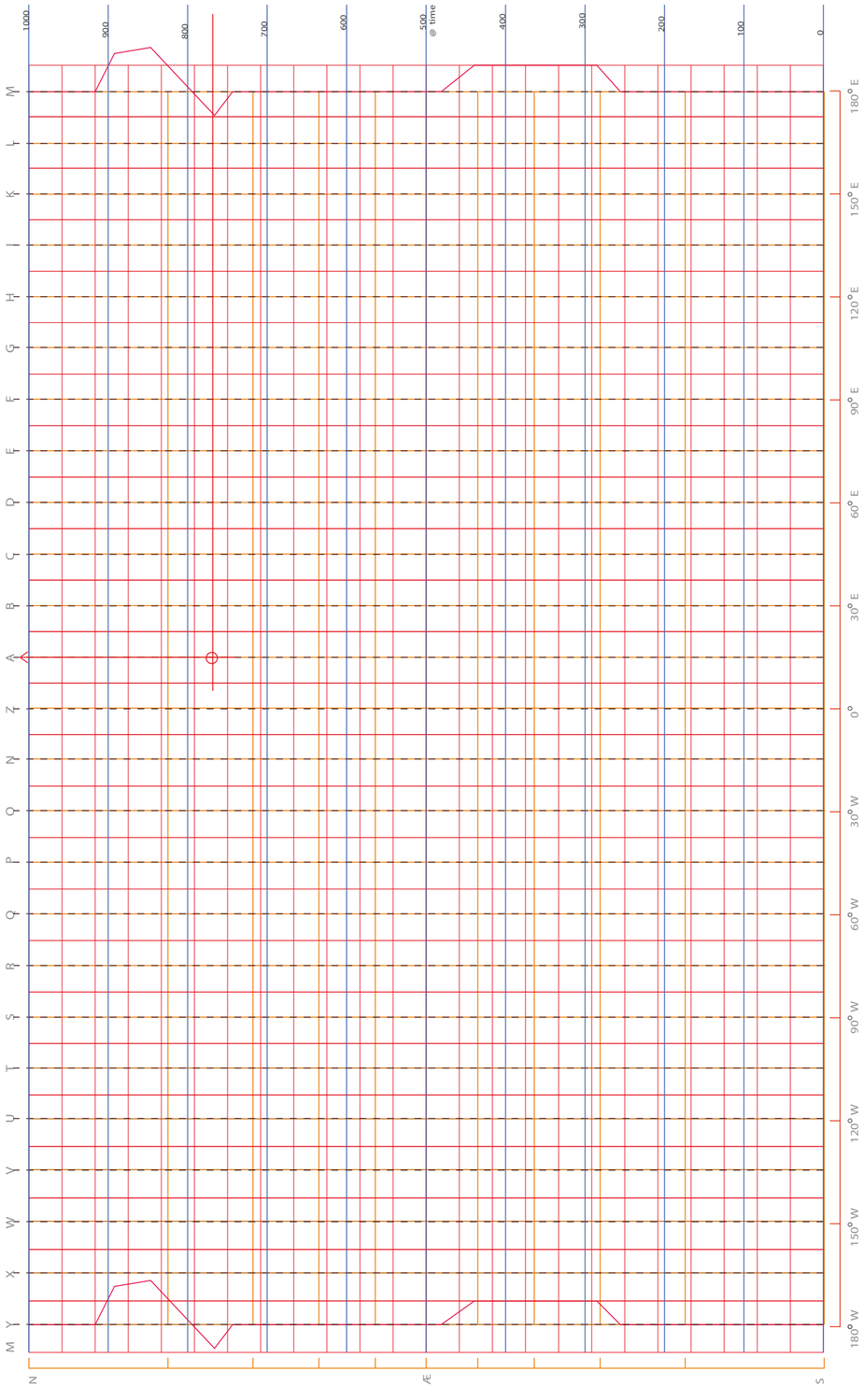
Fig. 5.
World Map of Time Zones. With courtesy of Her Majesty's Nautical Almanac Office (HMNAO).



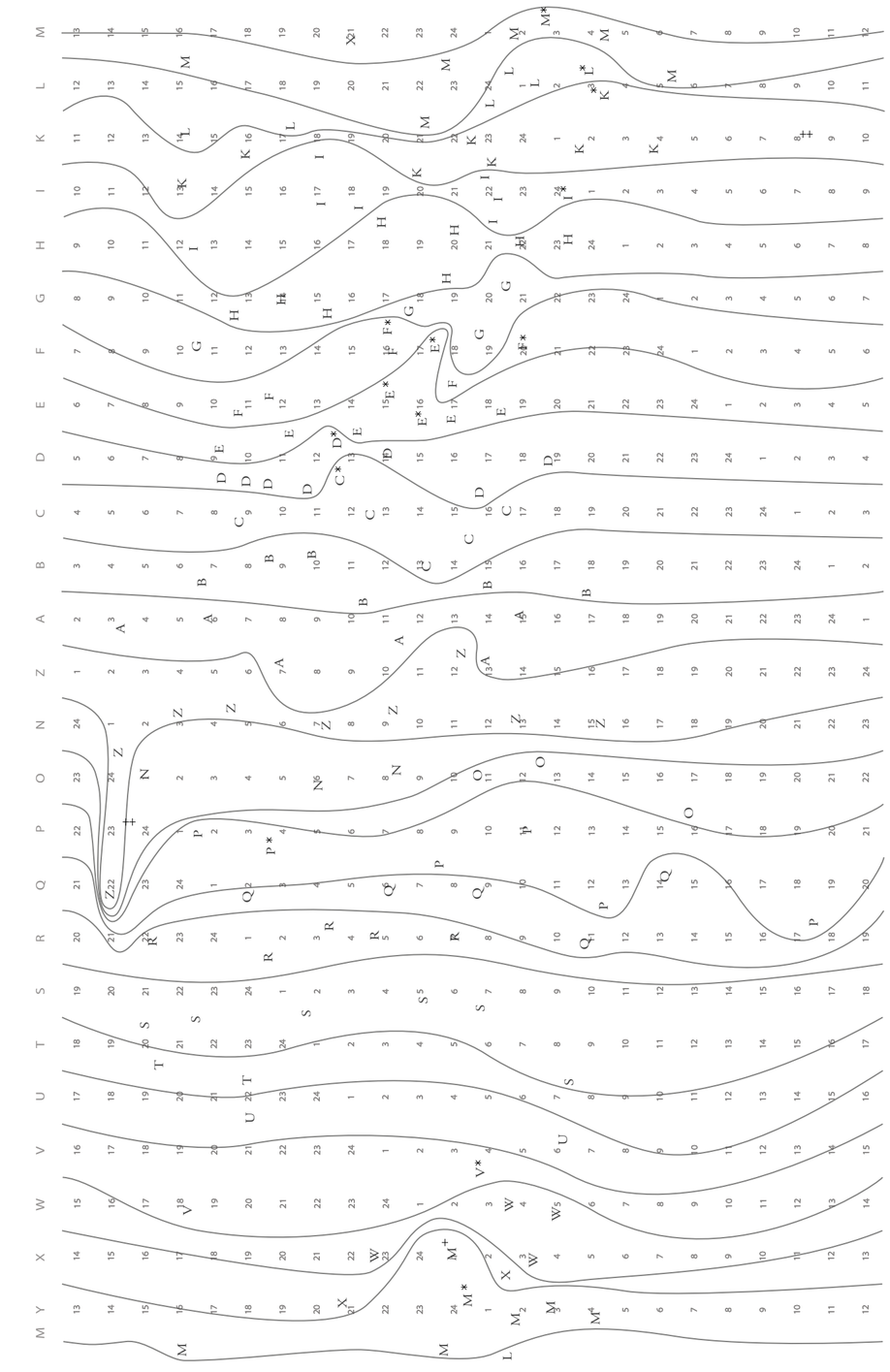
All layers prepared for dissection



Dissected graticule with numbers, counting 24 hours



Graticule of longitude, latitude, clock time and @-time



The timezones shown as numbers and areas

B C D E F G H I K L M

3 4 5 6 7 8 9 10 11 12 13

4 5 6 7 8 9 10 11 12 13 14

5 6 7 8 9 10 11 12 13 14 15

6 7 8 9 10 11 12 13 14 15 16

7 8 9 10 11 12 13 14 15 16 17

8 9 10 11 12 13 14 15 16 17 18

9 10 11 12 13 14 15 16 17 18 19

10 11 12 13 14 15 16 17 18 19 20

11 12 13 14 15 16 17 18 19 20 21

12 13 14 15 16 17 18 19 20 21 22

13 14 15 16 17 18 19 20 21 22 23

14 15 16 17 18 19 20 21 22 23 24

15 16 17 18 19 20 21 22 23 24 1

16 17 18 19 20 21 22 23 24 1 2

17 18 19 20 21 22 23 24 1 2 3

18 19 20 21 22 23 24 1 2 3 4

19 20 21 22 23 24 1 2 3 4 5

20 21 22 23 24 1 2 3 4 5 6

21 22 23 24 1 2 3 4 5 6 7

22 23 24 1 2 3 4 5 6 7 8

23 24 1 2 3 4 5 6 7 8 9

24 1 2 3 4 5 6 7 8 9 10

1 2 3 4 5 6 7 8 9 10 11

2 3 4 5 6 7 8 9 10 11 12

M Y X W V U T S R Q P O N Z A

13 14 15 16 17 18 19 20 21 22 23 24 1 2

14 15 16 17 18 19 20 21 22 23 24 1 2 3

15 16 17 18 19 20 21 22 23 24 1 2 3 4

16 17 18 19 20 21 22 23 24 1 2 3 4 5

17 18 19 20 21 22 23 24 1 2 3 4 5 6

18 19 20 21 22 23 24 1 2 3 4 5 6 7

19 20 21 22 23 24 1 2 3 4 5 6 7 8

20 21 22 23 24 1 2 3 4 5 6 7 8 9

21 22 23 24 1 2 3 4 5 6 7 8 9 10

22 23 24 1 2 3 4 5 6 7 8 9 10 11

23 24 1 2 3 4 5 6 7 8 9 10 11 12

24 1 2 3 4 5 6 7 8 9 10 11 12 13

1 2 3 4 5 6 7 8 9 10 11 12 13 14

2 3 4 5 6 7 8 9 10 11 12 13 14 15

3 4 5 6 7 8 9 10 11 12 13 14 15 16

4 5 6 7 8 9 10 11 12 13 14 15 16 17

5 6 7 8 9 10 11 12 13 14 15 16 17 18

6 7 8 9 10 11 12 13 14 15 16 17 18 19

7 8 9 10 11 12 13 14 15 16 17 18 19 20

8 9 10 11 12 13 14 15 16 17 18 19 20 21

9 10 11 12 13 14 15 16 17 18 19 20 21 22

10 11 12 13 14 15 16 17 18 19 20 21 22 23

11 12 13 14 15 16 17 18 19 20 21 22 23 24

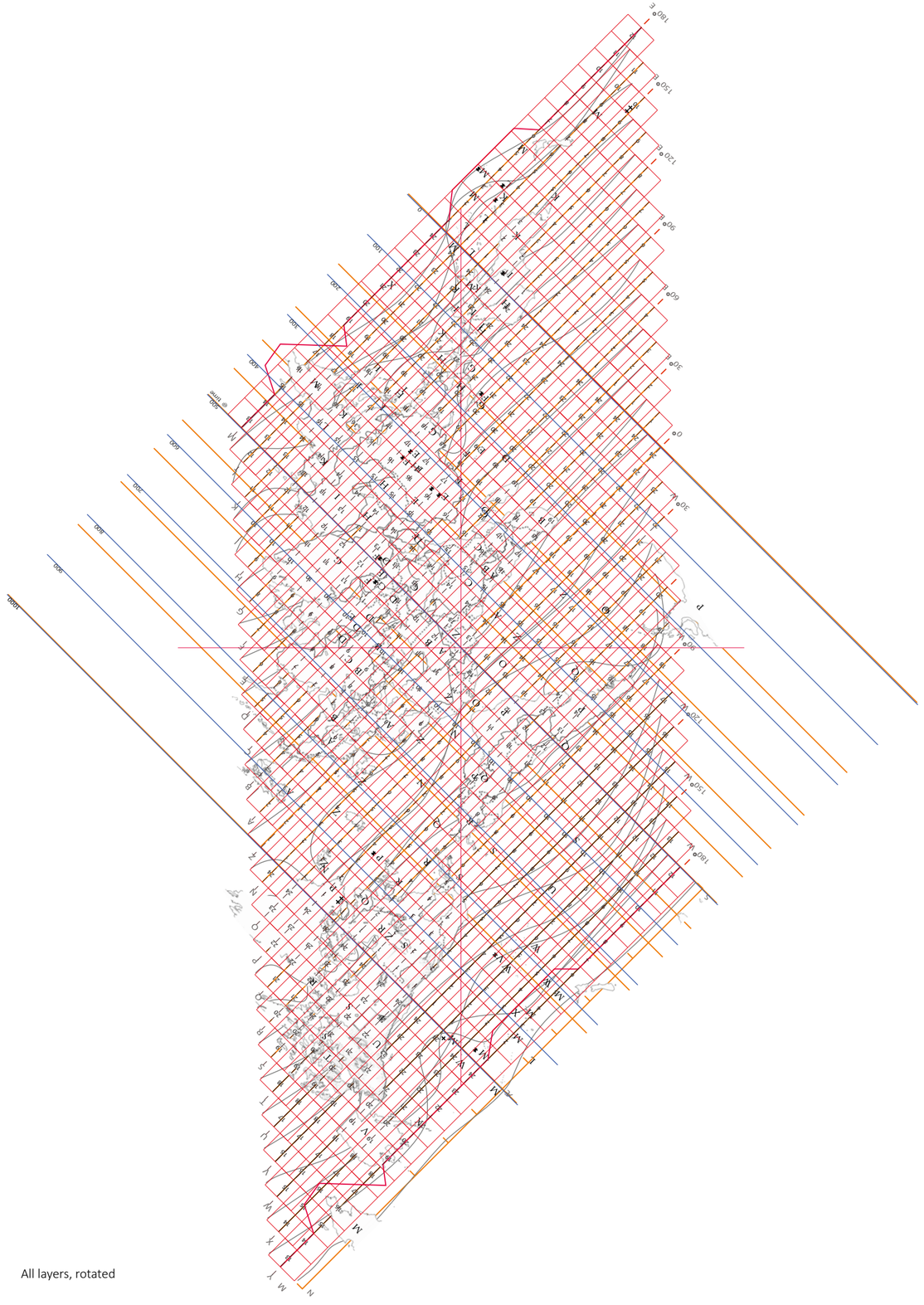
12 13 14 15 16 17 18 19 20 21 22 23 24 1

Layer of landmasses

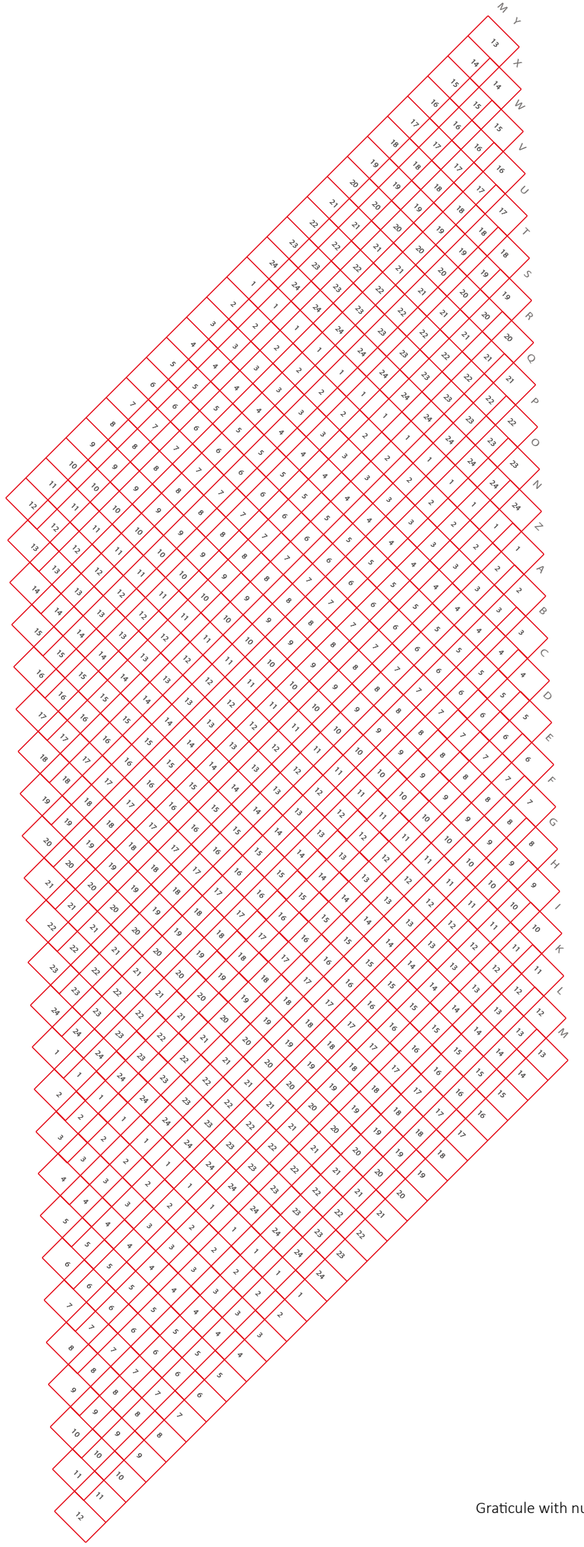
Synchronization (45 degrees rotation)

I wanted to make a translator map that could translate between Universal Time and @-time in the form of a map with rotating parts. I cut the projected image of the earth up into clusters of countries that belong to the same time zone by agreement, and rotated them by 45 degrees, then doing the same with the graticule. A map of time zones does not show what time it is at the outset (it is not a clock) but it shows which countries belong to the same time zone and how the 24 hours shift gradually, so you can figure out when, for instance, to call a friend on the other side of the earth, or how your flight should be scheduled. But by means of a 45 degrees rotation in orthogonal drawing space, geographical time is synchronized to @-time, so it becomes possible to compare Universal Time locally with @-time, and to synchronize to another location. It requires two moves to extract meaning from this game, one rotation for one's own location and one rotation for the location with which the comparison is to made.

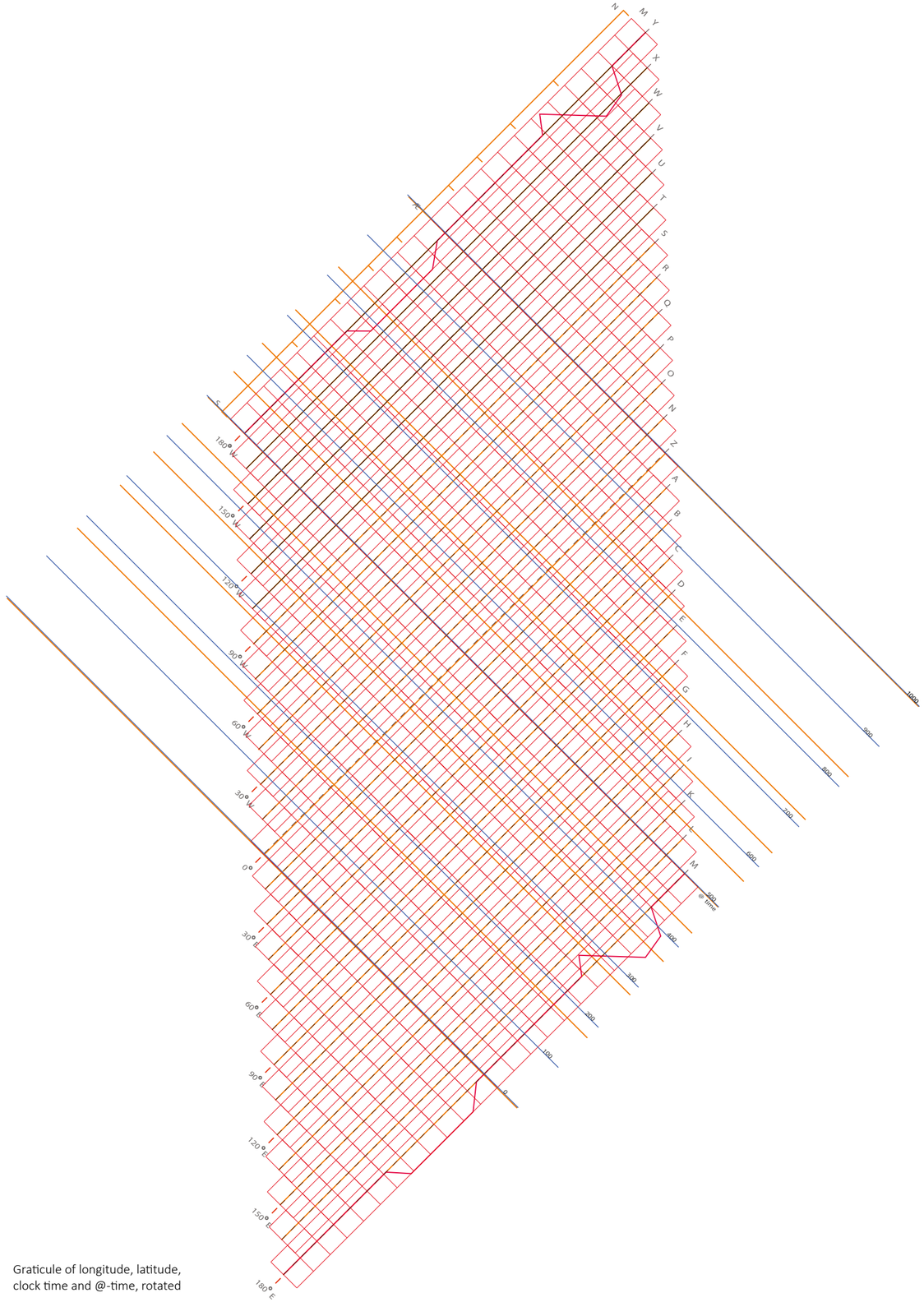
A paper model of the translator map from which I made the drawings. The background image is a topological mapping of the Internet.



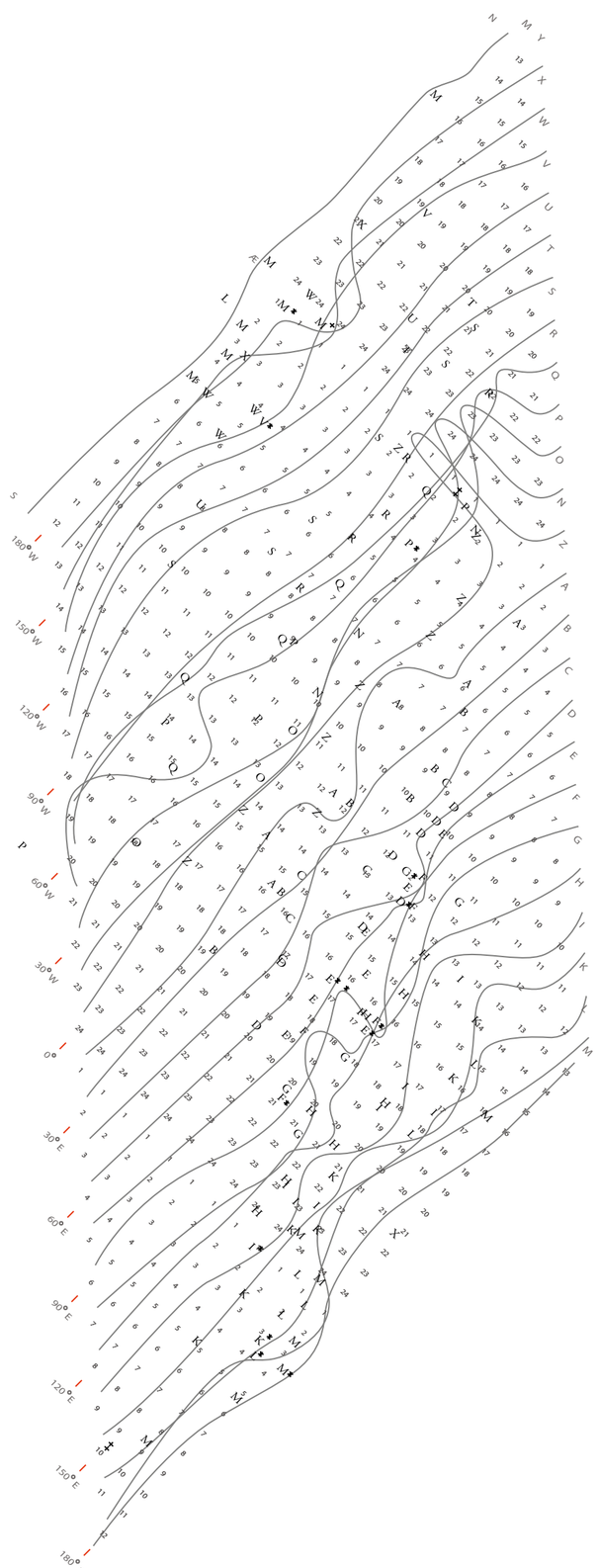
All layers, rotated



Graticule with numbers counting 24 hours, rotated



Graticule of longitude, latitude, clock time and @-time, rotated



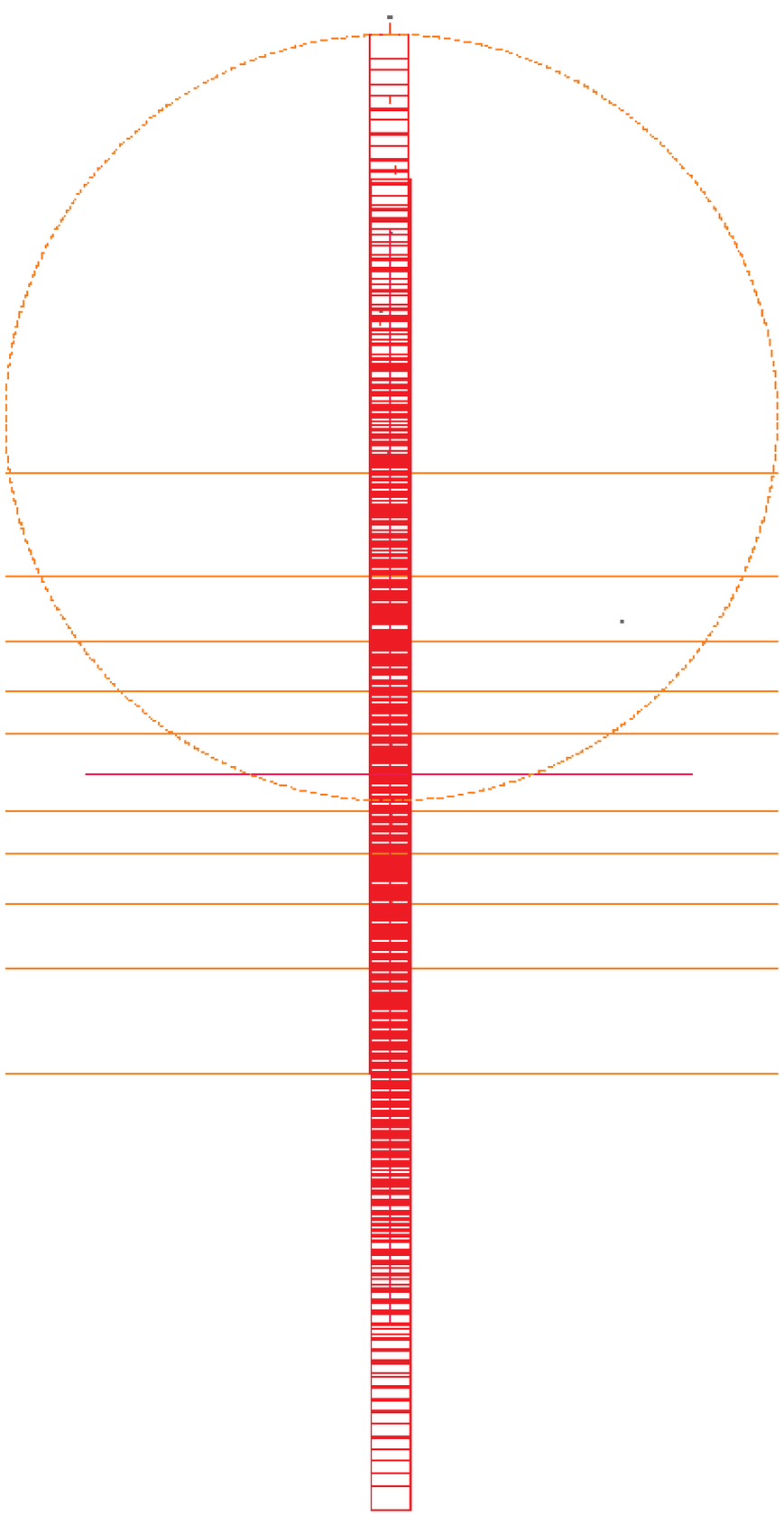
The timezones shown as numbers and areas, rotated

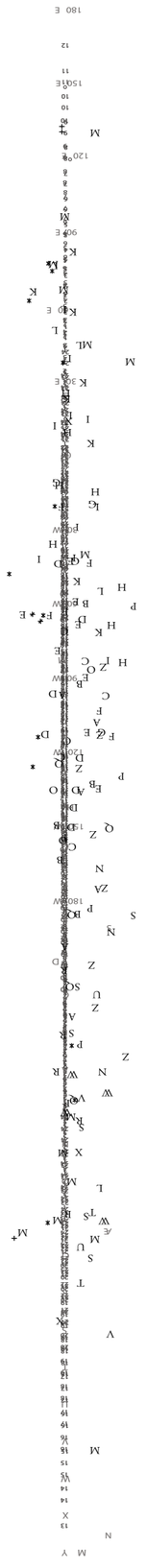
180° W
150° W
120° W
90° W
60° W
30° W
0°
30° E
60° E
90° E
120° E
150° E
180° E

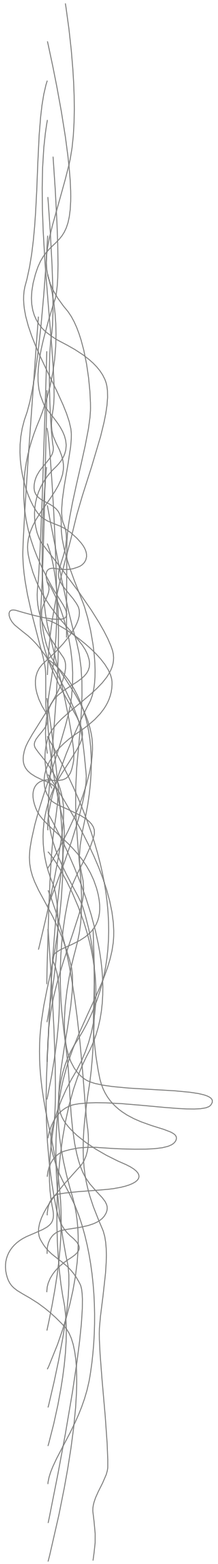
Landmasses, rotated

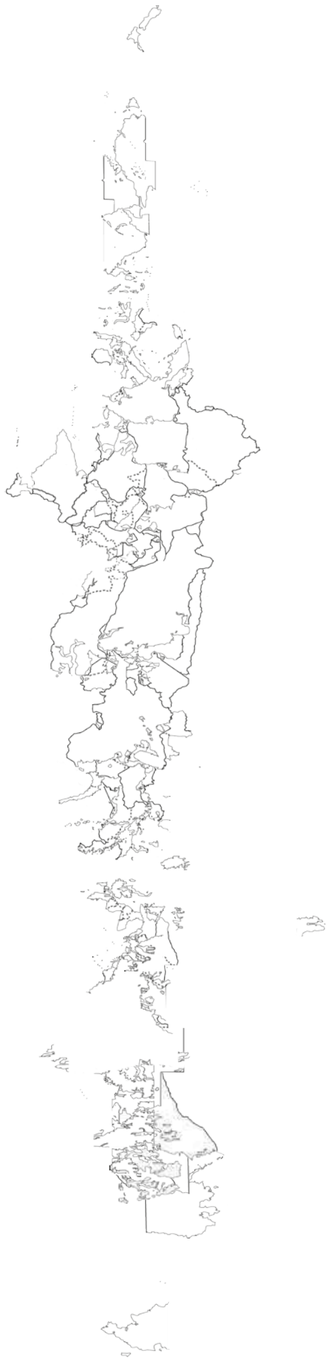
Virtual Pangaea (90 degrees rotation - Collapse)

Bring to mind Stjernfelt's account of Wegener's Pangaea hypothesis which emerged because Wegener had been making a notation of seismic activity on a world map. My last series also plays with the Pangaea hypothesis. It shows the dissected layers rotated by 90 degrees so that the landmasses subjugate completely to the @-time and become simply a line. This is a utopian operation which metaphorically speaking reunites the world's land masses in a 'Virtual Pangaea', where time is master and space is slave.

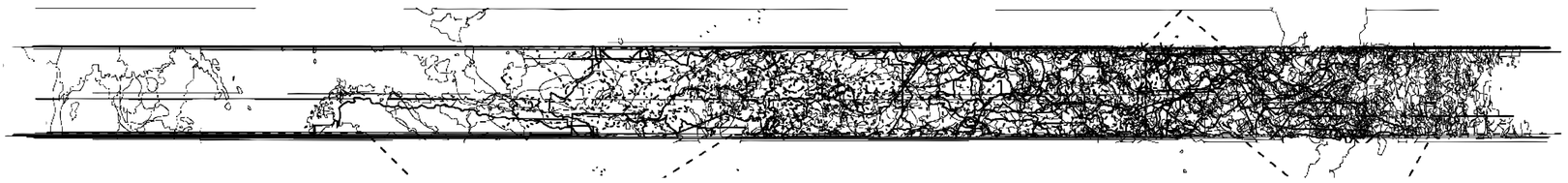


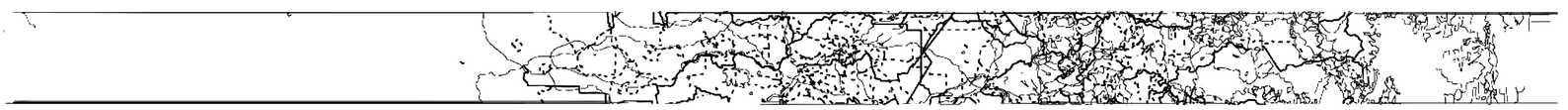


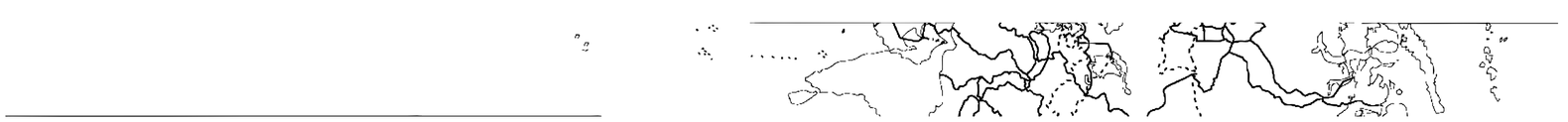


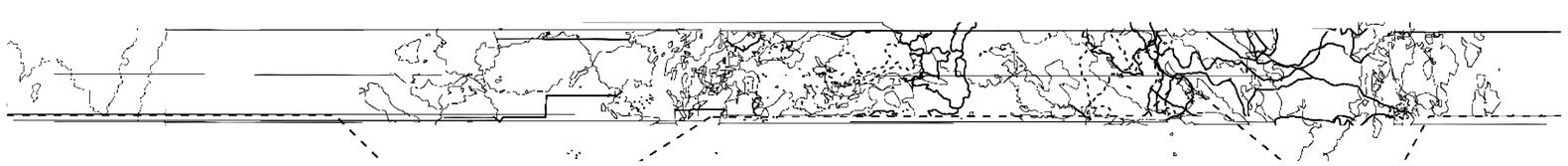


Virtual Pangaea









It is noticeable that architects seldom invent a mathematical mapping projection.[39] Most of the maps that architects work with are already made, and yet architects do at times also themselves make maps. A map must not necessarily have to do with geography; it can be a visualisation of data, a sketch map, etc.. Drawing a plan can also be considered to be an act of mapping, as the landscape architect James Corner puts forth.[40] Mapping does not necessarily mean working with large scale landscape designs, so Corner, but rather mapping is the "agency" of choosing the premises of a site that are important, a negotiation between the mapper and the ground conditions. Therefore maps are always "double-sided,"[41] providing both a top-down view of ground conditions and a possibility to record bottom-up readings of ground conditions.[42] Maps make a double space available to architects for both inventing and orchestrating their project while meeting the ground conditions through calculative frameworks such as scale, grids, and shared notational systems. Corner here speaks of *agency* in quite another sense than Carpo. Carpo opposed agency to "primary authorship," a sort of authorship of the making of the master map, whereas Corner presents agency as a creative condition of making a more situated map of one's own. In Corner's sense, agency is also an authorial mode of working with pre-given conditions by choosing the premises of the project in the making.[43] Corner says that maps are transitional and transformative sites, an undervalued design condition where the premises for further designing are chosen and negotiated: "As both analogue and abstraction, then, the surface of the map functions like an operating table, a staging ground or a theatre of operations upon which the mapper collects, combines, connects, marks, masks, relates and generally explores,"[44] Corner says. Apart from being an assemblage chosen by the mapper, maps in a wider sense can make compressed or dilated information visible and show patterns and events which, in their represented form, themselves become stepping stones for making new maps. Maps are products of choice, preparation, tools, techniques, and projections, and are therefore not neutral, although they are often taken to be so. But Corner describes a more subjective sort of mapping using already existing systems for measuring, folding the general systems and conventions into singular maps as a process of selecting, extracting and assembling anew, an idea of agency which is also taken up by Rikke Lyngsø Christensen in her theory about how the conventions for orthogonal drawing in architecture came into being.

Sketch becomes diagram

Christensen reads the historical cause of events around the becoming of orthogonal drawing through Peirce's diagram and Corner's idea of mapping. She combines Corner's account of mapping with her analysis of sketch sheets by Guiliano de Sangallo and other Renaissance architects who took part in the commission given by Pope Leo X to record the ruins of Rome.[45] They chose between ruins, extracted information, and rearranged this information in sketch sheets – sketch maps so to speak, that followed no particular rules for how the information was to be assembled. Christensen suggests that these sheets indicate a diagrammatic and mapping-like way of sketching, which transgressed an initially more painterly way of drawing with its emphasis on the depiction of light, shadow, surfaces and the like, and eventually became diagrammatic, structural and *suggestive*. Recording the ruins through sketching became a way of putting the recorded information together anew, and the sketches would become suggestive of new kinds of buildings as the antique architecture was rearranged.[46] Hence Christensen captures the transformative role of drawing as both *recording* of the past and *projection* into the future, and in this way the ruins of Rome were reanimated and reborn (renaissance). She describes this as a collective sketching process amongst several architects, which at first did not have any drawing conventions. There was not consensus at that time in the early Renaissance on *how* to draw.[47] The field was, so to speak, unstable, animate and open, and the ruins provided rich epistemic potential for the architects to extract and rearrange on their sketch sheets, which amounted to diagrammatic, map-like configurations. The sketches started as "local maps" but, from the 15th century to the 16th century the drawings became more and more linear – line drawings – Christensen notices, indicating an emphasis on structure rather than a painterly way of drawing with emphasis on haptics, light, and shadows.[48] Thus Christensen traces a shift from pictorial/mimetic drawing to structural, diagrammatic drawing.[49] Earlier in the process the sketch sheets appeared open to multiple readings,[50] while later on they converged towards a more stable, schematic condition with clearer reading rules. Christensen sees this as a diagrammatic process as in Peirce's diagram.

> Exactly because the diagram blots out all details, ornaments, and superfluities and cuts into the crux of matters, it is easier for the consciousness to focus on the decisive properties of that which is being represented. And, because the diagram thereby also can be grasped as a vague representation, it has a flexibility which allows for transformation and production.[51]

Thus Christensen explains the historical events with the double conditions of Peirce's diagram[52] being both a way of thinking about and structuring what already is, the ruins, as well as a way of opening up that which already exists in order for new designs to be made.[53] With Corner, Christensen furthermore conceptualizes these sketch sheets as an agency of mapping where existing building elements are extracted from the field, organized, and resituated.[54] These developments in the sketch sheets happened at the

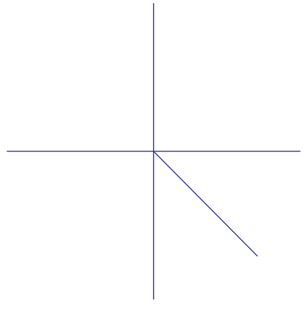
same time as plan, section, and elevation become conceptualized as a joint concept and Christensen suggests that the activity of making the sketch sheets could be the germ that led to the development of the joint use of plan, section, and elevation,[55] which then became the convention, the shared general diagram. But as opposed to Carpo, who ascribes the invention of orthogonal drawing solely to Alberti, Christensen's account of the cause of events is that many architects invented a diagram together. In this regard she emphasizes Raphael's letter to pope Leo X (1519).[56]

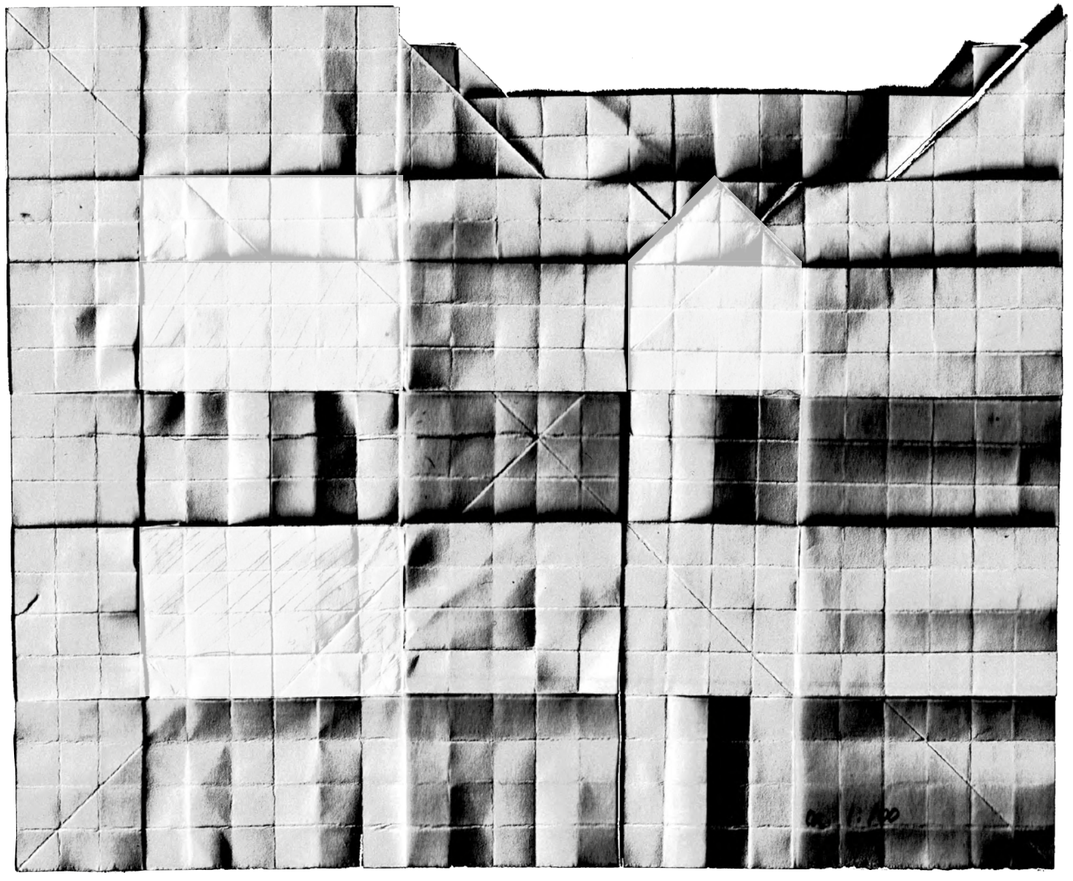
> …then Raphael suggests that the drawing is divided in three: the first part is the ground plan, the second part ought to show the outer wall (elevation) and the third part is the inner (section). It is through this tripartite division that the spatial form of the architecture can be represented on the surface. In the letter Raphael states that the tripartite division must be seen as a unity, so the three ways of drawing in combination represent the building as a whole. The tripartite division shows three points of view upon the building, as it is presented from the top (plan), front (elevation), and directly through it (section).[57]

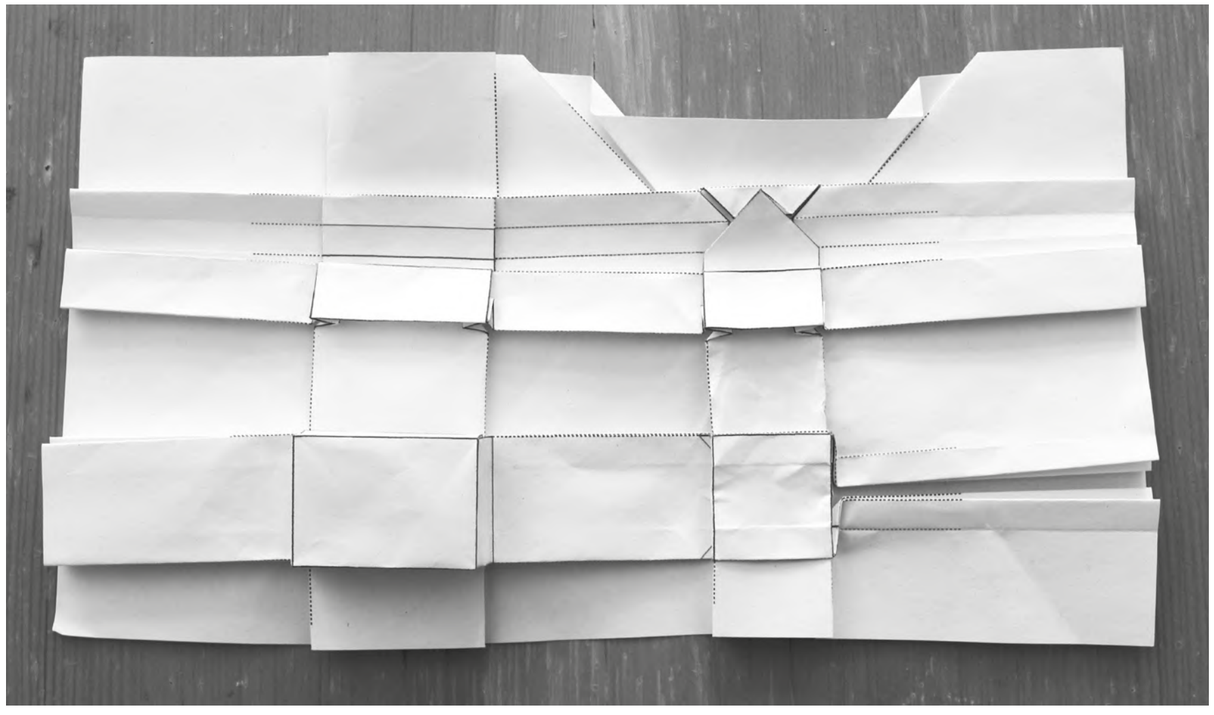
Christensen thus gives an account of the becoming of drawing as a convention which is much more related to an *agency of becoming* informed by the matter at hand (the ruins) being rearranged and abstracted. This happens as a socio-cultural process carried out by several different architects around the same time, and amounts to a more stable condition using the three particular kinds of orthogonal drawing together. Christensen's reading of the historical events also emphasizes the diagrammatic character of architectural drawing; i.e. how its projective space emerged. This can be seen in the light of our current state of affairs, where drawing is again in a process of change but in another role. The conventional drawing makes up a foundation, a projective, calculative framework that architects work and think with, and still it is open to transformation itself, as is any diagram. In the state of the arts chapter, I argued that the field of architectural media use is animate and more complex now than before the computer. Compiling an architectural working media, it was argued, is a subjective process which co-forms the architecture one wishes to make, and, when this is taken in this broader sense, making a map, making a medium, or making a theory are all procedural spaces where relations are arranged and connected in new ways, and I argue, although the technical equipment changes and opportunities widen, these spaces remain diagrammatic, now as before.

ORIGAMI DRAWINGS

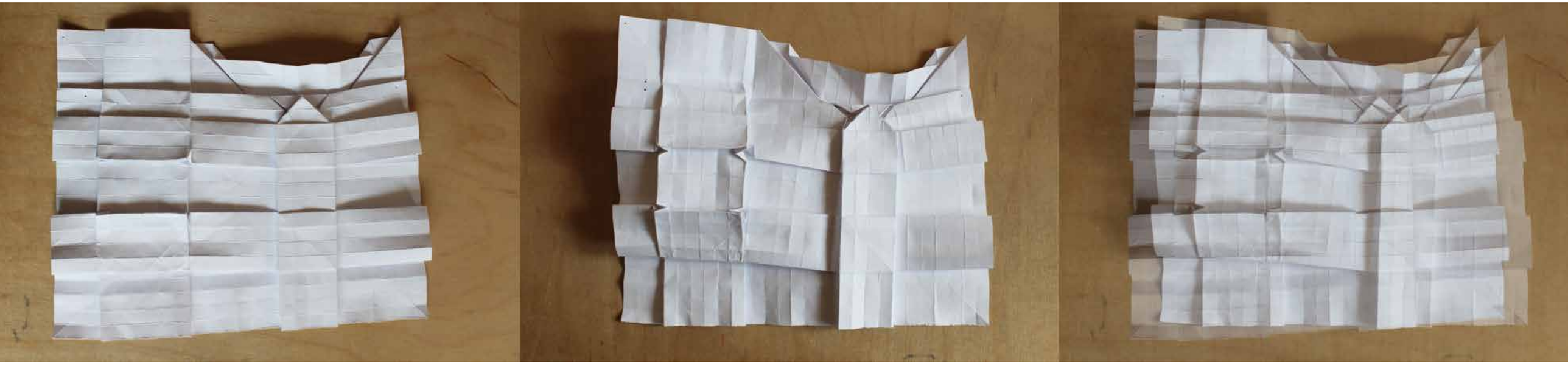
These drawings or rather paper foldings are attempts to fold orthogonal projection: to fold the orthogonal diagram in the typical tripartite layout with plan and two elevations or sections. This is of course not possible – a motif or object to depict is needed. The foldings are made with one of the origami artist, Eric Gjerde's tessellation techniques on the basis of a pre-creased grid.[58] The technique was adapted to describing a house in plan with two elevations. If the motif of the house were removed it would not be possible to show the orthogonal diagram, nothing would get caught in its web of projectors.
As opposed to a conventional drawing that describes objects outside its own space, an origami diagram describes objects embodied in the very paper on which it is drawn. The pattern of an origami folding is a way of endowing the paper with memory through mountain and valley folds. The origami diagram works with an abstract relation, the folding diagram, and a concrete relation, the paper, at once. The origami diagram was a way of 'coding' the paper to adopt the desired form; to endow it with memory.

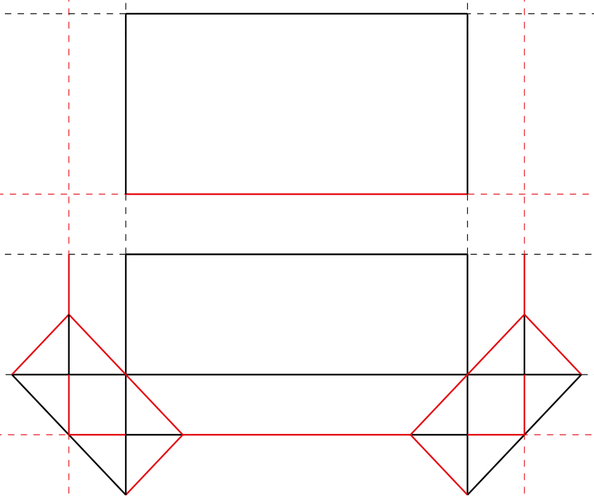


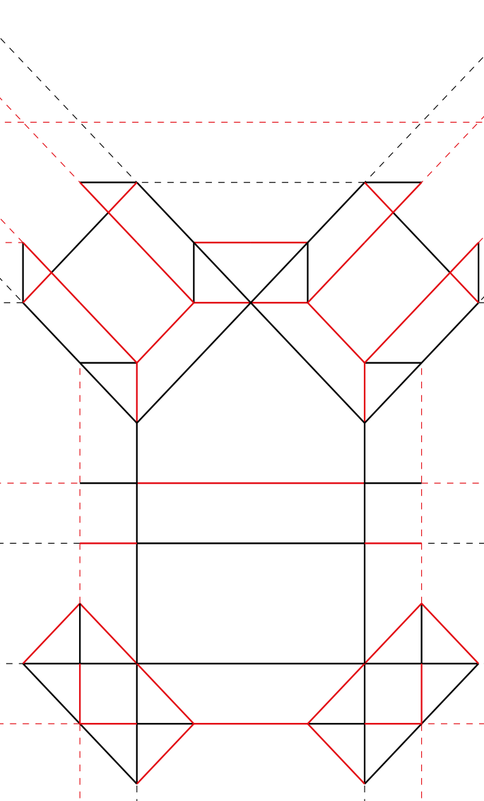


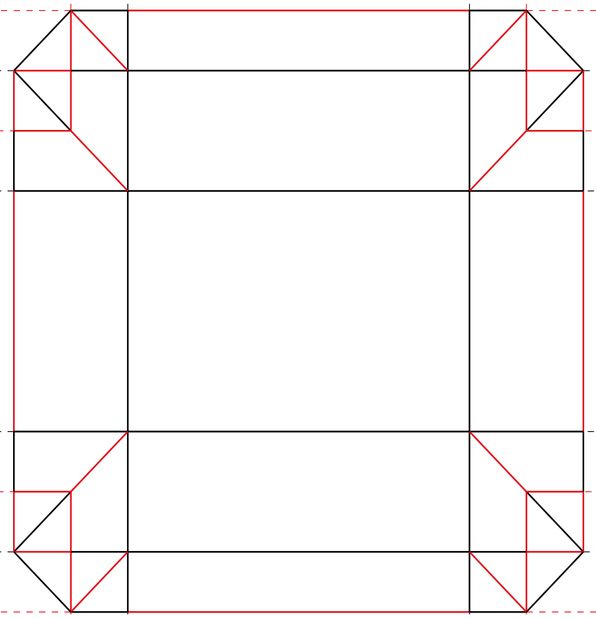


Here are two slightly different foldings of a house in plan and two elevations. The folding on this page is more three-dimensional, - you faintly see how one of the elevations is rising up from the paper as a box.









The folding pattern:
black lines = mountain fold
red lines = valley fold

Notes - Media Mutations I: How Conventions Come into Being

[1] http://www.merriam-webster.com/dictionary/medium (accessed 11.11.2015)
[2] I have also argued this in the paper "Sketches and Diagrams," currently in the process of publication.
[3] http://www.merriam-webster.com/dictionary/mutation (accessed 11.11.2015)
[4] David Turnbull, "Tricksters and Cartographers: Maps, Science and the State in the Making of a Modern Scientific Knowledge Space," *Masons, Tricksters and Cartographers,* (Abingdon: Routledge, 2000, repr. 2003) 89 - 129.
[5] Ibid., 92, 94-7.
[6] Ibid., 95.
[7] Ibid., 142-7.
[8] Ibid., 113. Turnbull refers to James Burke, *The Day The Universe Changed*, (London: BBC, 1985).
[9] Denis Wood, Ward L. Kaiser, Bob Abramms, *Seeing Through Maps*, (USA: ODT Incorporated, 2001), 7.
[10] One example that Turnbull gives is that America was not discovered by Christopher Columbus; that this claim is a retrospective, social construction. Not only were people already living in America, others such as the Vikings and the Basques had probably discovered America earlier on, and, finally, that Columbus believed he had found China. Turnbull, "Tricksters," 144.
[11] Ibid., 89, 105.
[12] Ibid., 105-10.
[13] Ibid., 119-20. Turnbull refers to J. Revel, "Knowledge and Territory," *Science in Context*, vol. 4, (1991): 133-61.
[14] Ibid., 121.
[15] Ibid., 121.
[16] Ibid., 99.
[17] Ibid., 135-40. One example of an alternative knowledge space given by Turnbull is that of the Pacific islanders and their way of navigating.
[18] Ibid., 99.
[19] Cf. Corner, "The Agency of Mapping," 217-21.
[20] Wood, Kaiser, Abramms, *Seeing Through Maps*, 4.
[21] For a list of different projections: https://en.wikipedia.org/wiki/List_of_map_projections (accessed 29.01.2016).
[22] Corner, "The Agency of Mapping," 217-18.
[23] Wood, Kaiser, Abramms, *Seeing Through Maps*, 8.
[24] Wood, Kaiser, Abramms, *Seeing Through Maps*, 11.
25 Wood, Kaiser, Abramms, p. 7
[26] Gene Keyes, http://www.genekeyes.com/FULLER/BF-2-1943.html (accessed 29.01.2015).
[27] To develop a surface in descriptive geometry is both to fold out a two-dimensional plane into a three-dimensional space, as in origami, and to fold out the adjacent surfaces of a three-dimensional body so that all its faces can be shown on a flat plane without distortion.
[28] Richard Buckminster Fuller, *Operating Manual for Spaceship Earth*, new edition 2008, ed. Jamie Snyder (Switzerland: Lars Müller Publishers, 2011).
[29] Werner Kinnebrock, *Was macht die Zeit, wenn sie vergeht?* (München: Verlag C. H. Beck, 2012), 95-96.
[30] Ibid., 34-35.
[31] Latitudes divide the globe in north-south direction; Equator's latitude is 0°, the northern Pole' 90°. Longitudes divide the globe in East West direction. One degree is divided into 60 minutes and each minute into 60 seconds.
[32] Kinnebrock, *Was macht die Zeit*, 34.
[33] Ibid., 34-39.
[34] Ibid.

[35] Ibid., 34-35.
[36] http://aa.usno.navy.mil/faq/docs/UT.php (accessed 22.11.2013).
[37] http://da.wikipedia.org/wiki/Swatch_Internet_Time (accessed 11.01.2016).
[38] Of course servers are placed around the world, but I mean the internet as a digital matrix.
[39] With exceptions like Buckminster Fuller's *Dymaxion* map.
[40] Corner, "The Agency of Mapping."
[41] Ibid., 214-15.
[42] Ibid., 213.
[43] Ibid., 216.
[44] Ibid., 214-15.
[45] Rikke Lyngsø Christensen, *Mellem Fund og Fremtrædelse, Tegning som Undersøgelsesredskab i Renæssancens Arkitektoniske Praksis*, 2013, 4-7. The article is published online: http://www.sbi.dk/arkitektur/generelt/at-give-arkitekturen-ordet/RikkeLyngsoChristensen.MellemFundOgFremtraedelse.pdf (accessed 11.01.2016).
[46] Ibid., 2.
[47] Ibid., 3
[48] Ibid., 5.
[49] Ibid., 6.
[50] Ibid., 9.
[51] Ibid., 7, my translation.
[52] Ibid., 14.
[53] Ibid., 7.
[54] Ibid., 11.
[55] Ibid., 13.
[56] Ibid. 12. Christensen refers to Francesco Paolo Di Teodoro, *Raffaello, Baldassar Castiglione e la Lettera a Leone X*, Bologna 2003 (1st ed. 1994).
[57] Ibid., 12, my translation.
[58] Eric Gjerde, *Origami Tessellations, Awe-Inspiring Geometric Designs*, (Boca Raton, London, New York: CRC Press Taylor & Francis Group, 2009).

MEDIA MUTATIONS II: ANIMATIONS AND MUTATIONS

Introduction to the chapter

This chapter discusses orthogonal projection as part of an architectural medium in more depth, now that the historical context of the conventions of architectural drawing has been briefly described. Whereas Christensen looked upon the emergence of orthogonal architectural drawing as a collective sketching process, Evans has scrutinized Piero della Francesca's orthogonal drawing of a human head, a drawing which, Evans argues, is the first recorded orthogonal projection. In this account Evans focuses less on the historical context and more on the relations that the orthogonal drawing enters into, firstly when it was made, and secondly when it was received. He shows how there are different kinds of *animation* at stake – one between the maker and the drawing, and one between the drawing and the receiver. I then proceed to the present time and consider the change from a pen and paper-led drawing space to a computer-led one, where I argue that that orthogonal projection is still a co-forming agent in architectural design, indeed an *agency of observation* coming from conventional drawing, which has moved into the computer. But before I proceed, some clarifications of the terms tool, technique, and technology are made, since the terms are used in this chapter.

Tool, technique, technology

I describe the differences between tool, technique and technology with concepts from philosophy in relation to drawing and architectural media. These terms are sometimes used interchangeably but usually describe a means to an end. A drawing *technique* can be seen more as a procedure than a tool: for example when drawing a plan, section, or elevation, and following the applicable conventions. As a relatively pre-planned procedure, the technique should lead to a result where the drawing is internally coherent and can be understood accordingly. A conventional drawing *technique* is supported by *tools:* rulers, squares, circles etc.. These tools make it easier to execute the technique. A technique is more of a procedure, whereas a tool is more of a physical instrument, but the two are mutually dependent.[1] However, when computers are used for design, a distinction between tool and technique cannot be outlined so easily. The computer is part of a larger technological development; it is a machine which cannot be easily defined as either tool or technique, but rather as a complex of systems – hardware and software – that work together in instrumental and technical ways. If one asks, *where does 'the computer' stop*, it would be very difficult to answer exactly where, because it is

part of communication systems which effect human behaviour in many different ways. On an instrumental level, during a design process the computer is linked up with other instruments and tools for receiving input and giving output, i.e. with technical equipment and procedures arranged in different networked ways. When used for design the computer thus becomes situated in a practice and is used in subjective ways as working medium. Because these terms, including 'the computer', involve extensive definitions on an instrumental level, I approach them here on a meta-level through philosophers such as Heidegger and Foucault. Heidegger – in particular as he is read by Bertram in relation to architectural media – together with the physicist and feminist theorist, Karen Barad, argues that natural-scientific techniques and technologies cannot be seen as separated from the social field in which they operate.

As I have mentioned in the chapter *DRAWING REASONING I,* art and science practices share the use of technical equipment. Diagrams and techniques are also shared phenomena between such practices. However, according to Bertram, a *technique* is both different from a *method* and from *technology*.[2] Technique differs from technology in the sense that technique is closer to the world as it is, being heterogeneous and dynamic in its material constitution. Technology, on the other hand, only works when the material of the world is homogenized and adapted to the technological system. Techniques, so Bertram, can be used to probe and examine heterogeneous milieus: complex environments where everything is characterised by being different. Whereas techniques in this sense can work in non-homogenized milieus, technology cannot. Technological procedures require that the material has been homogenized, or put into an overarching, frictionless technological system.[3] Technology is often thought of as being digital, but, as Bertram points out, analogue tools set into systems, as they were during industrialisation, are also technology. Hence, one cannot say that techniques are analogue and that technology is digital, although that may be a tendency. Indeed, digital techniques and analogue technologies can also exist. Even though one tends to think of technology as digital, and technique as analogue and having more to do with craftsmanship, Bertram states that the real difference between technique and technology is in their approach to the world. Approaching the world with techniques is to see the world as a material condition that carries differences within itself.[4] Bertram derives this point from Heidegger's *The Question Concerning Technology,* and on this basis what distinguishes technique from technology is not simply the technical equipment used – the tools, the hardware – but how human beings approach the world. A technological approach to the world is to view it as *energy source* and *available* resources,[5] where as a technical approach – *techne* in Heidegger – is pointed out as an alternative approach, where the world may indeed be transformed and things (pieces of art) may be produced, but the approach to the world is different, since all the differences come from the world, and the techniques can be used more singularly and in a less overarching manner in transformative processes.[6] To use technical equipment in order to approach a world of differences in a design process can become productive and animate, but the animate condition comes from the differences in the world and not from a technological system, Bertram argues. Hence techniques, rather than technology, allow for all joints and entities in a production apparatus to be different, whereas technology homogenises joints and materials. This could seem to infer that technique is good and technology is bad, but I would like to emphasize that no matter whether we subscribe to this distinction between technique and technology, technical ways of working are not neutral constructs that we control completely. Rather they are always interwoven in any particular situation, and correspond to various world-views. Technical developments work 'back' on us and impose changes in our behaviour and environment, just as much as we use the technical to achieve changes. As with maps, which can also be technical instruments, techniques are co-forming agents. As the philosopher Anders Fogh Jensen says with reference to Foucault, "[…] the same technique can have different purposes, different rationality. Technology is the use of technique with a rationale, a meaning and a purpose."[7] Jensen says that the human rationales for using technique and technology are changeable, for which reason new technologies come into existence. Just as Evans pointed out, drawing techniques are not neutral constructs that simply transport information, they also enlarge what can be imagined; and Jensen echoes this for technology too. In a design process, for example, the whole interaction between ideation and technical things is mutually productive. Therefore, to revert to Allen's phrase: "[t]echnology, Michel Foucault reminds us, is social before it is technical"[8] and for architects who use tools, techniques, and technologies to materialize the world, the dialogue with the social field is at the heart of how working media are compiled.

The complex thing here is that, whereas techniques and technology might indeed be used in relation to different rationales, technique and technology are 'themselves' *not* for that reason neutral. Looking at this point with respect to conventional drawing, Evans give a very precise observation of how a drawing is suggestive and non-neutral, bringing an effect with it almost without one noticing it.

> Five minutes at a drawing board will convince anyone unfamiliar with the technique that this is the way things have to be set out. The instruments at your disposal will lead you to produce frontal pictures of the several sides of boxes as soon as you have gained the slightest idea of what you are doing. It is easiest to deal with the three types of drawing if they are perpendicular to each other, and it is easiest to align the principal surfaces of an object with the surfaces on which it is drawn; in consequence, a building will be a box in a box of pictures.[9]

He points out the importance of *easiness* – which is caused due to the correspondence between the tools, techniques, and the idea of a house having angled corners. It is much easier to draw an object with techniques and tools that support the technique and support what one wants to draw, than if one tries to draw something with tools and techniques that do not support the idea.[10] In the latter case one might have to develop new tools and techniques, and here one's imagination pushes back or enquires what certain tools and techniques can offer, and reminds us that tools and techniques can be tweaked and developed.[11] Hence, this aspect of easiness also becomes suggestive of how one uses drawing technique to draw buildings, and – this is at the heart of Evans arguments – therefore the house tends to slip into the 'form of' the drawing technique. On the other hand, the orthogonal techniques above was developed in order to draw building (cf. Christensen), so the techniques have themselves also been shaped by ideas of how to build. For this reason, when one uses a conventional architectural drawing technique, one already taps somewhat into building, simply because the techniques are 'designed' for drawing buildings. This is also why one can imagine that a similar confluence between building and computational techniques could, at some point in time, be pointed out. The idea of a 'push back,' a mutual effect between the material world, the technical equipment, socio-cultural situations, and, not least, thoughts and imaginations, is coined by Evans, who also points out that effects created by certain techniques can be oblique, unintended, and indirect.[12]

> In architecture, technique and effect do not stand in a simple causal relation. Neither is determined exclusively by the other. Sometimes a technique will produce unexpected but desirable effects; sometimes, […], the desire for a particular effect will impose on technique, demanding of it more than it can easily deliver.[13]

This 'push back' is also one of the reasons why it is possible to talk about techniques and technologies as *animate*;[14] they have their own constitution that animates the imagination and desires of life, but are also themselves subject to evolution.

ORTHOGONAL DRAWING ANIMATIONS

An example of a *non-causal* relation between a technique and its effect is traced by Evans in the earliest orthogonal drawing made by the Italian Renaissance painter Piero della Francesca. Piero's drawings of a human head are the earliest record of an orthographic drawing, so Evans.[15] Piero called the orthogonal projection a sort of perspective, but Evans finds out that it is what we would call orthogonal projection today, and hence different from the linear perspective of Alberti. Evans names Piero's orthogonal projection "the Other Method"[16] since at the time it figured as an alternative to Albertian perspective. The Other Method is a kind of parallel projection without any overarching vanishing point.[17] The method starts from a recording of some object, in this case a person's head. A person would be standing still while being measured with a disk-like instrument (a *finitorium*)[18] that was placed on the top of the person's head with a pointer that could record positions in space.[19] Key positions of the head could be measured and notated as coordinates in a drawing, and the recorded points were then joined in outlines. Several sections were laid on top of each other, describing the head from the top to the neck, thus making up what is effectively an early 3D scanner.[20] The ingenuity of the Other Method's way of handling projection without a vanishing point was that the recording of one position could yield drawings of other positions of the same object by way of ancillary projections. One recording of an object could be made and then the object could be *moved around* or one could 'orbit' it.[21] Thus the drawing could be almost film-like in character, that is, amounting up to a sequential way of showing changes in an object's position, like an early sort of animation technique describing key frames.

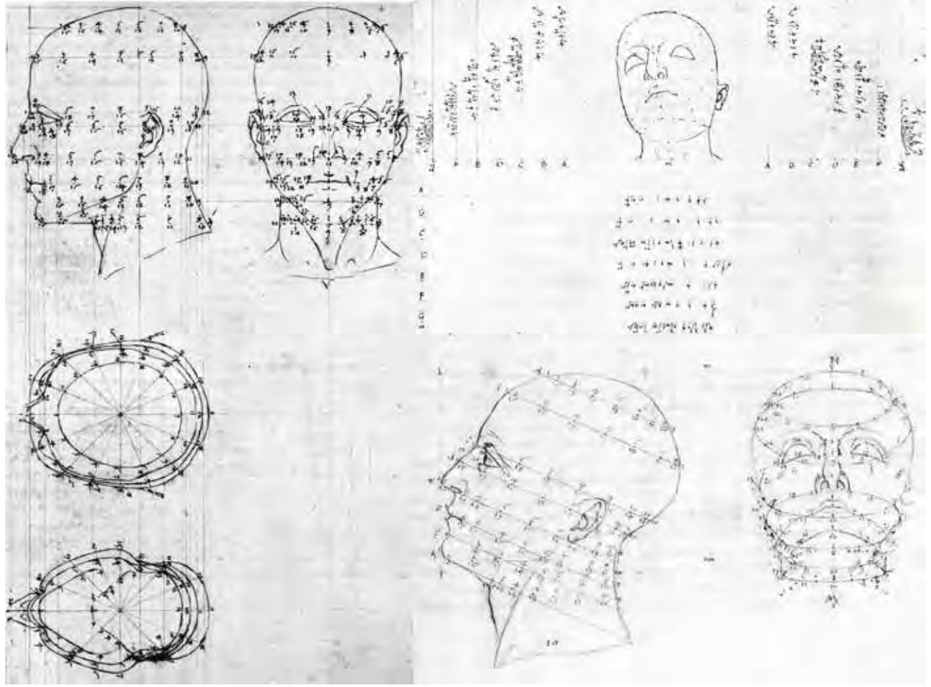


Fig. 6.
Piero della Francesca, *Elevations and Horizontal Outlines of the Human Head, De Prospectiva Pingendi,* 1474 -1482.

Evans says of Piero's drawing;

> A second series of orthographic projections shows the head tilted upward. […] Thus a man lifts his head, like Frankenstein's creation, in the imaginary, constructed space of orthographic projection. […] Piero's exposition of the Other Method is enough to change our idea of the way in which Renaissance perspective shapes the world that it portrays, enough to dislodge the tenacious idea that Alberti's perspective is Renaissance perspective.[22]

While Frankenstein moves his head in projective space, the effects that this animate situation brings about are not as straightforward as one might think. Whereas one might assume that an animation technique would lead to an animate expression in a drawing that was made with it, in Piero's case it was not so. The ability to construct human movement with the Other Method did not lead to human beings who looked particularly alive in his paintings, Evans notices. Quite the opposite in fact, people look stiff, frozen, inanimate, indifferent, and unrelated to their context; an impression which, according to Evans, has been intensely discussed.[23] Evans agrees that Piero's paintings are "less animated"[24] than other Renaissance painters', but not *more* geometrical, as they have been accused of. Other painters who were also working with geometrical constructions in their paintings, Leonardo da Vinci for instance, would paint people who looked very much alive. Hence, Evans does not see the liveliness in expression as such as a consequence of *geometry* as such. Piero's orthogonal projection did not have an overall vanishing point, unlike Alberti's linear perspective, although Piero conceived of his projection method as a kind of perspective. In Leonardo's drawings using Albertian linear perspective, human figures with a lively expression would be placed inside rigorous perspective cages.[25] The contrast between the free lines depicting a human figure and the perspective cage would give an impression of liveliness in the figure, in contrast to the geometrical cage, but one cannot say that *less* geometry was used for that reason, Evans argues. Hence, 'more or less geometry' alone was not determinate for whether a painting would have a lively or frozen expression. Evans suggests that Piero used the Other Method *loosely* in several of his paintings, an idea he gets from a sequence of five similar women's noses in slightly different positions in *The Proving of the True Cross*.[26] While analysing Piero's paintings Evans sees that the human figures are often slightly 'out of tune' with each other. People look "rootless" with an "air of paralyzed distraction."[27] Evans thinks that this effect emerges because Piero constructed the human figures independently using the Other Method, and then fitted them into the one painting afterwards.

Fig. 7.
A section of Piero della Francesca's fresco, *The Proving of the True Cross*, ca. 1466. Showing the mentioned heads in Evans' example.

That would explain why each character has a slightly different 'perspective' and angle than the others. Anybody who has made a *Photoshop* collage knows how easy this effect can come about when elements with different points of view and vanishing points are montaged together. Assembled together, diverse parts can give the whole an incoherent, non-unifying effect, that almost seems to quiver. The Other Method can be understood as an animation technique, enabling the projection of sequential stills, although it did *not* animate the paintings per se. But Piero's paintings were animated in other ways, since the motifs seem to quiver and be unstable due to the collaging of the locally conceived projections. Therefore Piero's motifs do not to show animate bodies in static, box-like spaces;[28] instead static bodies are shown in animate spaces. What is more, the painting also had another non-causal effect from the animation technique, namely that "these paintings, apparently conceived as virtuoso performances without expressive intent, induce speculative emotion in the observer seeking to account for what is absent," Evans says.[29] This means that the paintings – due to the fact that one is puzzled to see people looking frozen and detached from their context – leave a co-forming role to the beholder. There is no clear way of reading this. This indeterminacy is similar to a filmic montage where viewers may interpret a meaning into what they see. Viewers of Piero's paintings become active as they must fill in the "missing link," so Evans.[30] Piero's combination of an orthographic animation technique and montage technique created instable, vibrating wholes, where the animation technique did not seamlessly record objects and depict them in painting in any lively way. But, for the same reason, it animated the receiver and created quivering, painted spaces. Hence we see that animation as such was not a property of the technique which wandered seamlessly from one realm to another, rather the technique, as it was used by Piero, led to a displacement between cause and effect which was animating. Therefore Evans poses the still relevant question:

> To what extent is motion transmitted via Piero's technique, and to what extent created by the technique? The question will fall like either a brick or a gauntlet. Everyone knows that art is more than technique; but art must involve technique as more than an obedient instrument of intention, otherwise the accomplishments of art will not transcend intentions either, in which case there would be little point in venturing further than intentions.[31]

Evans here targets how techniques, instruments, and intentionality are all at play in the creation of these paintings, but that the way in which the artist connects these elements is decisive for the art. Did Piero's technique transmit motion or did it create it? Probably both, which prompts us to consider the influences between elements that constitute a medium and how 'the stretch' all the way between a maker and a receiver is animated in the medium.

A Working Nexus Mutates

We shall now delve into another example of Evans', dealing with a somewhat different relationship – a mutation. "The Developed Surface – An Enquiry into the Brief Life of an Eighteenth-Century Drawing Technique"[32] describes a mutation in the conventional way of drawing, which developed ca. 1760-1820 in Great Britain. The mutation in the conventional, orthogonal, architectural drawing happened due to mutual influences between people's way of living, how they desired their interior spaces to be, and the way plans and interiors were drawn. Due to this mutual effect, architects began to use a special orthogonal drawing technique – the so-called developed surface drawing technique – because this particular technique had properties that made it easier to draw what was desired. As said, Evans was very interested in how plans for buildings are directive of human life without being completely imperative of it,[33] and he found that drawing techniques also play a role in this relationship.[34] That is because drawing techniques are used by architects to negotiate between human life and building, whereby the techniques themselves add their own agendas to the negotiation.[35] In the case of the developed surface drawing techniques, mutual influences – which Evans calls "sets" of "related practices"[36] – in the drawing were "embedded in a nexus of other events,"[37] and as this set changed, the drawing technique mutated. In the essay, Evans scrutinizes the *set* of influences between the developed surface drawing technique where a room is unfolded (developed),[38] and the social practice of the time relating to the spatial desires of eighteenth century Britain.[39] He notices that the use of the drawing technique is limited to a specific period in time, ca. 1760-1820, and describes how the

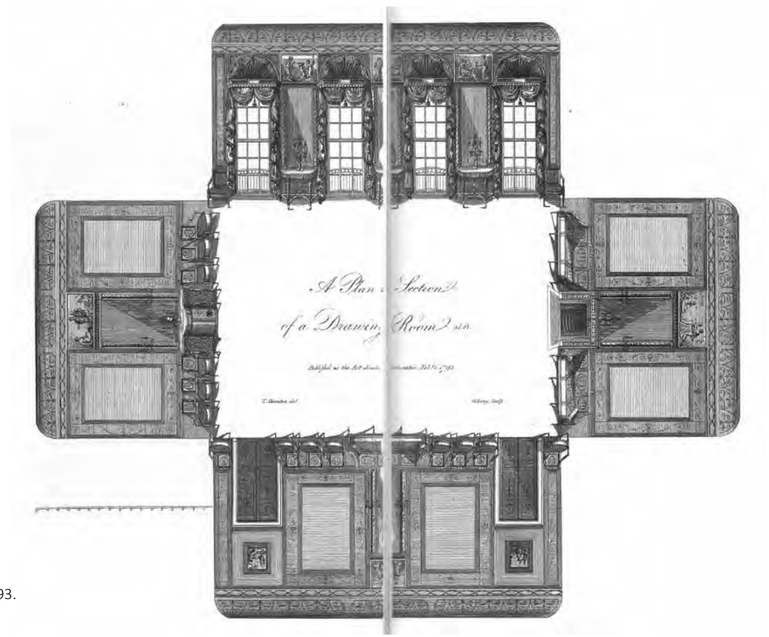


Fig. 8.
A developed surface interior drawing by Thomas Sheraton, 1793.

developed surface drawing technique became a temporary convention because it was particularly good for drawing the wall-mounted and heavily decorated interiors desired at the time. Hence a nexus emerged that worked well. At the time people did not really inhabit the floor, but arranged furniture and themselves strictly along the walls in hierarchically defined social patterns. Along with this, each room in a house was intended to be a world in itself, decorated in different styles, such as the Grecian salon etc.,[40] and therefore the connection to the next room was of minor importance. For these reasons the developed surface drawing technique was handy: it allowed architects to easily draw wall decoration and furniture *on* the walls, as if the paper were the interior skin of the room. Connections to any neighbouring rooms stepped into the background because in this technique a plan did not show connections between rooms, but showed all the inside surfaces of a given room. Walls were folded out from the room's middle point, unifying attention on that room only. The technique therefore *invited* the architects to decorate the walls because it was "centrifugal"[41] and spread everything out along the walls leaving the centre empty. In this way the desires of this particular form of social life were easily accommodated by the technique, at least temporarily. But in time the different parts of the working nexus began to change, and the nexus first mutated and finally died out.[42] One of the changes that caused the mutations was the desire of residents to inhabit and put furniture on the floor. This could not easily be drawn with the developed surface technique, which then became an obstacle rather than an aid as it invited drawing actions that led to spaces that were not desired by the life form. Evans thus describes the historical 'life' of the drawing technique as an evolutionary process: first the technique came into being, then it lived well for a while, but then mutated and finally died out.

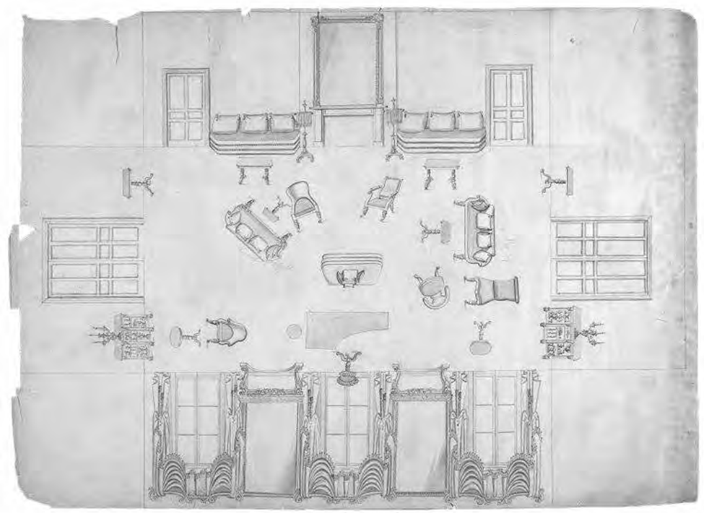


Fig. 9.
A mutated developed surface interior by Gillow and Co., early 19th century.

The drawing technique was a convention for as long as the working nexus was living well, but it had come into existence as a mutation and eventually went away again through further mutations. And although the final mutation caused its death, it was also in the mutations that the openings occurred: openings for new ways of practicing architecture and new ways of inhabiting a house. Such an opening can be seen in the drawings by Gillow's and co., which are a record of a mutation. Here the architects mixed perspective and orthogonal projection as they were looking for new ways of drawing interiors that would accommodate inhabiting the floor. In the mutation drawings the furniture is drawn in perspective although the technique's overall scheme is orthogonal. It looks as if the furniture has not really settled down yet, but can be moved around as in a doll's house – and thus the drawings are given a searching, sketch-like feeling despite their high degree of finish.[43] These mutations are relevant because they open up the conventions for new ways of practicing drawing, life, and architecture respectively.

ORTHOGONAL DRAWING MUTATIONS

I will continue the theoretical motif of *animation* and *mutation* further here, and attempt to conceptualize the conventional drawing's current situation as animate and mutated and indeed alive. The cause of the mutation in the nexus described by Evans was a change in the way of living, whereas for our contemporary mutations the cause comes instead from changes in technical equipment. Today conventional drawing techniques stretch far into the computer. One can draw with the computer and simply mime conventional techniques, but this practice, as Scheer says, is not really a computational practice, since, although one uses the computer, one remains representational, reasoning more through figurative representations (icons), than through code and algorithms (symbols). However, the argument of this chapter is that orthogonal, projective drawing is nonetheless still an active, co-forming *agency of observation* used in many design practices.

From drawing technique to drawing apparatus

In the essay *Digital Imperfection* the architect and researcher Claus Peder Pedersen also asks what happens to drawing when architects draw with computers. In line with Sheil and Scheer, Pedersen claims that computational design enables both a *more direct* and a *less reflected* translation of form into a material via 3D fabrication. He proposes that the distance between the designed object in the computer and the physical, plotted object has, on the one hand, decreased because of computer-controlled fabrication possibilities. On the other hand, he reasons that this distance has also increased because the translation of data and information into architectural form via codes, algorithms, and parameters is an even more 'secure' way of bridging the gap between drawing and building, and this in spite of the fact that coding, scripts etc. are even more abstract and indirect ways of describing an object than drawing is. This is a very good way of describing the paradox of how production 'moves closer' even as the representational system becomes more distant and abstract. Moreover, it also indicates that the conventional closeness between an architect and a drawing shifts to be concerned with another kind of closeness, namely to a medium which is also a machine that is able to fabricate a 3D artefact. There are new strings of dependencies within such a working medium, but it is still the medium and not the building on site with which architects have a close interaction. To that, he writes, one must add that the *ambiguity* of drawing – understood as the reciprocal relationship between sketching and constructing – must be retrieved in other ways when designing with computational means.[44] The computer has caused a shift from a ratio between the body's relation to pen, ruler, paper, and scale to a ratio between hand, mouse, zoom, screen, and printer,[45] and the challenge of this shift in ratio, this shift in how the medium is compiled, is accordingly how to overcome too much *unambiguity* and *precision* of the computer, and find a dynamic exchange between sketching something forth and directing it towards building, as with in a traditional drawing used to sketch a design forth.[46] Especially sketching is often emphasized as being an activity where one can move fluently between exploratory openings and ideation, and more a formalising type of drawing that tends towards building, and, as was also discussed at the *Is Drawing Dead?* symposium, it is often the role of sketching that is pointed out as lacking a computational counterpart.

Pedersen's way of describing the string of relations decisive of drawing: body – pen – ruler – paper shifting to hand – mouse – zoom – screen – printer, demonstrates well how the chain of dependencies in the media changes. This also calls forth the thought that such a string of dependencies might not stop here but continue on, – craftsman/machine – building – inhabitant etc.. Pedersen's way of accounting for a change in the media seems to have similarities with Karen Barad's idea of an *apparatus*, which is derived from the physicist Niels Bohr:

> Apparatuses, in Bohr's sense, are not passive observing instruments. On the contrary, they are productive of (and part of) phenomena. […] …while focusing on the lack of an inherent distinction between the apparatus and the object, Bohr does not directly address the question of where the apparatus "ends." […]. For example, if a computer interface is hooked up to a given instrument, is the computer part of the apparatus? Is the printer attached to the computer part of the apparatus? Is the paper that is fed into the printer? Is the person who feeds the paper? How about the person who reads the marks on the paper? How

> about the community of scientists who judge the significance of the experiment and indicate their support of lack of support for future funding? What precisely constitutes the limits of the apparatus that gives meaning to certain concepts at the exclusion of others? […]. What is needed is an articulation of the notion of apparatuses that acknowledges this complexity.[47]

Apart from referencing Bohr here, Barad also takes up Foucault's idea that technology is not just a technical device but also a social device, and her idea of an apparatus is double in nature, since it is a technical device but also a situated, socio-cultural construct. Barad's *apparatus* concept emphasizes that technical, mediated processes are both social and technological; and what is also of relevance for this argument is that Barad uses the term apparatus interchangeably with the term "agency of observation."[48] Said differently, an apparatus is a technical construct, the limits and effects of which are hard to define, and which constitutes an *agency of observation*. The conventional drawing with orthogonal projection could also be thought of as an agency of observation, indeed Evans has called it the architects "field of visibility,"[49] and orthogonal projection is still very relevant in the technical apparatuses that architects design with, since a lot of software has viewports in orthogonal or perspective projection.

Being a physicist, Barad draws on Bohr's ideas of experiments in the natural sciences which she thinks of as apparatuses / agencies of observation. Barad says that technical apparatuses that constitute an agency of observation both directly and indirectly materialize the world.[50] This, I think, could also be said of architectural media. Differing from Rheinberger, who emphasizes not so much the agency of observation, but the epistemic value of experimental systems and artefacts, Barad's concept emphasizes precisely the agency of looking at something in a particular way – for example, how looking through a particular projection co-forms the thing that is looked at, as we saw with the example of world maps. Therefore the systems for looking are active agents when the world is materialized. Barad is both a physicist and a feminist theorist of knowledge, and her idea of agency of observation is grounded in the well-known fact that in quantum physics it is not possible to observe anything without altering it. Barad extends the implications of this, however, to the social field, and her idea of an apparatus aims at both how the world is produced with the help of technical equipment, and how there are also invisible structures at stake – similar to projections – that co-produce material configurations. Hence, apparatuses are not separated from reality, they are, so Barad, phenomena of reality themselves, just as a drawing or any other architectural medium can be thought of as a reality in its own right.[51] With Pedersen's idea thus extended, we are conceptually entering into the 'machine room' of making an architectural medium, and can see that a medium can be compiled in different ways and that different dependencies will enable the materialisation of architecture differently, passing something on while also transforming that which is passed on.

The drawing kicks back

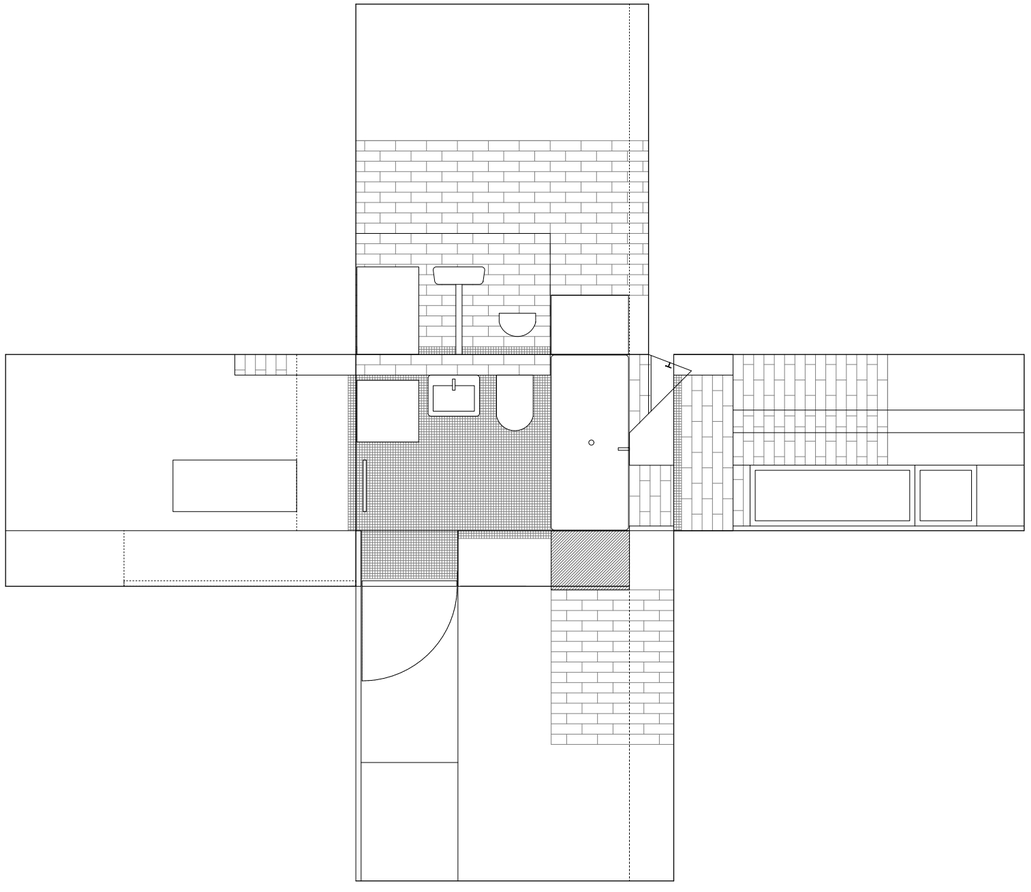
The feminist theorist Donna Haraway also contributes to Barad's *apparatus,* for instance in the text "Situated Knowledges"[52] where Haraway coins the concept of an "apparatus of bodily production."[53] This is a feminist text, and fundamentally has to do with how human bodies are shaped by socio-cultural apparatuses: that is, how the way a body is looked upon shapes its appearance and behaviour. Again this resonates with Evans' *Developed Surface* essay where there is an intimate relation between how life can unfold in the buildings that were made with a particular drawing technique. The technical apparatus co-produces the frames for the body, so to speak. But Haraway also asks whether *apparatuses of poetic production* and *apparatuses of bodily production* have something in common, and she thinks they do. With reference to literature (as art form) she says the "apparatus of literary production is a matrix from which 'literature' is born."[54] Writing a poem is a creative act similar to drawing, and, with relevance to my attempt to conceptualize drawing mutations and animations, Haraway asks:

> Are biological bodies 'produced' or 'generated' in the same strong sense as poems? From the early stirrings of Romanticism in the late eighteenth century, many poets and biologists have believed that poetry and organisms are siblings. *Frankenstein* may be read as a meditation on this proposition. I continue to believe in this potent proposition but in a postmodern and not a Romantic manner.[55]

Frankenstein, a story of an absolute animation was also used by Evans as a metaphor for Piero's creation with the Other Method. These direct and indirect relationships between the technical equipment and procedures and the way both practical and poetic things are made is both interesting and complex. The idea of animating something inert with technical means concerns a certain sense of poetic production too, where the animation is not monstrous but rather generative; and indeed Haraway talks of a generativity characteristic of both poetics and biology here. Barad's idea of the apparatus as a matrix for production also works around this idea of generativity. It is not a simple cause and effect situation between two well-defined parts, but an embodied procedure in which the world is materialized.[56] It is in this process that Barad coins that "..there is a sense in which 'the world kicks back'".[57] Once again, something similar was at stake in Evans' *Developed Surface*, where the different parts – human beings and techniques – making up a working nexus would push back on each other and therefore the nexus would

change. But Barad's example is the ultrasound *apparatus* used to look at foetuses,[58] not a drawing technique. It is a fact that a living foetus kicks back, but that is not the main point, but it underlines the close connection between life and technical apparatuses. The ultrasound apparatus is a technical construct but it is also influenced by many other factors including political interests, physical matter, the people, who perform the ultrasound scan, etc.[59] And it is here that Barad makes an observation similar to Sheil and Sheer's concern about there not being enough difference between a building and its simulation. Whereas one could emphasize that 3D production has moved closer to the architect, and that she is becoming more of a craftsman than a draughtsman for that very reason, as Carpo does, I would emphasize the aspect that the agency of looking at a 3D simulated object is, by and large, the same as with 'drawing only', although even more precise and dynamic. Concerning the ultrasound apparatus, Barad cautions us to not mistake the "object of observation" – that is, the actual foetus – with the "objective referent," that is the representation of the foetus. The "objective referent" is a distorted representation,[60] mapped with projections that distort that which they represent. The image of the foetus is indeed a reality that we *look through*, literally speaking, but the apparatus for looking also co-forms what we look at. Therefore it is so important to try and catch sight of the apparatus as construction in order to avoid that unquestioned value judgements that are embodied in the apparatuses remain unquestioned and live on as far too general norms. In parallel to Sheil's and Scheer's caution with respect to architectural simulations, Barad says that 3D simulations of babies inside their mother's womb may be received as "so 'lifelike' that the viewer thinks that the representation of the object is isomorphic with the object itself."[61] Representation and simulation are realities too, but they are realities made with technical apparatuses that add their own way of 'kicking back' to the nexus, which I do not think are inherently good or bad, but can be used in many ways.[62] This underlines the importance of understanding what for Barad constitutes an apparatus and in this thesis constitutes a situated, architectural medium.

Against this background my argument is that orthogonal projection – being a property of conventional drawing – even has a *heightened* effect, when drawing with computers, since architects look at architecture through various drawing programs using orthogonal projection as a basic way of visualizing architecture. Even 'less predefined' programs such as Processing have an easy orthogonal projection, although the default setting is perspective. This argument looks to Evans once again, and his account of drawing consisting of three geometries 'on top of' each other. These geometries were closely intertwined with the conventional geometrical tools being used to draw with, but with the computer the relationship between projection and tool is different. Evans established that the geometry and projection of drawing co-shapes the built architecture in both causal and arbitrary ways.[63] Moreover, he pointed out that architectural drawing is actually geometry used as a medium.[64] This medium consists of *projective geometry for looking*, *descriptive geometry for measuring and composing* and, lastly, "signified geometry,"[65] which has to do with how geometry can be used to expressive ends. Seen against this background, the current mutations in conventional drawing are located around the relation between *projective* and *descriptive geometry*. Signified geometry, I would say, is a concept that does not change much, since just as geometry can be used with conventional tools and techniques to expressive ends (recall the example with Ronchamp), computational geometries can also do the same. I think the largest change has to do with computers being able to describe geometry in many other ways than is possible with a drawing. As Scheer says, computational design practice is characterised by scripts, codes, and algorithms that handle geometry in ways that enable building. There is still geometry, but it can be handled differently, and yet it still aims at building. Now, since geometry can be handled by computational processes, and not by processes supported by geometrical tools, this affects the way architecture is *described*. For instance, other building forms become possible, complexity can be heightened, and complex changes made easier, since they are handled by a script rather than manually. And yet, the projective geometry that architects look through has, by and large, remained the same. Viewports in various software applications are of course more dynamic – zoom, pan, and orbit – but the way of looking at and reading architecture through orthogonal projection is the same as with a pen and paper drawing. Hence, projective geometry has 'moved in' quite comfortably with the various software, and one could say that architects look *at* 'new geometry' *through* 'old geometry.' A separation has been introduced into conventional drawing tools, in that in a pen and paper drawing the same tools would support *both* projective geometry for seeing and descriptive geometry for composing. Architects do not really look through an algorithm (as Neo can do in *The Matrix*) but rather at algorithmically generated architecture in parallel projection. This is a mutation, where properties belonging to the drawing become a sort of orthogonally projective, grounding framework, providing a way of reading and understanding architecture. Thereby an iconic way of reading and looking at architecture is still very much at play in architectural design, and, in this mutated state of affairs, parts of conventional drawing have mixed with computational affordances, while orthogonal projection, although much scorned,[66] seems to have mutated successfully, reproducing conventional effects, perhaps even in a heightened way.



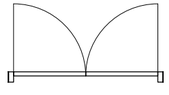
Before knowing Evans' essay, I had drawn a bathroom as developed surface. I had done it because the drawing technique was a practical way of drawing details on the walls – the tiles, fittings, etc.
1:50

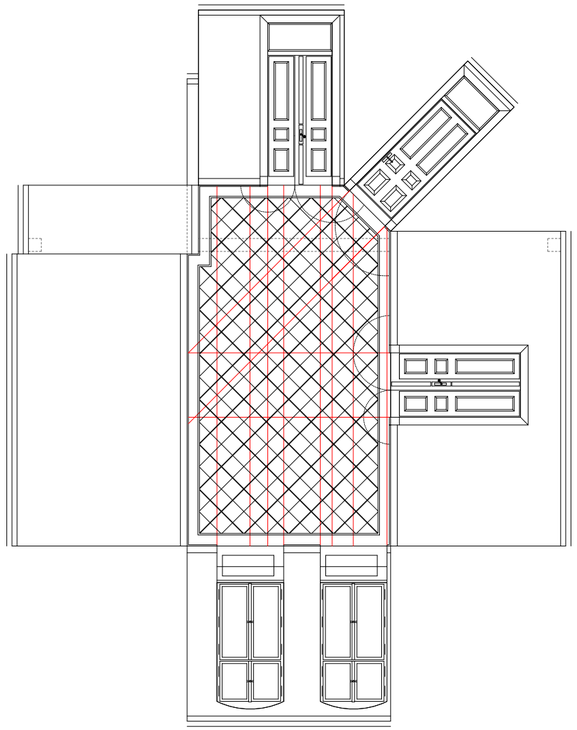
REANIMATING THE DEVELOPED SURFACE DRAWING TECHNIQUE

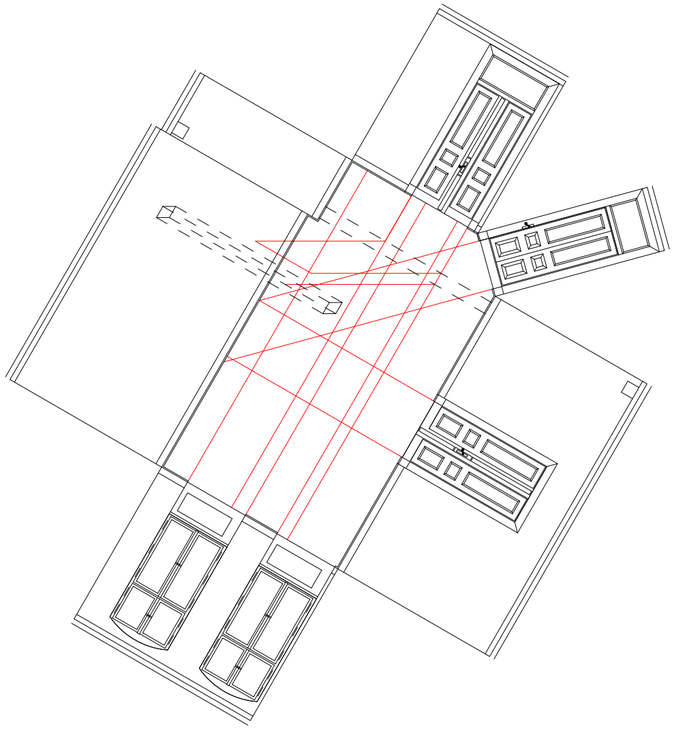
In the following drawings I re-animated the developed surface drawing technique by drawing my living room with it. The technique has just been discussed as part of a nexus between a way of living, interior design and architectural working media, arguing that there is a mutual affect between the parts. Since in Evans the developed surface technique is closely intertwined with the way people live, one might ask what sort of life my drawings relate to? Well, the relation to a particular way of living remains indirect. However, the idea of a flexible space that can be reconfigured over and over would be one way of relating these drawings to a desired quality of life. The concern for drawing and designing flexible ways of living were also much thematized in the structuralist movement in architecture in the 1960s, which I discuss in the last chapter.

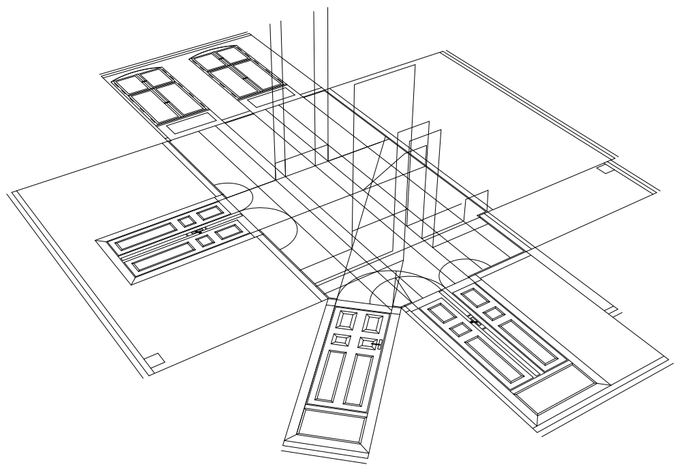
Another way of relating these drawings to life is to see them as a living medium. That would be another sort of aliveness that has to do with the relation between the maker and the drawing becoming animated, more than the aliveness people bring to buildings by living in them.

More concretely, I was fascinated by the way the drawing technique describes its own movement in a way similar to the origami foldings and the toy snake from before. The way a room is unfolded with the technique suggests that the paper on which the drawing is made can itself be folded into the room depicted on the drawing. This is just like an origami diagram where the paper it is drawn on can be folded into a 3D space. However, the developed surface drawing technique folds along the lines of orthogonal rooms, which is part of the conventional way of drawing in architecture. The technique folds or rotates orthogonally along straight axes similar to a door or a window on a hinge. In the case of the developed surface technique, walls are 'hinged' to the floor, the ceiling to the walls, etc.. It is as if the technique is a hinge, bringing orthogonal movement with it, so that should one draw an elevation or section of a room with the technique the whole thing becomes a movement notation.

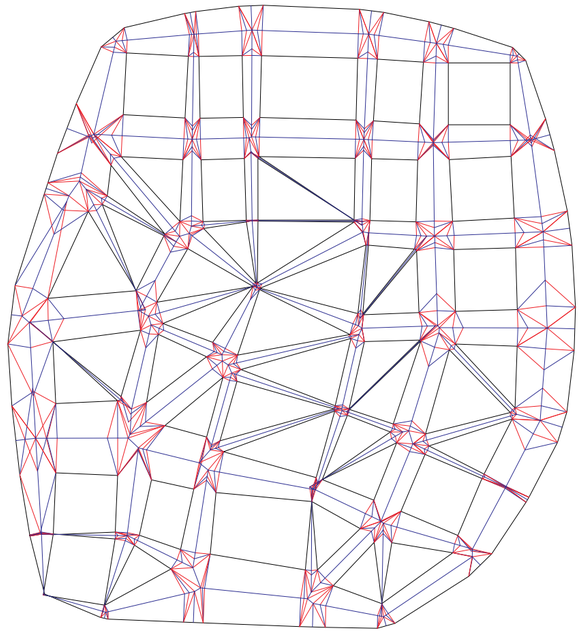


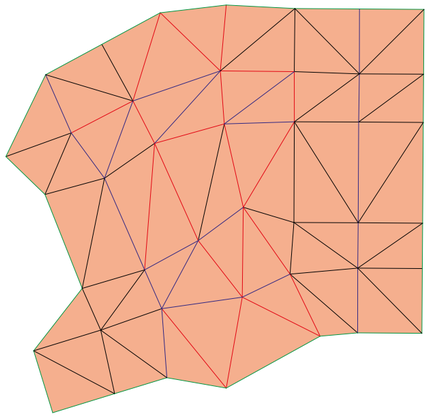


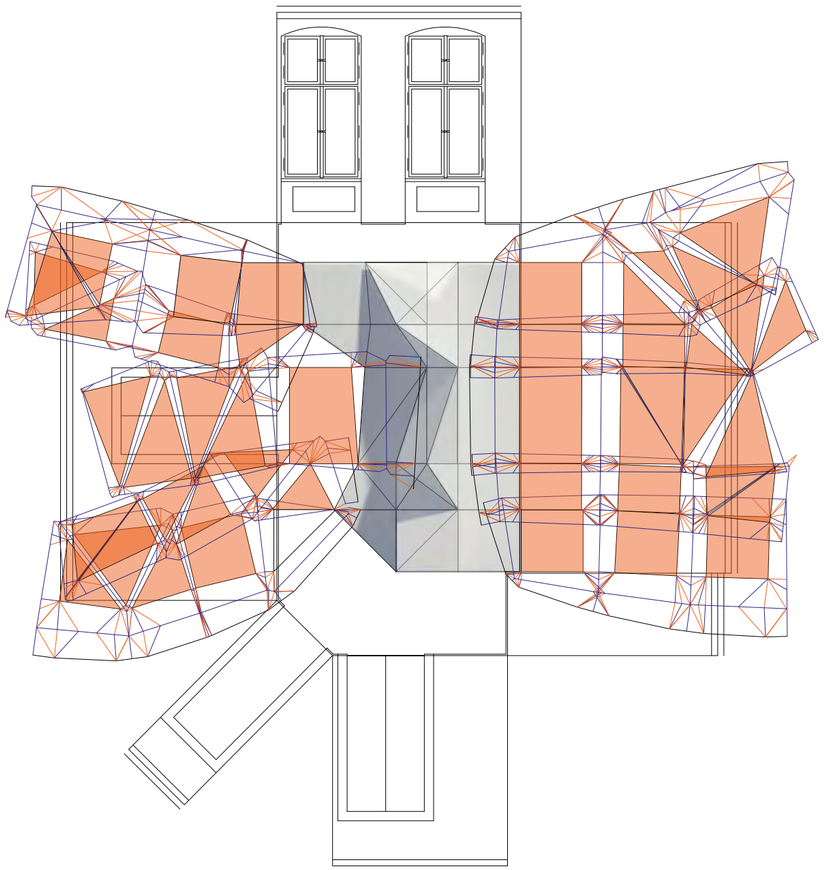


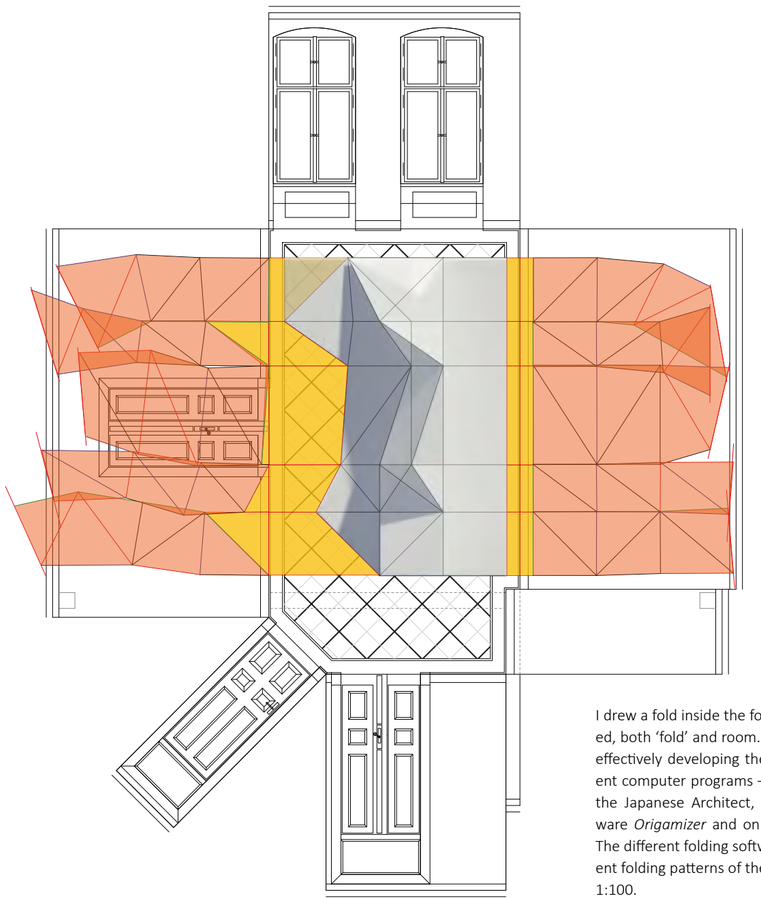


Here we see my living room as developed surface drawing. As a way to start designing with the techniques own agena, I extended some of the lines from the sizes and proportions already present in the room, mainly, the windows and the doors. This gave a drawing on the floor similar to a gym floor, which can be used as a gameboard for playing various games.
1:100

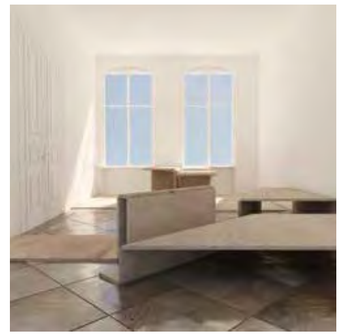


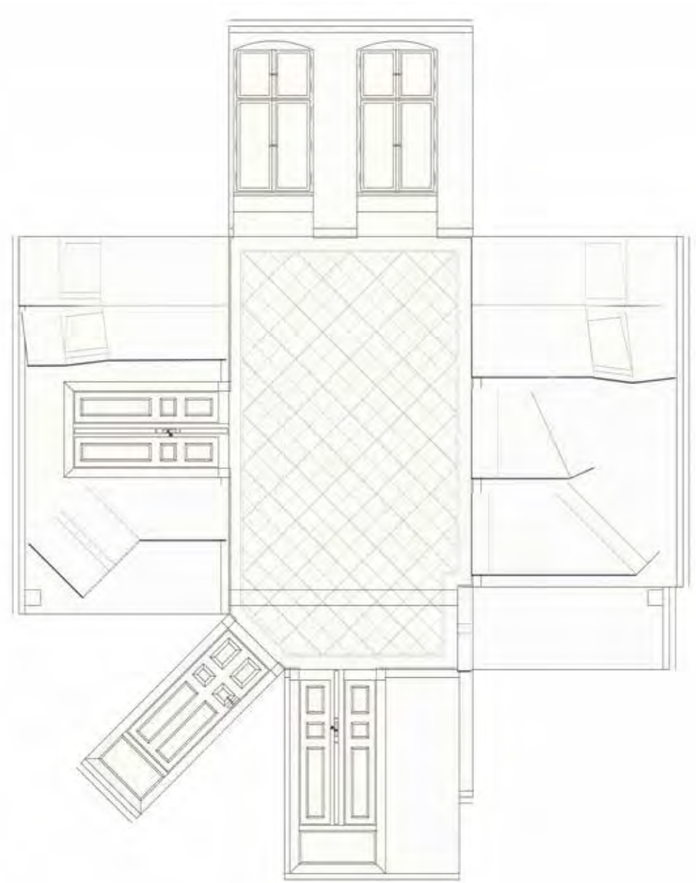




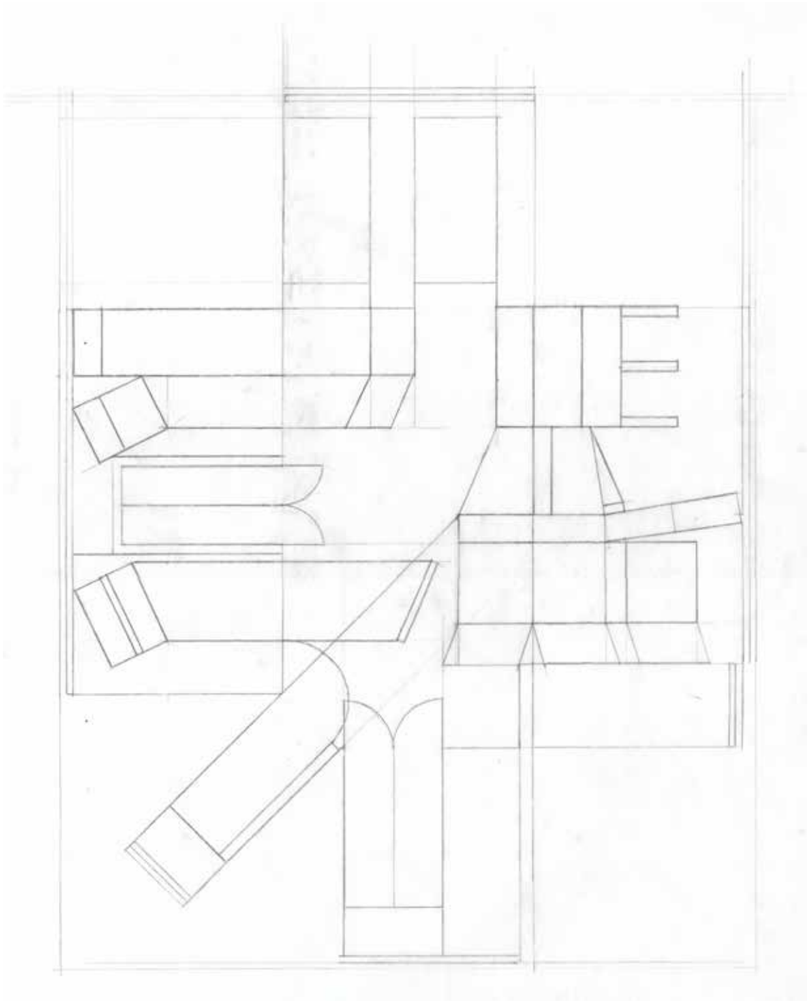


I drew a fold inside the folded room and unfolded, both 'fold' and room. I did some unfoldings, effectively developing the drawings with different computer programs – on the left page with the Japanese Architect, Tomohiro Tachi's software *Origamizer* and on this page with *Rhino*. The different folding softwares gave quite different folding patterns of the same object.
1:100.

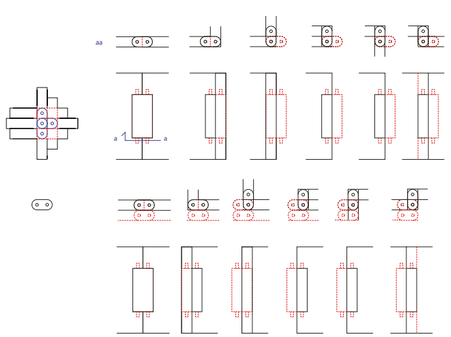




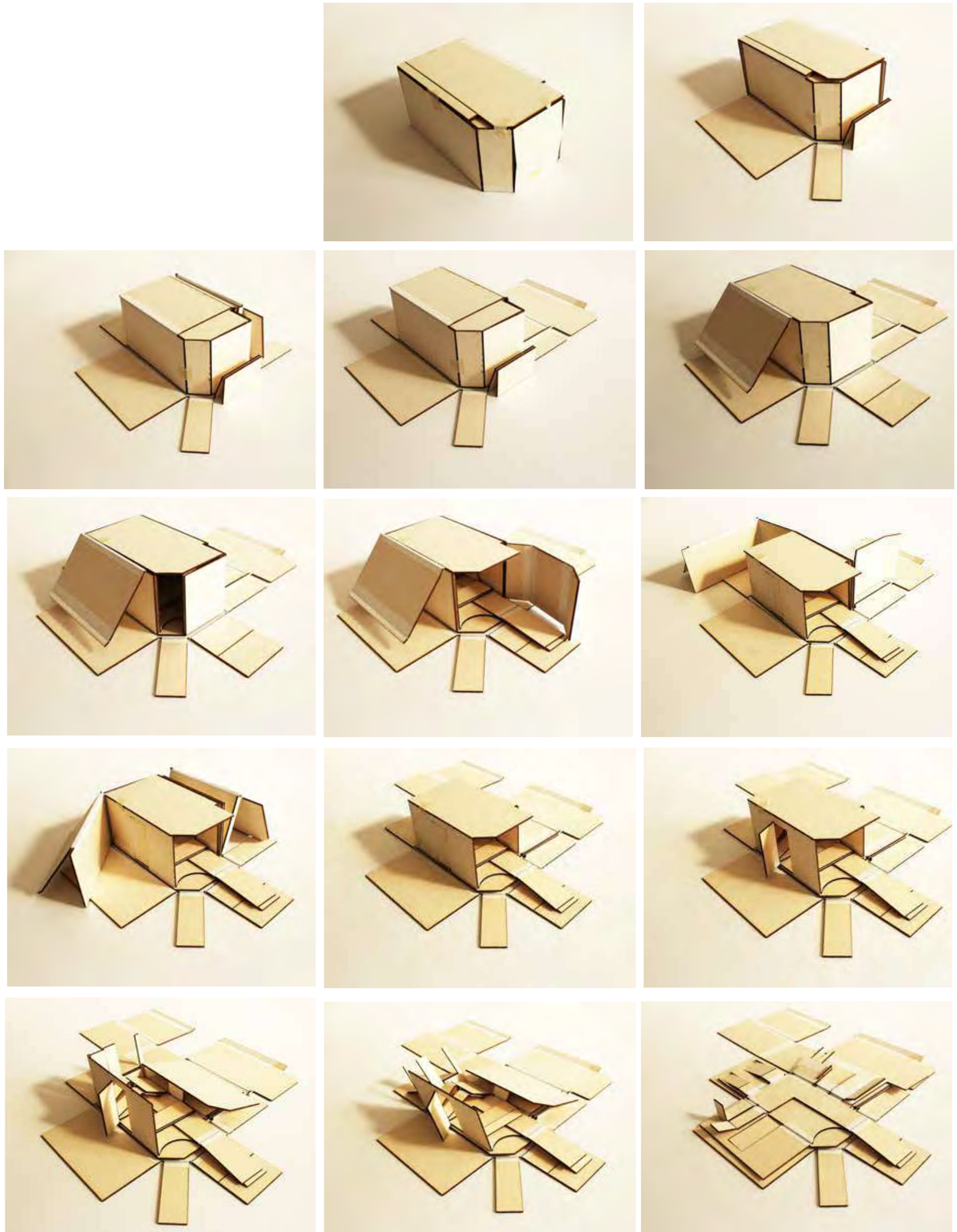
These renderings express some ideas about foldable, wall-mounted furniture that can be folded in and out. But it almost becomes too practical in the wrong way, since there is a limit to how much folding back and forth people can live with.

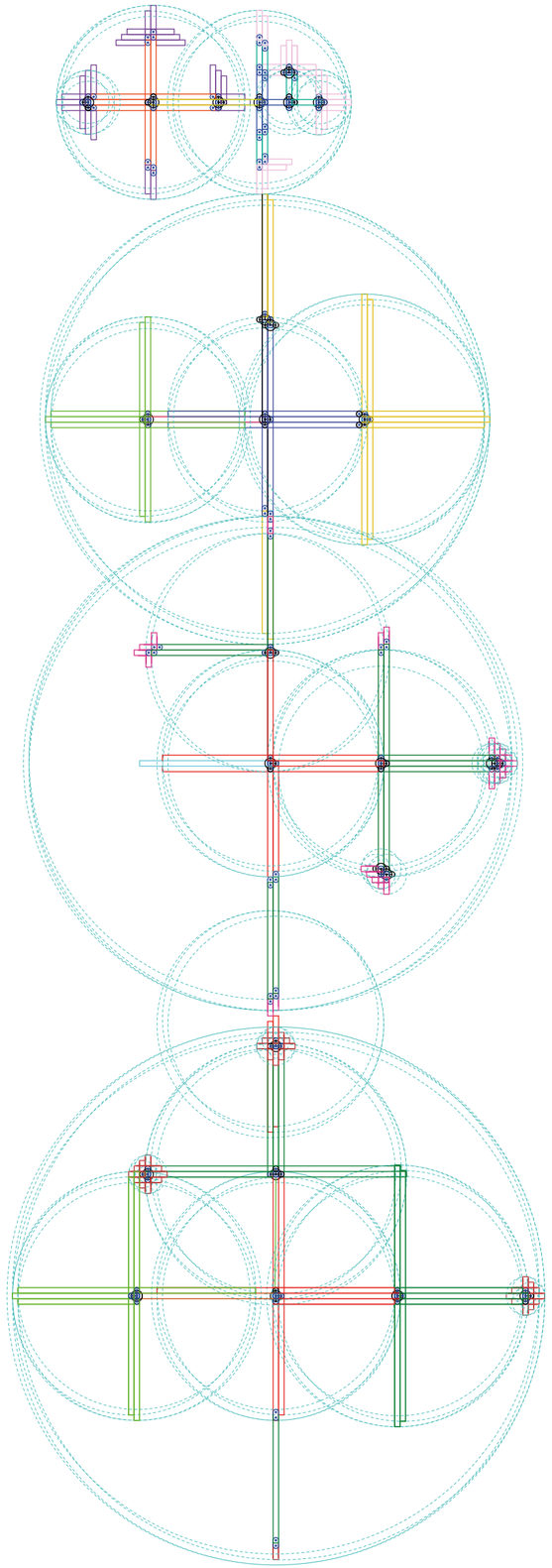


The idea to fold the furniture in and out from the walls came from Evans' essay (where the furniture at first 'clung' to the walls and was later 'set free'), and this hand drawing still have some furniture-like sizes. But in stead of working with designing furniture, I thought about the implied movement of the walls, ceiling, floors etc. This drawing led to making a model of the room consisting of four layers fitted into each other, like a box in a box, where walls and ceilings can rotate around a double hinge and be folded in and out in different ways. Unlike the origami foldings which have almost no thickness, the plates of the model did, and in order to enable the same kind of rotating movements as with paper I worked with a double hinge.

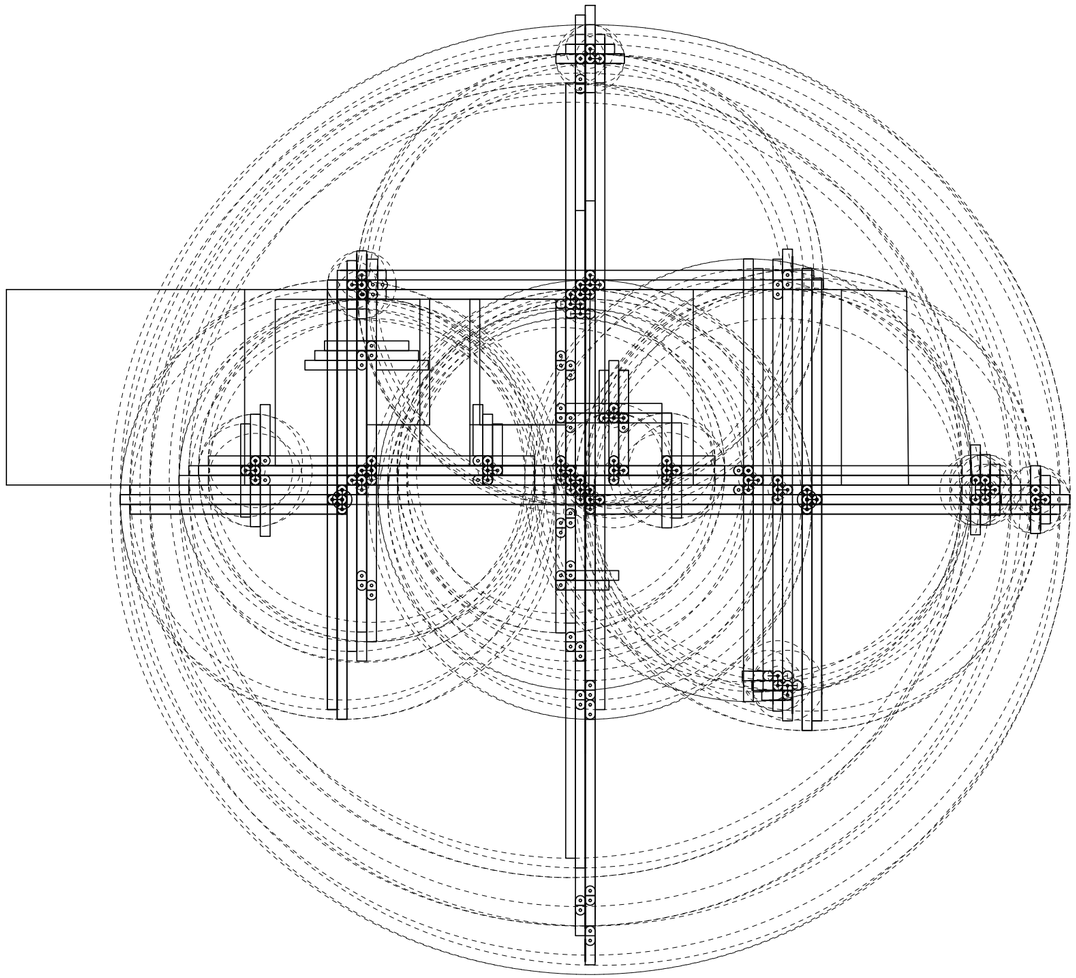


Here we see the possible movements of the double hinge in plan and section.

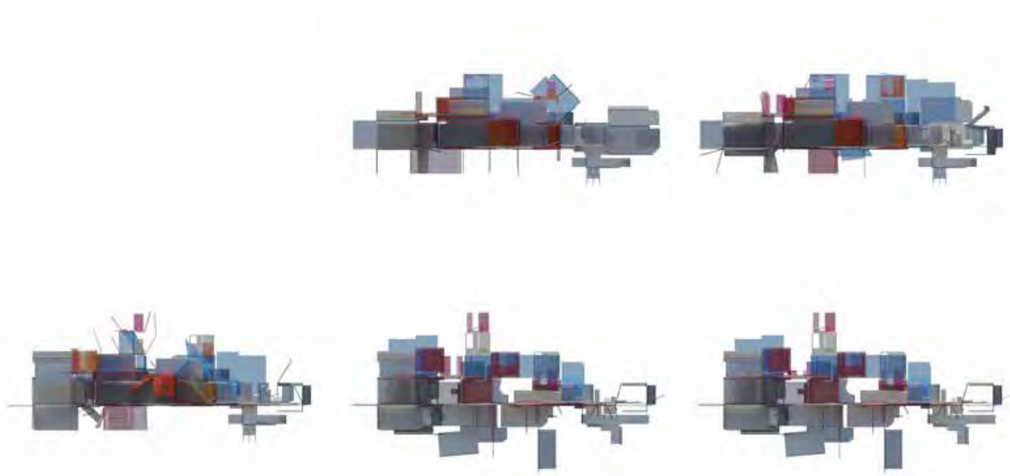


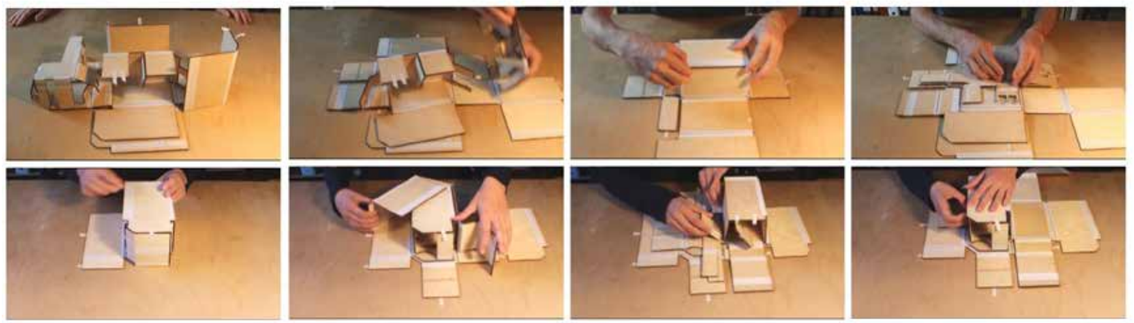


Here we see the possible movements of all the four layers of the model in elevation.

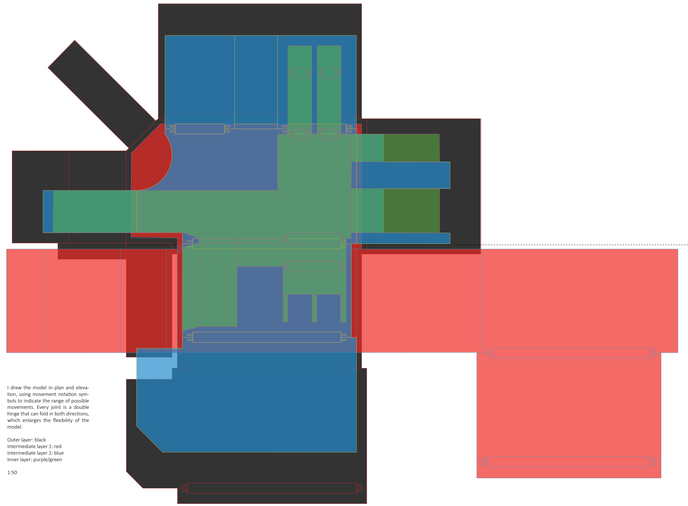


Here we see the possible movements of all the four layers of the model in elevation superimposed.





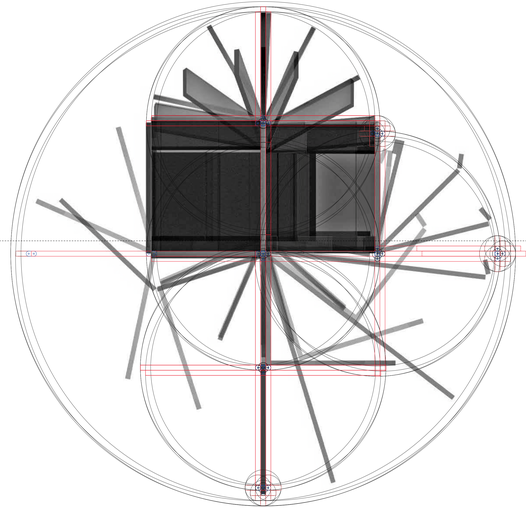
3D animations of the model can be seen on my homepage: http://annahougaard.com/portfolio/developed-surface-drawings/

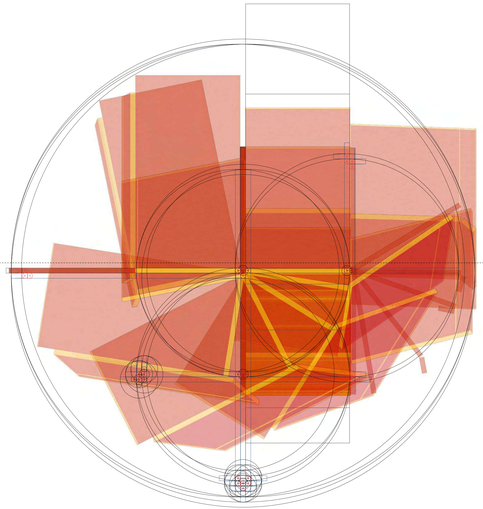


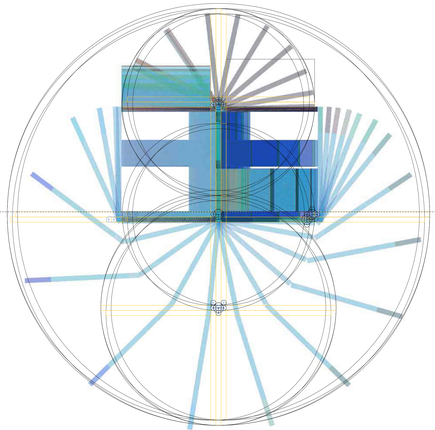
I drew the model in plan and elevation, using movement notation symbols to indicate the range of possible movements. Every joint is a double hinge that can fold in both directions, which enlarges the flexibility of the model.

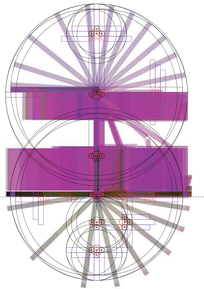
Outer layer: black
Intermediate layer 1: red
Intermediate layer 2: blue
Inner layer: purple/green

1:50









[1] Cf. Peter Bertram, *Frembringelse* (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2011).
[2] Ibid., 21.
[3] Ibid., 23.
[4] Ibid.
[5] "The essence of technology is not something that we master, but rather a particular understanding of being which marks our time. An understanding of being which only lets the being appear to us as raw material, energy sources, and available resources." My translation of Dan Zahavi's introduction to Martin Heidegger, *Spørgsmålet om teknikken og andre skrifter* (Copenhagen: Gyldendal, 1990), 25-27. Zavahi's emphasis.
[6] Bertram, *Frembringelse*, 23.
[7] Anders Fogh Jensen, *Mellem Ting - Foucaults filosofi* (Copenhagen: Det lille Forlag, 2005), 43. My translation of: "[…] den samme teknik kan godt have forskellige formål, forskellig rationalitet. Teknologien er brugen af teknik med et rationale, en mening og et formål."
[8] Allen, *Practice*, 73.
[9] Evans, *Cast*, 118.
[10] Evans, "Architectural Projection," 21, 23.
[11] Evans, *Cast*, 121.
[12] Evans, "Architectural Projection," 21.
[13] Ibid., 228.
[14] Cf. Greg Lynn, *Animate Form* (New York: Princeton Architectural Press, 1999).
[15] Evans, *Cast*, 151.
[16] Ibid., 148.
[17] Ibid., 151.
[18] Belardi explains what it is and how it is the predecessor of the 3D scanner. *Why Architects Still Draw*, 96.
[19] Evans, *Cast*, 155.
[20] Evans compares Piero's method with the way computer graphics worked at his time of writing in the early 1990ies. Evans, *Cast*, 154, note 67.
[21] Ibid.
[22] Ibid., 156.
[23] Ibid., 142.
[24] Ibid., 143.
[25] "Alberti's perspective gave them [the Renaissance painters] a second order of freedom within a second order of confinement. Inside the rigid cage of central perspective they developed unbridled, graceful bodies, conceived without any recourse to geometry but directly dependent on it for the intuition of their liberated form." Ibid., 135.
[26] Ibid., 153, 160-1.
[27] Ibid.,163.
[28] Ibid., 167.
[29] Ibid., 143.
[30] "Piero's figures show no emotion, yet they arouse strong responses in us. … Piero's figures, which look so static even when portrayed in movement, evoke tenderness, perhaps because their postures are reminiscent of children learning to walk, always seeking stability." Ibid., 143.
[31] Ibid., 145, (his emphasis).
[32] Evans, *Translations*, 195-233.
[33] Ibid., 89.

[34] See for instance Evans, "Figures, Doors and Passages" and "Rookeries and Model Dwellings," in *Translations*, 55-117.
[35] Evans, *Cast*, 176-7.
[36] Evans, *Translations*, 200, 227.
[37] Ibid., 200.
[38] Development in geometry is both to fold a two-dimensional plane into a three-dimensional object and to fold the adjoining faces of a three-dimensional object out like origami, so that all faces lie flat. See also Evans, *Translations*, 202.
[39] Ibid., 223.
[40] Ibid., 216-7.
[41] Ibid., 209-10.
[42] Evans finds two mutations, one around 1760 and then again one around 1810. Ibid., 224.
[43] Evans, *Translations*, 219.
[44] Claus Peder Pedersen, "Digital Imperfection – Polemical outline of a digital form of drawing, in Cartography," *Morphology, Topology*, ed. Cort Ross Dinesen (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009), 83.
[45] Ibid.
[46] Ibid.
[47] Karen Barad, "Getting Real: Technoscientific Practices and the Materilization of Reality," *Differences: A Journal of Feminist Cultural Studies,* vol. 10, no. 2, (1998): 98.
Retrieved from https://conceptsinsts.wikispaces.com/file/detail/Barad+differences98.pdf
(accessed 13.01.2016).
[48] Ibid., 94 and throughout the text.
[49] Evans, *Translations*, 199.
[50] Barad, "Getting Real," 90-94.
[51] Karen Barad, "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs. Journal of Women in Culture and Society*, band 28, No. 3 (Spring 2003): 816.
See also Barad, "Getting Real," 104.
[52] Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective,"*Feminist Studies*, Vol. 14, No. 3. (Autumn, 1988), 575-99. Retrieved from jstor http://links.jstor.org/sici?sici=0046-3663%28198823%2914%3A3%3C575%3ASKTSQI%3E2.0.CO%3B2-M (accessed 13.01.2015).
[53] Ibid., 591.
[54] Ibid., 595.
[55] Ibid.
[56] Barad, "Getting Real," 113 and Haraway, "Situated Knowledges," 591-2.
[57] Barad, "Getting Real, 112.
[58] Ibid., 100.
[59] Ibid., 100-1.
[60] "[...] its origins in SONAR technology developed during WW1, ultrasonography is not an idealized surveillance technology, a merely physical instrument that provides a view of the foetus as it exists independently of observational apparatuses. Rather, ultrasound technology designates specific material-discursive practises, limiting what is seen and produced in accordance with its own iteratively intra-active technoscientific, medical, economic, political, biological, and cultural, etc. developments as an ever changing phenomenon, and by its related and particular usages as a material discursive apparatus of bodily production in intra-action with other historically and culturally specific apparatuses." Ibid., 109-10.
[61] Ibid., 118.
[62] Ibid., 119.
[63] Evans, *Cast*, 228.
[64] Ibid., xxv-xxxvii, 37-8.
[65] Ibid., 349.
[66] I discuss this later in the chapter *Projection and Notation.*

MEDIA MUTATIONS III: DIAGRAMS AND SKETCHES

Introduction to the chapter

Orthogonal drawing has been discussed, and now this last part of the thesis examines concerns as to what happens to sketching when architects draw with computers.[1] My approach outlines a way of sketching that does not have so much to do with sketching as an analogue, hand drawn activity, but rather with how sketching can be a precise and productive way of creating art and architecture with indeterminacy being an important ingredient: sketching being a way of *making* a diagram in the first place.

The chapter is structured in three parts. The first part, *PROJECTION AND NOTATION*, is about *notation* in architecture, a concept often contrasted with *projection*. Here I read Stan Allen and Tim Ingold's concepts of notation through each other, and discuss how, although both are critical of projection and oppose it to notation, they each in fact have a very different understanding of what notation is. In the second part, projection and notation are related to analogue and digital notation in Nelson Goodman's theory of notation. His idea that diagrams can be made with both digital and analogue notation is accentuated, since firstly it shows that diagrams can be both analogue and digital, and secondly, because Goodman argued before the existence of the contemporary computer that, in terms of notation, architecture is "a mixed and transitional case,"[2] neither completely analogue nor completely digital. This is then discussed in relation to Carpo's prognosis that the notational language of architecture has finally reached full, digital status, as I have summarised in the state of the arts chapter above.

The discussion of Goodman's diagram joins the discussion about diagrammatic reasoning from previous chapters in this thesis, and, with this, there are now three diagram concepts at play: from Peirce, Deleuze, and Goodman. Goodman's concept is used to approach that part of the research question that asks what the potential of conventional drawing is, in the context of the computer. This chapter has a drawn part, *FIELD OF SUNDIALS*, with drawings that I have made showing simulations of sundials; these drawings were inspired by an equivalence of technique between sundials and conventional architectural drawing, namely that both work on the basis of parallel projection.

In the last part of this chapter, *SKETCHES AND DIAGRAMS*, a diagrammatic concept of sketching is developed on the basis of drawings by John Cage, Bernard Tschumi, Candilis, Josic and Woods, Junya Ishigami and Jorinde Voigt. This is an attempt to outline an idea of sketching that is not bound to the hand, but is rather an opening, diagrammatic activity to create art and make the process of creating it generative. This, it is argued can

encompass that rational and logical rules are directed towards poetic and aesthetic ends. This also embarks upon a notion of sketching not as a way to solve problems (for which sketching is perfectly adept), but rather as a way of sketching forth a diagram that both depends on and conveys instructions, but is nonetheless open to many readings.[3] Sketching, then, can be the beginning of a design process, but also be the opening for chains of mediation. Sketching can be a way of inventing a medium so as to investigate which techniques and tools to use in order to reach a desired result. The idea of the diagram as a sketch emphasizes that, rather than attempting to bridge perceived gaps between makers, drawings, and things in the most clear and determinate of ways, these gaps can actually be both productive and generative. This plots a course for a mixed way of engaging with architectural working media which encompass both digital and analogue notation.

PROJECTION AND NOTATION

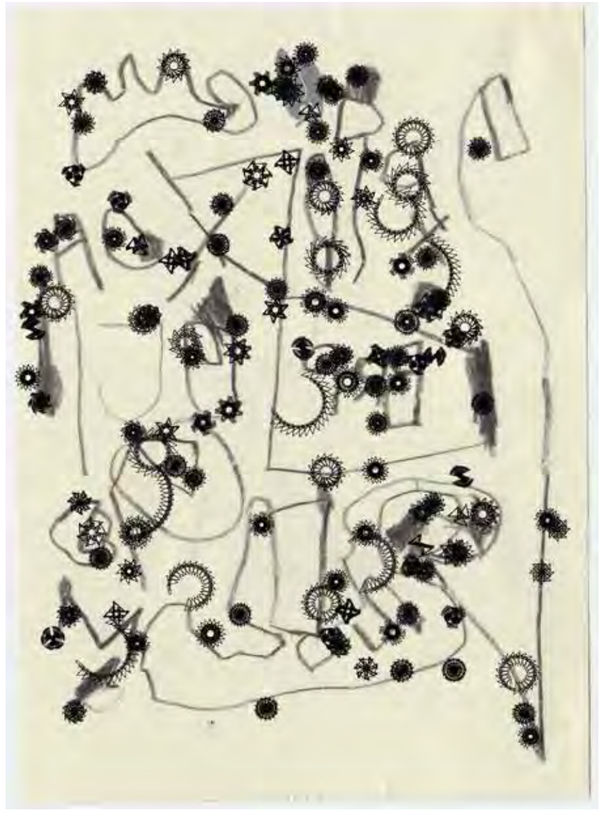
Although for Nelson Goodman the *notational* is the *digital*,[4] the term notation has other meanings too, like scribbling something down by hand, remembering something, taking notes, or sketching. Goodman's concept of notation as digital, however, is reworked by Stan Allen in his manifesto on architectural notation,[5] while Tim Ingold gives a completely different definition of what notation is. For Ingold, notation is fundamentally connected to the body and the hand – hand-writing, or hand-drawing. Because Ingold works with a history of the line that does not take Euclid and Alberti's geometrical lines as their reference point,[6] his theory of notation is quite different from Allen's who stands on the shoulders of Goodman.[7] Ingold does not see drawing and writing as being two separate practices, but rather thinks that both drawing and writing are gestural, inscriptive, bodily practices that take place within a broader history of notation. Notation, he believes, takes place within an even broader history of *the line*.[8] Ingold says "[s]o long as writing is understood in its original sense as a practice of inscription, there cannot then be any hard-and-fast distinction between writing and drawing".[9] It is only when lines become projective that they lose their origin as being bodily gestures,[10] at which point, instead of being lived lines, the projective lines die and instead form part of processes of construction and assembly[11] at a distance from real life. Because the marks that make up notations in Ingold's sense are made by indexical and physical lines, he places the history of writing within a broader category of notation, and maintains that writing is not essentially different from drawing. According to Ingold, writing is a kind of drawing that first becomes notational when we learn to read.[12] Before we can read we simply *draw* symbols and letters.[13] A script, then, is only a script when we can read what it means, otherwise it is a drawing, and scripting thus only becomes meaningful as something other than a drawing when we understand it as language. Notation as scripting hence makes up a subcategory of drawing, while notations as such can be "both written *and* not written":[14] words and images in fluent combination. Notation, hence, describes a fluent combination of drawing and writing, as is well-known in architects' sketches where image-like depictions often have written descriptions.

Thus, whilst for Ingold lines are thought of as the smallest parts of a notation being physical, gestural and *performative,* for Allen *performance* is also a quality of notation but is understood differently. Whereas notation is emphasized as *coming from* bodily performance in Ingold, notation is emphasized as *leading to* performances in Allen.[15] Notations, so Allen, carry with them instructions for performance, as seen in musical notations. Allen, like Goodman, thinks of notation as a special kind of diagram, namely a digital diagram.[16] He says "[all] notations are diagrammatic, but not all diagrams are notational,"[17] this is again in line with Goodman, who argues that diagrams can be both analogue and digital. And when the digital is the notational, then not all diagrams are notational but all notations are diagrammatic: thus in this terminology every notation is a digital diagram. This is quite different from Ingold, where the notation is intimately connected to the body and the hand. However, diagrams in architecture – both digital and analogue ones – are, according to Allen, generative when thinking about space and organization, while notations (i.e. digital diagrams) are generative when thinking about performances and processes unfolding in time. Interestingly, Allen, like Ingold, sets notation in opposition to projection but then, unlike Ingold, places value on the two concepts of notation and projection. For Ingold projective lines lack connection to life as they lack the physical, indexical trace, whereas Allen argues that *projective* architectural drawings maintain a trace back to an original sketch which is continuously transformed. Allen's projection that maintains an analogue trace to an original sketch can be thought of, for instance, as a sketch in plan which then iteratively becomes closer and closer to a working drawing. In such a process the trace to the original sketch is, as a rule, traceable. Notations, however, overwrite the trace since they do not have any image-like similarity with the object they describe; thus unlike projective drawings, even sketches for notations do not look like that which they represent.[18] Thus where notation for Allen is digital, for Ingold it is analogue, and both see it as being more *performative* than projection. These opposing understandings of notation show that there is no single or simple definition for notation. As an anthropologist, Ingold emphasizes the relation between *life* and lines, and as an architect Allen emphasizes the relation between the architectural working medium – notation and projection – and building. Ingold emphasizes the performative relation between the maker's body and the notation, whereas Allen emphasizes the relation between the notation as independent of its author, passing on instructions on its own.

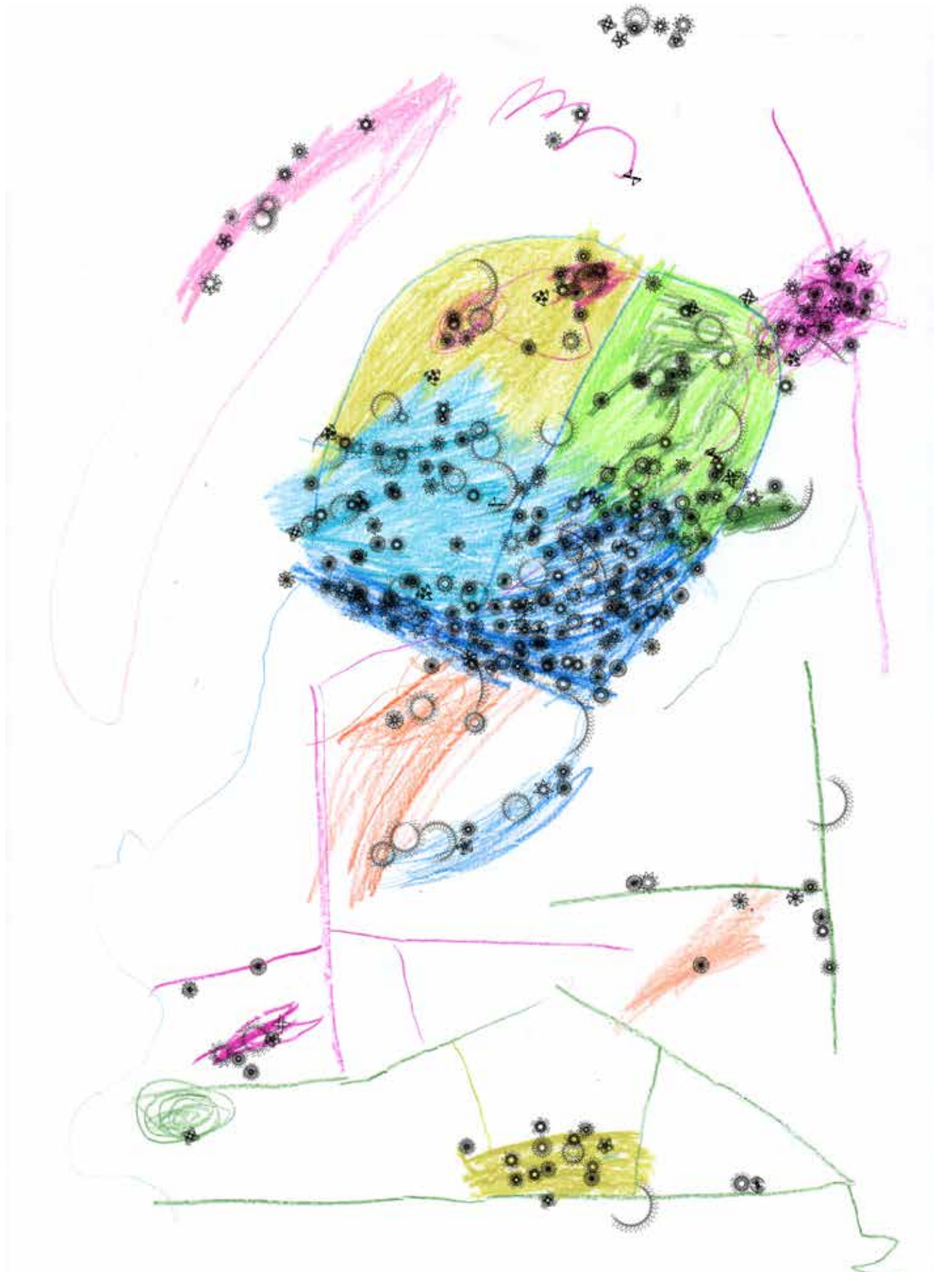
For Allen both notations and diagrams work diagrammatically, but he emphasizes that notations are essentially digital and therefore 'born' for computation; this differs completely from Ingold who emphasizes that notation is an analogue, indexical, and gestural, embodied, human practice. Allen emphasises that notations are not ends in themselves,[19] but media, and as such the importance of any single artefact or any particular building or drawing is reduced, while how a building or drawing performs on its own in the world, as detached from the body that made it, increases in importance. A notation such as a musical score can be performed innumerable times in the absence of its author. Whereas this is due to its unambiguous and highly conventionalized way of passing on instructions, notations, so Allen, can also be helpful for directing indeterminacy in our "messy and inconsistent reality".[20]

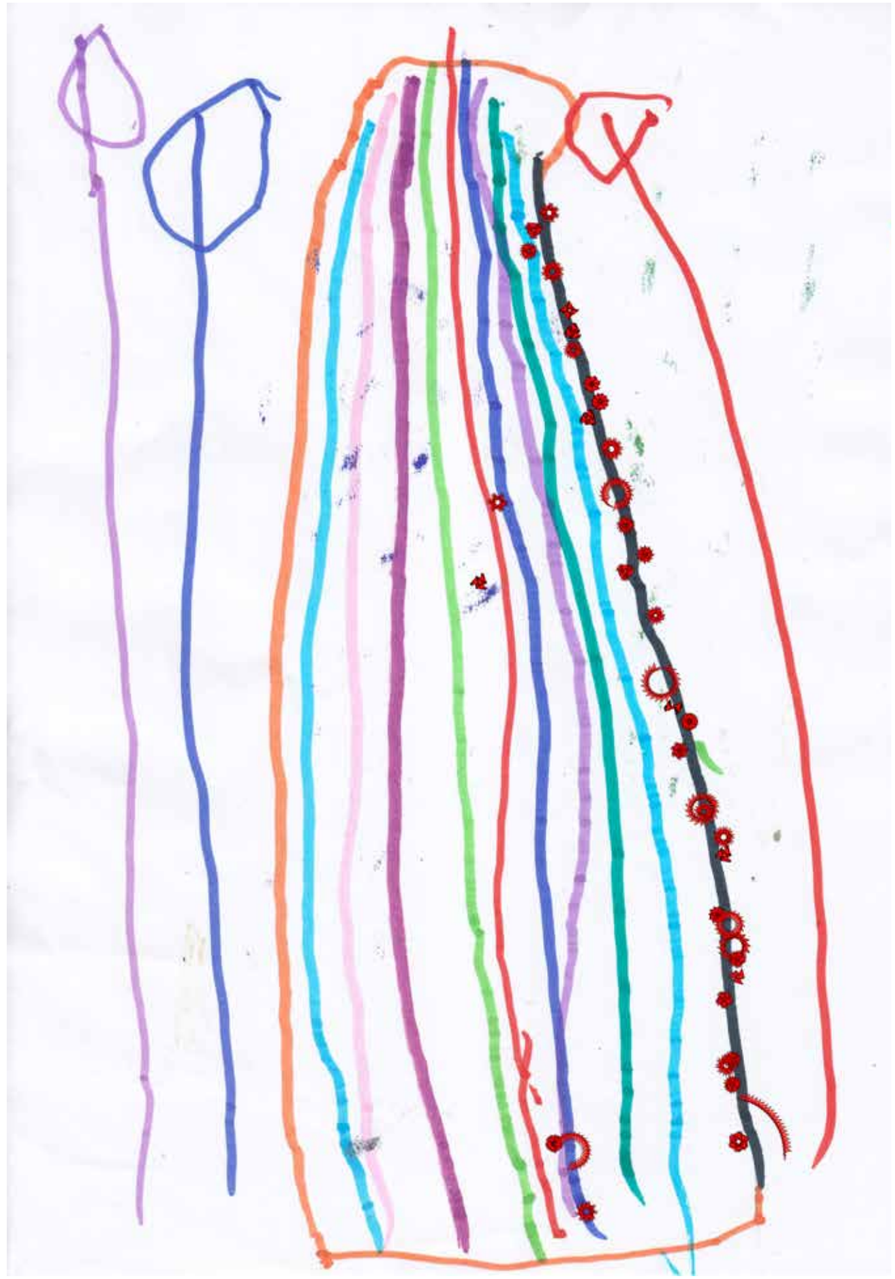
Where Ingold takes a stance *for* life and analogue notation but *against* separating projection, Allen takes a stance *for* life and digital notation but *against* projection, with the latter maintaining a continuous trace to a sketch, an origin and an author. Both are dismissive of projection for completely different reasons, Ingold because projection obliterates a direct surface of contact with life, Allen because projection does not obliterate that contact enough.[21] Whereas Allen encourages architects to work notationally – that is digitally – while being relaxed about the affordances of the computer, he also emphasizes notations as diagrams (which hence can be both digital and analogue) with a field-like character that might be used as an architectural tactic to accommodate the unfolding of life in the contemporary city in *loosely* organised ways.[22] This resonates with a tactic that John Cage also employs in some musical compositions, where he does not give a predefined, complete set of instructions, but organises his compositions loosely, and yet with great precision, for the performer to perform.

When Ingold and Allen are read together their shared implication of notation is *performance*. Ingold emphasizes notation as a performance on the part of the human being, while Allen emphasizes notation as a performance on the part of the architectural medium itself, which gives instructions. But the shared implication of notation as performance has a dual nature: there is both the performance of making the notation, the 'maker-notation' relationship, and the performance that a notation passes on, the 'notation-performance' relationship; i.e. these two relationships are situated at two different 'nodes' in a medium. Tension remains between notation as a human gesture that varies from performance to performance in Ingold, and Allen's notation as an architectural medium that can accommodate the indeterminacy of human life, as it is cut off from its author. But exactly this is what Ingold criticises projection for: for having no contact with life, for being separating and discrete and – since the digital is inherently discrete one could argue that for Ingold, in effect, projection is digital due to its being discrete and separating. Allen on the other hand criticises projection for keeping a trace



Cross generation scripting
The idea of notation as a mix form of drawing and writing was interesting in relation to the scripts Abe and I made. Ingold says that children's drawings of letters before they can read, are scripts. I took some of my children's drawings where they have drawn letters and patterns in fluent transition, and used them in the scripting sessions with Abe. The *Processing* script reads the drawing and puts geometrical patterns on it, randomly and yet following the hand drawn lines. Therefore, these drawings are scripts with scripts on top, a cross-generation scripting performance by Sofie, 3, Abe, 40, Anna, 36, and a bit more indirectly by Ben Fry and Casey Reas, who initiated *Processing*, who again stand on the shoulders of other developers of computer languages and so on.





to an original source, sketch, or author – an analogue trace indeed, so for him projection is analogue. I argue in the next chapter that one could say that both are right. Although Goodman puts forth in his theory of notation that a plan drawing is a *digital diagram*, he cannot make this determination complete, since even a conventional plan drawing cannot avoid having some analogue aspects. Therefore Goodman concludes that "the architect's papers are a mixed and transitional case,"[23] a point that this thesis aims to extend further.

THE ANALOGUE AND THE DIGITAL

A vinyl record stores sound waves in an analogue fashion. It has a continuous groove which is an actual imprint of physical sound waves, just as an old-fashioned photograph on light-sensitive paper stores an imprint of light waves. Analogue storage devices can typically record physical readings such as temperature or pressure directly, as opposed to digital devices which depend on a translation from an analogue source into a digital code. Digital systems make it easy (and potentially noise free) to copy information, whereas analogue systems, physical as they are in character, tend to include noise in copying or transmittance. Because of the physical relation between an analogue transmitter/medium and a source, the analogue in Goodman has the character of the signs that Peirce considers to be indexical, in a similar way to the imprint that remains when two things have been in direct contact or have 'touched' each other. A digital system is in principle noise-free and when a digital code is correct, it can be copied again and again without any loss of information. For this reason digital storage seems more secure and free from obliteration due to copying or transmittance. But this is only how it works in principle, since a digital file, for instance, can easily become unreadable and obsolete when the software it was made with is replaced by newer versions, which cannot be read by older technical equipment. The same can be said of analogue storage like vinyl records, where older instruments are needed in order to perform a play-back.

Analogue and digital notation

These distinctions are the basis of Goodman's assessment of analogue and digital notation from before the contemporary computer. Goodman tries to distinguish whether a symbol system or the "language" of an art form is amenable to *notation* or not. This aims at defining whether an art form uses a mediating vessel, as does architecture and music, or if the art piece *is itself the vessel*, as painting. Goodman bundles the *notational* with the *allographic* and the *digital*, while the *non-notational* is bundled with the *autographic* and the *analogue*. These definitions give a good foundation for understanding the characteristics of the two notational forms.

The notational is digital and allographic, and a digital, allographic piece of art is characterized by being detached from its author or source. Digital, allographic notation is discrete; syntactically and semantically disjointed and differentiated throughout.[24] A conventional musical score is good example of a digital notation as used by Goodman, as it passes on instructions via shared and unambiguous conventions of syntax and semantics in the form of language or code that everybody/everything who knows the language or code can understand. A digital notation, hence, relies strongly on conventions, on shared rules for translating and reading. An autographic piece of art, on the other hand, is characterized by being in a close relation to its author, a relation that is sometimes indexical, for example when a painter's hands leaves traces of pressure via a brush on a canvas. Analogue notation is syntactically and semantically *dense* and *undifferentiated* throughout,[25] like a pencil line drawn on a paper; it is dense and continuous to a degree where no notational differentiation can be clearly pointed out.

These aspects of digital and analogue notation have to do with the relation of a notational form to an origin, and not so much with the physical, technical equipment that was used to make the notation. The distinction here is important, for digital and analogue notation is not only defined by technical equipment, but also by how a notation is to be read and how it relates to its context.[26] Take a seismograph, for instance, which notates an earthquake in an analogue way, even though a seismograph is not necessarily close to the human body in the same way that a pencil is. The same argument applies to analogue devices for recording music or for taking photographs. An analogue camera is the technical equipment that records a situated event in an analogue way. Goodman exemplifies this aspect of what defines analogue notation by pointing out that the graph that a seismograph draws when it records an earthquake is an indexical recording of a specific event in time and place in a "closed continuum".[27] A digital graph, on the other hand, is more general – he says for example that it can be a graph of the annual production of cars. Such a graph is digital, since it 'only' counts and can count in relation to basically anything. The analogue, hence, is not necessarily defined as being directly made with the human body, but is also defined by situation and context and by how it is to be read, because, for example, reading the graph of a seismograph only makes sense in relation to the specific event in time and space in the closed continuum earth.[28] Such a graph does not pass on any other meaning than of this particular earthquake, however, after starting to assess the graph a scale might be introduced, such as the Richter scale, and thus digital notation enters the picture and forms an understanding with the analogue notation. The analogue event and the digital scale make sense *in relation to* each other, and in relation again to man-made standards of measurement. The digital scale gives measure to the analogue recording of a specific event in time and space: as one sees in the world map of time zones, where a man-made

standard for measuring time gives measure to the earth's own rotation. Situated events in time and space can of course be recorded and played back with analogue systems, but within digital systems such information can be stored and passed on via generalized codes, that is, via an allographic, digital notation. An analogue notation is not per se passing on or translating anything, rather it is something itself, and indeed the prefix *auto* means *self*, while the prefix *allo* means *other*. That is reflected in Goodman's assessment of painting as an analogue art form: the painting is the art piece itself. In music, an allographic art form, the score passes on the art piece. In that sense autographic/analogue art forms are translated to a lesser extent than allographic/digital art forms, and as such are more singular.

Translating an analogue event into a digital code adds *nodes* in the string of translation, which makes questions of authorship relevant since in every 'node' of translation more distance is inserted between the author and the work, and more generalisations – however small and insignificant they may seem – are made. Digital notation with clear meaning and clear rules for translation succeeds in bridging the gap from node to node in a determinate way. Remember that Carpo claimed that conventional drawing is completely digital, because it could secure "identicality"[29] between a drawing and a building. This claim can only be made with regard to elaborate working drawings, because – *in principle* – they bridge the gap between architect and building in a completely unambiguous way, where a reverse causality can be established. But this claim overlooks the continuum between a more analogue act of sketching and an elaborate working drawing, as Robbins pointed out, and also overlooks that it is within the gaps of translation that not only determinacy, but also indeterminacy may enter. (Moreover, it overlooks that there is not always *identicality* between drawing and building, as has been scrutinized by Evans, for instance, in his analysis of Philibert de l'Orme's chapel of Anet in *Translations from Drawing to Building*.)[30] Where Carpo is interested in the heightened possibilities for determination of translation from a computer design to production, I am interested in the indeterminacy that may just as easily enter into a mediated chain of translations in the nodes of translation. This has to do with the already mentioned paradox of conventionalized forms of notation, which can be a limitation but can also enable shared communication, as Edward Robbins argued. So where determination can be heightened in the gaps of translation it can also be loosened due to the same qualities of being a shared form of notation. A loosely-defined translation, as we shall see, can be a productive quality in some works of art – open musical works, for instance – which shift our attention to the chains of dependency in a medium and how that enable translation in different ways. Awareness of the medium, how it is put together, and how it may open things up, might also be a foundation for investigating further into Carpo's point when he discusses Wikipedia-like participatory ways of making architecture. This also points to the opening potential of conventions, in similarity to Robbins. Indeed, although a code can be both intended and used to keep a secret, it is also, by definition, translatable and has the potential to become a shared convention. Hence code can be a means to ensure that translation happens in accordance with an author's instructions in that, but when the code is shared it can also open up the way gaps are bridged – I am reminded here that a bridge in a Nordic folktale is a dangerous place, because the protagonist risks arriving *neither* safely *nor* unchanged on the other side. With regard to architectural notational forms, these can carry instructions more or less 'safely' across the bridge, i.e. with more or less determinacy. Digital notation is more able to allow information to travel in clearly defined ways, whereas analogue notation does not necessarily carry any instructions or shared meaning at all. But it is precisely the generality/the conventionality of digital notation that also makes it open – that is, as long as the source code itself is open. I would say that digital and analogue notation can open up in different ways at different nodes of translation. Digital notation can open up because every node of translation is also an entrance for discussion for those who know the code because the meaning is clear and understandable. Analogue notation can open up because its meaning is not necessarily defined, so it calls for imagination and interpretation.

There are good reasons for using general, shared, coded notations that can give clear instructions: for example, when many people have to work together as in both music and architecture. Robbins pointed this out, but he also pointed out that the passage between the analogue and the digital, between the sketch and the working drawing, is a continuum. And analogue notation is good for grasping and developing vaguely defined ideas, and for communicating in ways that cannot necessarily submit to a conventional reading. Analogue notation works with authorship in a different way to digital notation. Painting, an analogue art form *per excellence*, works with one artefact, *the* original, as opposed to a musical score that can be performed repeatedly but despite this, each of the many performances is an original. Of course a painting has an effect beyond itself too, but it does not (usually) give instructions about how something is to be carried out. This particular, unambiguous way of reaching beyond itself makes a digital notation a means rather than an end, while an analogue notation in comparison is more of an end. In a musical score the author's instructions are secured in a relatively general way, whereas a painting remains singular and not necessarily amenable to conventional meaning. A musical score is a medium between a maker and a performance in a very different way to how a brush or pencil is a medium between a maker and a painting. As with a painter and a painting, the relation between an architect and a drawing is close and the drawing might be considered by the architect as an end in itself. But if the drawing passes on instructions via conventional notation then it reaches beyond itself in

a different way to a painting. This is unique to architectural drawing, and gives it its double nature of being both a work itself and a set of instructions for building. And it is exactly this double nature of architectural drawing that experimental musical notations have also cultivated – they have focussed on the graphical and image-like appearance of the score and cultivated it graphically, while also insisting that it give some level of instructions.

The main point to be drawn from this discussion is that it is not simply the fact that a drawing is made with a hand held pencil that defines drawing as analogue. It also becomes analogue if it is to a great extent an end in itself and gives few instructions, being more like a painting. Moreover, if it is drawn with the computer for a certain place on earth that relation gives the drawing an analogue aspect as well. Nor is it so that when a computer is used to make a drawing then that drawing is, per se, digital. One can make a digital notation by hand too, by writing the code down. The notational forms and the technical equipment and tools are hence two different things that can be combined in different ways. In principle one can paint a digital code, or create an analogue drawing which is more like a painting via a computer interface. So, different combinations of notational forms and technical equipment will open up different possibilities. An instructive nature is characteristic of digital notation, aiming at carrying information that can be understood without the author, while the less mediated, specific event in time and space is characteristic of analogue notation. This is also the reason why it is possible for Goodman to say that conventional plan drawings without material specifications and without any specific site are "scores" and "digital diagrams"[31] when in fact plans were drawn by hand before the modern computer existed.

Mixed and transitional notation

One main argument of this thesis is that diagrammatic reasoning 'cuts across' both digital and analogue media practices, so when Goodman says that diagrams can be both digital and analogue it is relevant to this argument.[32] As said, curves directly attached to analogue events, such as those made by a seismograph, are analogue diagrams, whereas statistical curves that simply connect dots are digital. Roadmaps, however, are mixed analogue and digital diagrams.[33] Goodman indeed outlines a contrast between analogue and digital diagrams, but also a continuum between them.[34] This could be read as similar to what Robbins captured – that there is a span between the sketch and the working drawing, the double nature of drawing as both a cultural and more singular act, and as a social and conventional act. It is important to note that at both extremes – the analogue and the digital diagram – there are openings. Both the shared, broad conventions that make a diagram digital in Goodman's sense and the singular, inventive sketching act that falls outside conventions can be ways of opening.

According to Goodman, it is the tendency of all art forms to start out as autographic and analogue and then to move towards becoming allographic and attain "full notational status".[35] But in architecture full allographic status has not been achieved, Goodman states in *The Languages of Art* which is from 1972. Nonetheless, Goodman thinks that architecture is a prevailingly allographic and digital art form, because plans are so important for communication cut off from the author and plans are "digital diagrams".[36] Plans are digital because of their notational character which does not speak against a building being built more than once, thus being similar to a musical score that is usually performed more than once. Plans are also digital because they refer to building parts and procedures in another space (allo) than the drawing space itself (auto) via shared notational references. In that sense a plan is also a generalized 'code', unambiguously passing on instructions. However, it is not often that a building is built more than once, and indeed, if the Taj Mahal were to be built again we would tend to see it as a copy and not as an original work, Goodman remarks.[37] In architecture more than in music the situatedness of the work does seem to matter, after all. Goodman must therefore conclude that a plan drawing with material specifications at a specific site has a more singular character than a musical score, which is easier to 'move around' and perform in different places. Goodman says:

> We are not so comfortable about identifying an architectural work with a design rather than a building as we are about identifying a musical work with a composition rather than a performance.[38]

For Goodman the design – the drawing – counts *less* as art work than the building does in the discipline of architecture. Goodman presupposes, like Allen, that "[t]he drawing as object, like the musical score in performance, disappears at the moment of construction."[39] But this is not the whole truth. Both architectural drawings and musical scores can sometimes lead independent parallel lives to either buildings or musical performances.[40] Drawings of buildings that have been built sometimes become templates that can be shared, whereby they have an indirect but quite traceable influence on other buildings. They can also become art objects or be distributed in architectural magazines and in retrospect can be idealized or abstracted further.

Goodman is aware that there are different kinds of architectural drawings, including the sketch which he thinks of as analogue and more like painting, and the working plan drawing which he thinks of as digital and more like a musical score. But he places them in categories and not in the design process, unlike for instance Robbins. Thus, Goodman somewhat misses seeing the continuum running from analogue sketch to digital

diagram. Moreover, sketches can have digital aspects already, as when architects sketch in conventional ways. For example, making a sketch in plan already taps into the conventional reading rules, the 'codes' that grant meaning, although one might not know when starting to sketch what meaning the sketch will ultimately transmit. But Goodman chooses to emphasize the digital way that a plan drawing conveys instructions and specifications for buildings, and decides that architecture mostly tends towards being a digital and allographic art form. But he cannot dismiss the fact that plans have autographic, analogue, and situated elements such as when they are provided with local and material specifications. And he is also aware that analogue sketches also belongs to the "architects' papers".[41] So it is only without sketches and only when plans are drawn without material and site specifications that plans are "digital diagrams".[42] Hence it is a generalisation to say that architecture is a completely allographic art form, and thus Goodman concludes that architecture on the whole has too many autographic elements, and is therefore a "mixed and transitional case".[43]

However, although I just said that a digital code can be hand written or a computer drawing can be analogue, the technical equipment does play a role as to whether a diagram is to a greater extent analogue or digital.[44] The computer is a digital machine and it enhances the possibilities of digital notation. This is at the heart of Mario Carpo's argument, for instance, when he says that Alberti's digital notational form was forced to 'play' together with 'analogue storage media', that is, with pen, paper, and drawing, and with human beings as performers who could include errors into the notation when copying it. Finally, Gutenberg's printing press enabled identical copying, granting security that information would travel safely.[45] The digital notation held in drawing simply lacked the appropriate technology at that time, so Carpo. Today, with digital technology, Renaissance drawing is obsolete, because architects can work with computers and algorithms that can translate their instructions directly to fabrication machines. And digital notation and computers together do ultimately attain what Carpo has called full notational (digital) status. But I think that Carpo forgets that there is a continuum from autographic/analogue sketch to allographic/digital diagram as if the whole process were a problem in architecture, which can finally be solved. In the next chapter I will argue that diagrams can be both digital and analogue *and* sketch-like. Carpo's argument about how architects today can ensure notational identicality between digital notation and 3D fabrication is mainly directed at the phases of the design process after sketching. Where Evans has already shown that one sometimes thinks that identicality exists where there is actually none,[46] this is ultimately not the point here. Rather, my argument is that the media situation in architecture is still mixed; the architect's relation to the medium is still close and situated, and nodes of translation that can be determined even more tightly due to the unambiguity of digital code, can also be opened up due to the code's conventional nature. Despite of the powerful nexus between digital tools/technical equipment and digital notation, I wish to hold on to Goodman's idea of the mixed analogue-digital character of architecture and its media because it underscores architectural design as a continuum between the analogue and the digital where diagrammatic reasoning and, not least, projections interweaves.

Where Goodman thought that it was because of a lack of ripeness in the art form of architecture that it had not reached full allographic status,[47] and where Carpo thinks that architecture has now reached full allographic status, I have argued that architecture is still a "mixed and transitional case".[48] With Goodman's diagram, digital and analogue notation has been related to my previous conceptualisation of architectural drawing as diagram. It has been re-introduced that architectural drawing has always had digital aspects, although it is usually considered to have been analogue until the emergence of the modern computer. Moreover it has been argued that whether a notational form is analogue or digital is not just a matter of whether the technical equipment used to make it is analogue or digital, but also a matter of the relations that are connected.

Shadow notation

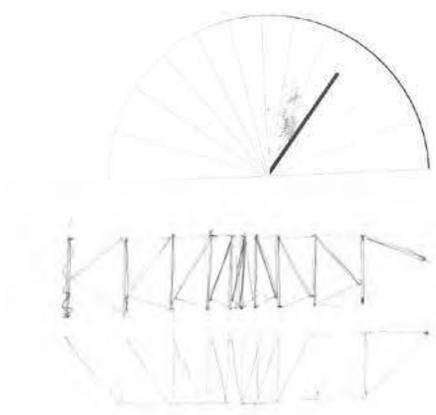
Reading Ingold and Allen through each other does not clarify whether projection is analogue or digital. However, in *MEDIA MUTATIONS II* it was argued that orthogonal projection is defining what Evans called the architect's field of visibility, whether architects draw with computers or by hand. Orthogonal projection, then, can be thought of as itself being a diagram, relating decisions made in the drawing to the building – as would typically happen through digital notation – but also relating more sensuously to the maker of the drawing. As diagram, projection is able to cut across the analogue and the digital. In relation to the next drawing series which discusses orthogonal projection, the myth of the origin of drawing is worth recapturing. A painting by David Allan called *The Origin of Painting* from 1773 shows the legend of Kora, a young woman who traces the shadows of her departing lover, thus showing the idea of the origin of drawing. But it also shows how drawing is a substitute for the real thing. The lover's shadow is projected onto a wall inside a house from a simple source of light. Evans notices that in a painting of the same title by Karl F. Schinkel, who was also an architect, the origin of *architectural* drawing might be portrayed. The painting depicts a similar scenario – but the man is

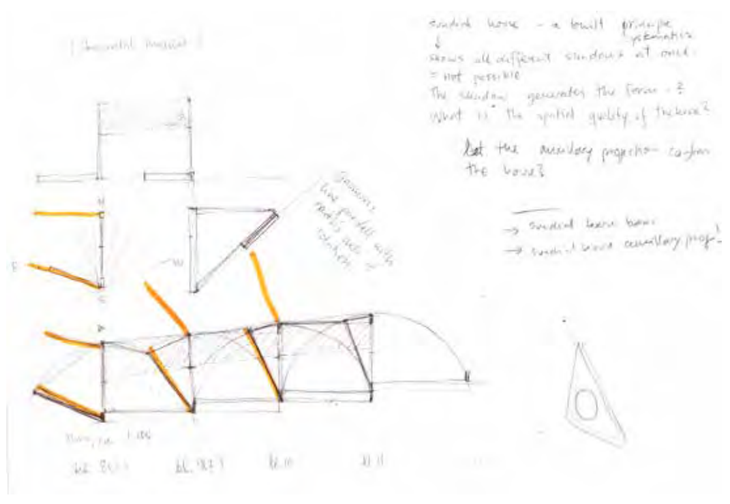
Fig. 10.
Karl F. Schinkel,
The Origin of Painting, 1830.

tracing the shadow of the woman (presumably the lover is tracing the shadow of Kora) now in an outside setting with the sun as the source of light.[49] The sun's rays are parallel and therefore shadows will fall in parallel projection, the same principle that is used in sundials as well as in the invisible projection lines of orthogonal drawing. Evans also notices that when architects construct shadows geometrically in drawing there is a double performance of projection at play, since the parallel rays of the sun already cause real shadows, and when this effect is drawn in parallel/orthogonal drawing it creates 'projection on top of projection'. Interestingly, Evans also points to the difference between the constructed, static shadow in the geometrical drawing space as opposed to real and ever changing shadows cast by the sun on a column. The movement of the sun creates an animation: it draws an ever-changing shadow image on the column, and challenges the stability of both the column and projective space:[50]

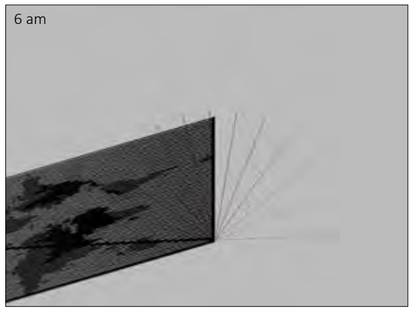
> The shadows, precise as they are, dissolve the structural form [of the columns]. They do so by superimposing a derived pattern, a projection within a projection, which throws one contour of the simplest of capitals against its own curved surfaces. Shadows are insubstantial and impermanent. Their properties are exactly opposite to the properties of the column they glide across. The one thing they share, in this instance, is the frozen sharpness of geometric delineation; the indication of a strong sun held in the sky. And strangely enough it is this one shared characteristic that allows the shadow to take its revenge over the stable column. […] eaten up by shadows […] : ghosts that come out in good weather to turn the double signification of classical stability into a disruptive gyration of glancing lines. …Columns **are** threatened and animated by strong sunlight. But the effect, which is among the most beautiful and subtle in architecture (as well as among the most common), is not of instability: rather it allows the observer to imagine the structure as quickened instead of deadened at its crucial points.[51]

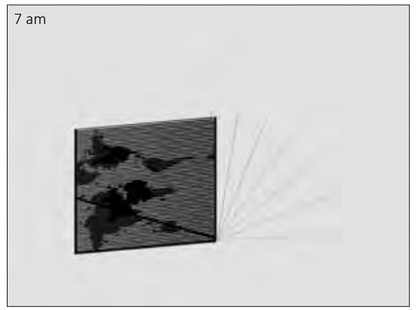
This quote points out an arcane and mythical connection between shadow tracing and architectural drawing, a connection which is also exemplified in sundials in the way they measure and notate time. A sundial is a mix between an analogue and a digital computer, Goodman says.[52] The gnomon or pointer is the analogue source placed at a specific location on the earth in the universe. The dial gives measure to the pointer and is the digital part of the computer. Together the pointer and the dial make visible what time it is in a way that is meaningful to those of us who can read it.[53] A gnomon is calibrated to an exact location on earth; the dial, on the other hand, is general and can count with respect to anything. We usually think that sundials tell the time only approximately, but that depends on how we need to use time. As the British railway gained ground, a need emerged for time to be synchronized on a larger scale than just locally, so people would know exactly when the train would arrive and leave. The synchronized time system allows this use of time and introduces a leap second into the scale when the deviation from earth's rotation becomes too large. On a sundial the gnomon is always in contact with the rotating earth, built upon the earth itself, so sometimes the dial that sometimes needs to be adjusted to the pointer. The analogue source, the gnomon, works by projection, and throws a shadow that onto the dial, which works by digital notation and together the analogue source and the digital scale become mutually dependent and notate time.

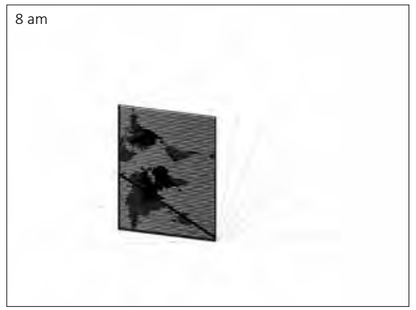


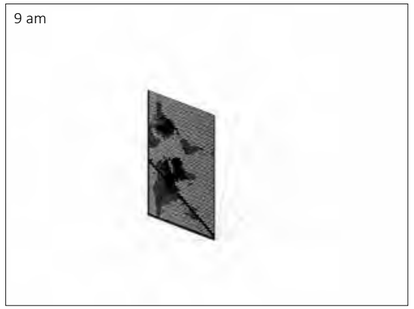


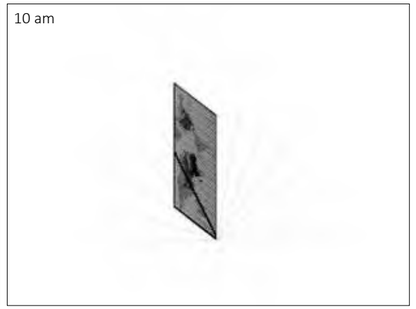
Sketches for the next drawings, *Field of Sundials.*

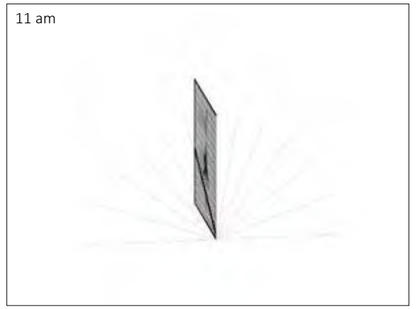


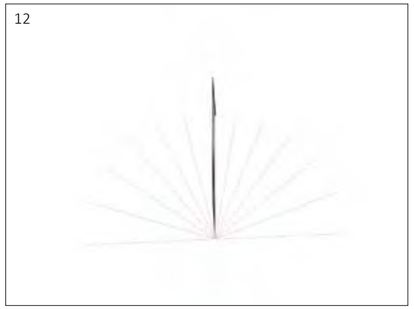


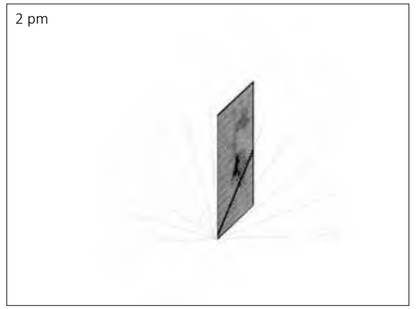


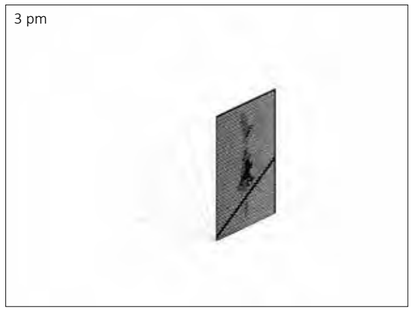


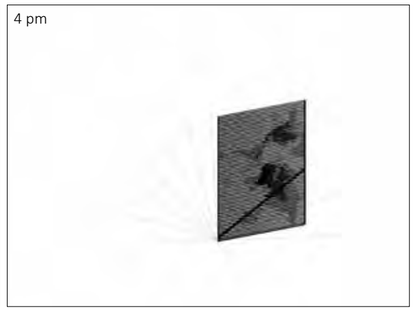


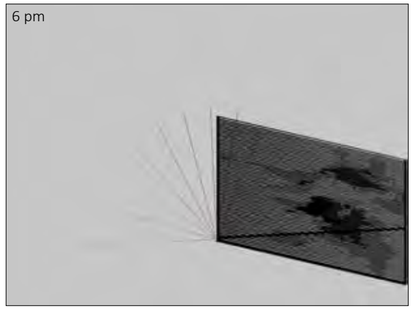












Here we see a sundial with a triangular gnomon in plan view. A scanimation image of the rotated world maps is attached to the gnomon. Depending on how the rays of the sun hit the gnomon, the image of the scanimation will change. This combination of sundial and scanimation has been brought to perfection by the designers of the so-called 'Digital Sundial'. SEE APPENDIX. Towards 12 o'clock the shadow of the gnomon will only cast a thin line shadow corresponding to the world map which was rotated into a line. We see the different full hours: from the top left: 6 o'clock in the morning, 7 o'clock and so on, ending with 18 o'clock in the evening. All renderings are from the 21st of June as simulated with *3D Studio Max*'s sunlight system.

FIELD OF SUNDIALS

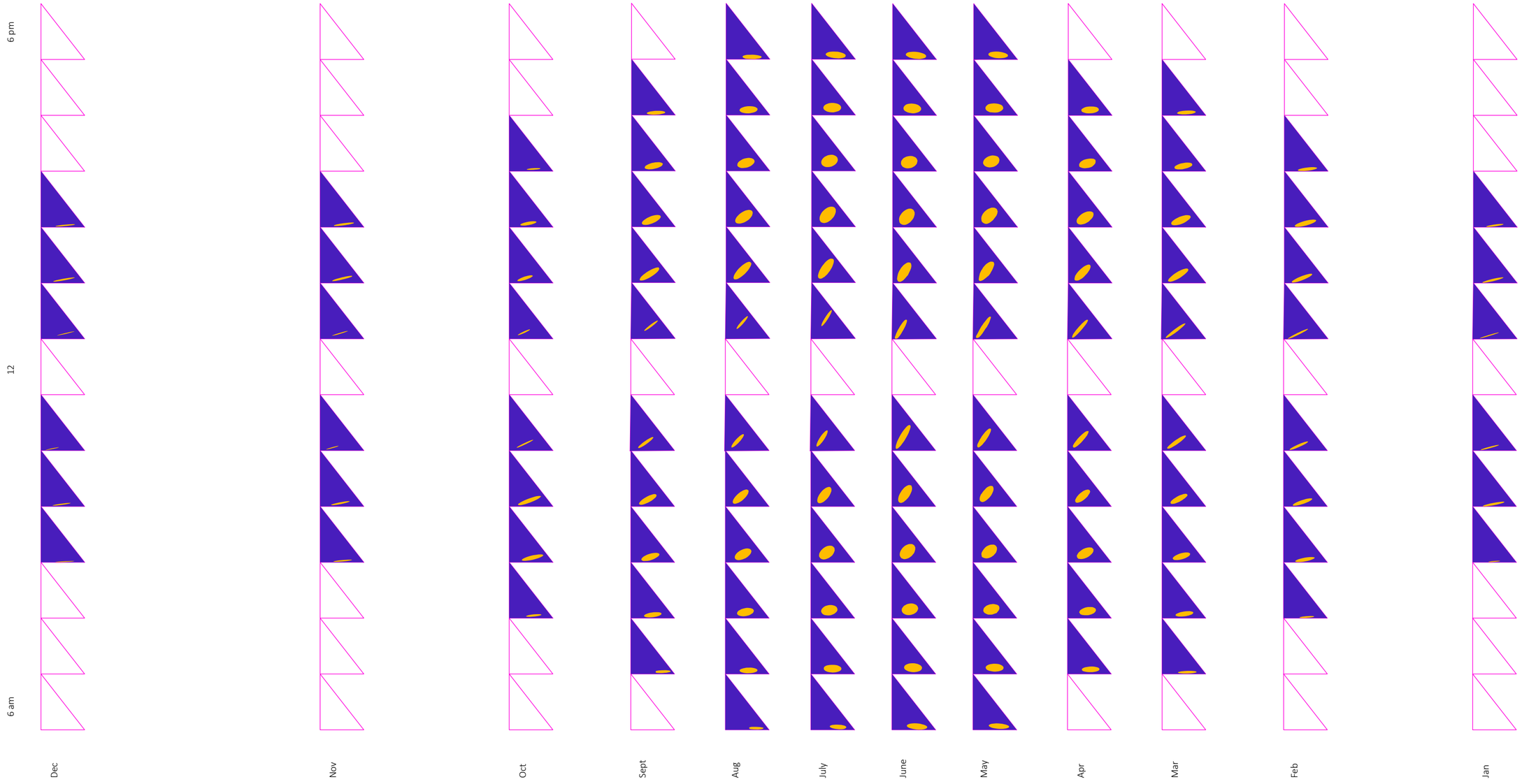
I drew a field of sundials located in Berlin, which is about the mutual dependencies between projection and analogue and digital notation. These drawings are kindred to the world map of time zones maps, a sort of inverted version of the same principles and themes. Whereas the world map of time zones showed a generalized image of the earth and counted time in a graticule to enable time at different places to be compared, these drawings strike down at a specific place, Berlin. The world map of time zones had twelve o'clock on the Greenwich meridian as its reference point, and this field of sundial has the 21st June in Berlin as its reference point. That is the longest day of the year where the shadows are shortest and there is the most light.

A triangular gnomon is placed in the centre of a half-circle dial, and the long side (hypotenuse) is running parallel to the axis around which the earth is spinning. The angle of the gnomon's hypotenuse must be adjusted to the exact location on earth where the sundial is placed in order for the shadow to fall correctly onto the dial and show the time at this exact location. The drawings are made with *3D Studio Max's* sunlight simulation system, and if we take one sundial (see opposite page), the almost horizontal line marks six o'clock (am, ante-meridian) on the far left and six o'clock (pm, post-meridian) on the far right, while twelve o'clock follows the almost vertical line in the middle. The sundial only shows what time it is as long as there is light enough for shadows to fall. In the winter period it will not be possible to tell time on the extremes, because it will be dark from around four o'clock (pm) onwards. The field of sundials I have imagined here follow this principle:

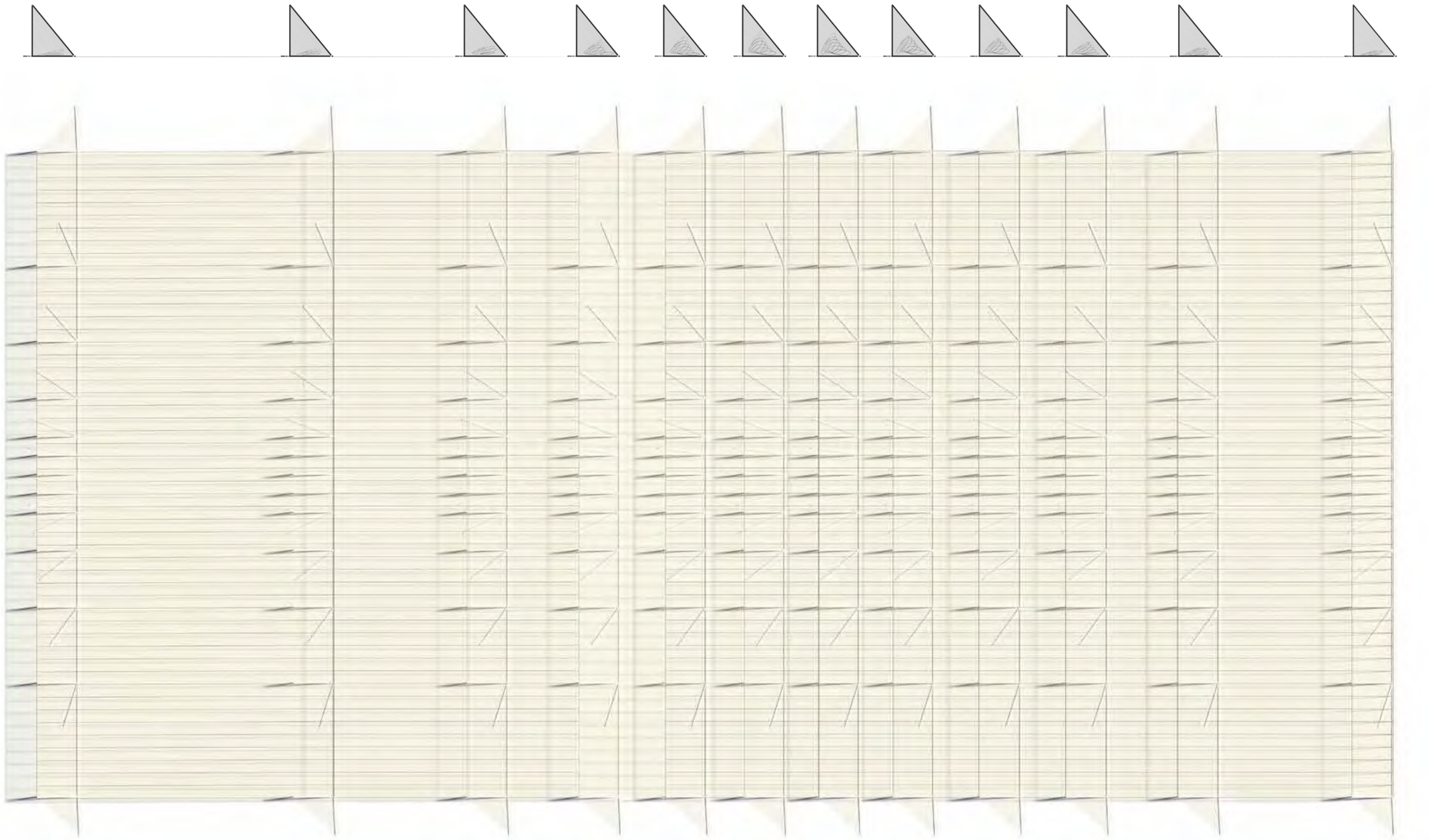
At every full hour a complete circle of light will show within the triangular shadow that the gnomon casts onto the dial. The circle is drawn in light and emerges due to parallel projection through an ellipse that is cut out of the gnomon. A cut-out ellipse will project a full circle when the light flows through it at the correct angle at every full hour. The drawing is composed of twelve rows of sundials, one row for each month. Each of the rows consists of twelve gnomons, and each gnomon has had an oval hole cut out of it, where the sunlight can shine through. This means that the drawing is structured like a calendar with twelve hours per month. As such, one could write the drawing like this:

21st of December: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of November: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of October: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of September: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of August: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of July: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of June: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of May: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of April: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of March: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of February: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
21st of January: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

This is a line drawing of the field of sundials in 1: 200. The circles mark the light as it shines through an elliptical hole in the gnomon every full hour. Every gnomon has a slightly different elliptical area cut away, because the sun moves across the sky and its rays hits the gnomon in slightly different angles as time passes.



A line drawing of the gnomons in elevation, 1: 200. Here we see the ellipses that are cut out of the gnomons. During the winter season the light comes later and disappears earlier and therefore some of the gnomons do not cast a shadow early in the morning or late in the afternoon. These gnomons are left white.



A rendered plan and elevation, 21st of June 12 o'clock.

SKETCHES AND DIAGRAMS

Structure, indeterminacy and coincidence

Now I will look more closely at the aforementioned nodes of translation and how they may be used not necessarily to make translation processes more 'tight' but rather to open translation processes up, more like sketching. I have argued several times – both with Peirce's diagram in Stjernfelt's reading (icon + symbol), and with Edward Robbins – that conventions in media use grant not just limitations, but also openings. For drawing this opening potential could be said to be sketching. Making a sketch in plan, section, or elevation is a good example of this openness in the convention – one might not yet know what it is that one is sketching, but reading the sketch as if it were a plan already provides the drawing with a set of reading rules, and thus one can imagine that part of the sketch is a room, another is a stair, etc.. This is one way of sketching *within* an openness of the conventions. But it is also possible to sketch *on* the convention itself, that is, to trying to sketch forth alternative reading rules. Sketching, then, is a way of opening conventions up.

Musicians and architects have sometimes felt that the conventional ways of mediating their art form could not accommodate the music or the architecture that they wished to make. In architecture this has, for instance, been the case with Robert Venturi, Denise Scott Brown, and Steven Izenour who felt faced with an urban situation in Las Vegas without having the right medium to engage with it, and thus had to invent new notational forms.[54] Claus Peder Pedersen also mentions a group of architects who felt that conventional geometry was an obstacle to living a free life, for instance, Friedrich Kiesler who attempted to use geometry in new ways in his *Endless House*.[55] Also Bernard Tschumi wished to expand conventional ways of drawing architecture in *The Manhattan Transcripts*. In music, notational conventions have experienced deliberate resistance from the current broadly referred to as *neue Musik*,[56] where graphical notations are cultivated in order to enable new music to emerge and to broaden what it is possible to think of as music. It seems as if notating music in unconventional ways is a way to generate new sorts of music. It is to such 'sketching acts', where conventions are themselves sketched upon, that we will now turn. The combination of conventional projection, *digital* notation, and 3D fabrication tools has been criticised for 'translating too little', as it was discussed in the state of the arts chapter. But how can this construct, which changes too little in translation, be opened up? This chapter takes a first step into answering that question by trying to catch a glimpse of how a translator medium can be more or less indeterminate in the way it conveys instructions, and how that can be considered as a sort of sketching.

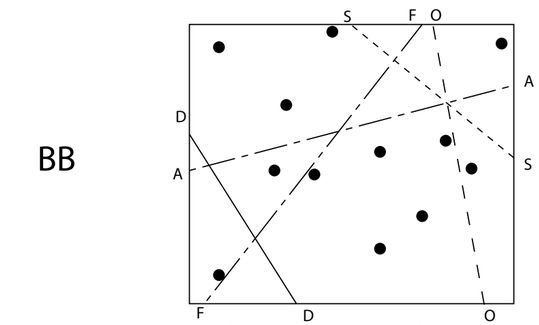
A musical sketch diagram

In his theory of notation Goodman analyses John Cage's musical composition *BB,* part of his Concert for Piano and Orchestra (1957-58), and discovers that he cannot place it into either of his categories of allographic or autographic notation. Goodman calls it an "autograph diagram"[57] and resembles it to a sketch that comes before an event.[58] In painting, a sketch comes before the final painting and, in some cases, the sketch is directly transformed into the painting, while in music a sketch notation is not *transformed* into the performance in the same way, but rather the musical notation exists in parallel to the performance. (Again, the difference is reflected in the prefix *auto* meaning *self*, and the prefix *allo* meaning *other*.)

What an architectural drawing shares to a greater extent with musical notation than with a painting is the difference *in kind* between the notation and the performance or end product: an architectural drawing does not become a building, but it instructs one. Here architecture and music both work with allographic scores in a way that painting does not. But architectural drawing shares with painting the fact that that a sketch can become a working drawing, and in that sense a drawing goes through the same transformation *itself* as a painting, although it still ultimately orchestrates something else, a building, in a way that is more like a musical score. Painting and architectural drawing also share in being iconic in appearance. Cage's *BB* shares these qualities too: it has an iconic, image-like quality to it as well as being sketch-like, as Goodman says. Moreover, it communicates many simultaneous, non-linear relationships that are to be performed, although the signs it gives do not conform to conventional reading rules.

A sketch in Goodman's terminology is like a painting and does not orchestrate something other than itself, as opposed to a score, which orchestrates something other than itself.[59] And this is the paradox of Cage's notation: it is *simultaneously* a sketch – its image-like appearance being intended in itself – and a score – intended to orchestrate something external to itself. A sketch *is* an artwork in itself, but in the notation of *BB* we have a sketch that gives instructions and therefore becomes score-like. Comparing it to a sketch which comes before an event could imply that *BB* was not quite finished, but that would be wrong to think, since it is finished, and its indeterminate mode of giving instructions is a point in itself. *BB* is notated with such a level of indeterminacy that it is impossible to say of any performance with certainty that it stems from the notation. However, it is a very precise way of notating indeterminacy, a point that Hans G. Helms discusses when talking about the particular Cage concert that *BB* is part of:

> In his Concert for Piano and Orchestra of 1957-58, Cage has […], refrained from laying out the individual parts in a network of relations fixed by a score; instead, he has equipped each voice with certain directives and certain freedoms; the conductor also has a part, and signals the acceleration or slowing of the course of time with arm movements similar to those of the hands of a clock, so that the participants can orient themselves. Instead of a system of dependence on the conductor, there is only the orientation to the course of time, equally binding for all.[60]

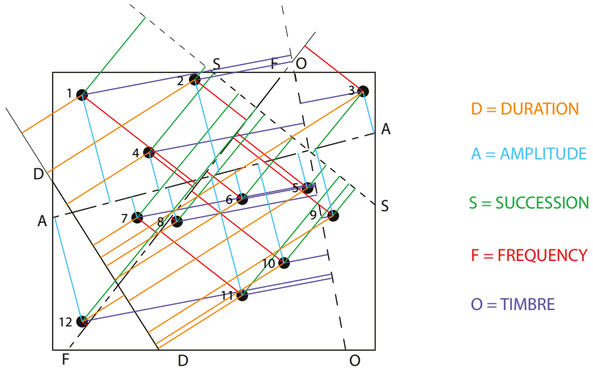


BB by John Cage, from *Concert for Piano and Orchestra, Solo for Piano*. Redrawn by me.

This description says that it is first and foremost the conductor's control of the course of time that is the framework; beyond this there is a great deal of openness as to what will finally be performed. However, *BB* comes with some guidelines: one could call it an open rule set which conveys instructions and refers to actions outside the graphical space of the notation. Because of this rule set *BB* has allographic elements with similarities to signatures in a map being explained in a legend.

> … dots, for single sounds, are placed within a rectangle; across the rectangle, at varying angles and perhaps intersecting, run five straight lines for (severally) frequency, duration, timbre, amplitude, and succession. The significant factors determining the sounds indicated by a dot are the perpendicular distances from the dot to these lines. … [61]

But the instructions are insufficient to determine what exactly is to be played, or to identify which performances stem from this notation. Therefore the criterion of identicality between notation and performance which Goodman lists as decisive for being an allographic, digital notation is not satisfied. On the other hand, together with the graphics this rule set does give *some* idea of how the composition is to be performed; some reading rules are provided along with the icon. But in order to learn more the performer literally has to draw the composition further and try to dismantle



D = DURATION

A = AMPLITUDE

S = SUCCESSION

F = FREQUENCY

O = TIMBRE

My interpretation of the instructions. Cage has told us that S is the line that expresses succession. And he has also told us about the relationship between the dots and the lines- which is orthogonal. The progression in time of the twelve tones is defined by the distance of the dot to the line. But I do not have a scale that translates the distance into minutes; what I have is the conductor but I have to decide how the progression of time maps on to the various twelve tones. The first tone, which I have marked with the number 1, would have to be played before the time scale actually starts and would thus not be played at all. I could therefore choose to extend the S-S line until it would meet tone number 1 and thus make tone number 1 the starting point of my measuring scale. Moreover, this is only considerations to line S. The other lines express other things in the music which I simultaneously would have to decide and connect with the succession.

more clues. This leads to a necessity for interpretation, where the performer must decide how to translate the relation between the notation and the tones to be played – the performer is actively required to decide at 'nodes' of translation, where, in a typical score, a decision has already been taken. Despite the clues achieved by drawing further, the composition does not have a scale, so any measure that could inform us of the exact meaning of the distance of any of the orthogonal lines from a dot to an oblique line is missing. Therefore the musician must either apply a scale himself, or interpret an approximate meaning into the composition in order to create a coherency. The only thing that is clearly defined is that twelve tones (twelve dots) are to be played, but when a dot does *not* lie in an orthogonal relationship to a guideline such as *S-S*, then there is insecurity as to how this is to be dealt with. Moreover, the tones to play and the order to play them in are undefined, and the duration, pitch, frequency, etc. of each tone is little more than hinted at, and then only hinted at once the composition has been developed further *and* interpreted. The performer never acquires clear meaning. The simple-

looking composition consists of five overlapping relationships of duration, amplitude, succession, frequency, and timbre, and as such it is an iconic representation of several relationships at once, although intended to unfold linearly in time. Here relationships in time are laid out simultaneously in an operational icon (a diagram) instead of as a linear sequence. Because of the inconsistencies and indeterminacies, Goodman thinks that syntactical and semantical distinctiveness is lacking, and therefore that the notation is not allographic, although it contains allographic elements in that it passes on instructions and has a reference system that conveys meaning to some extent. Also the instruction to play twelve tones gives a common feature to all performances stemming from this composition, but that is not sufficient to determine notational identicality between the notation and a performance of twelve tones.

This means that, in making this composition, Cage is not sketching forth an image, as one might do with architectural drawing, but rather he is sketching out a set of rules. He is sketching forth a diagram, and even if it is finished it is not completely coherent. And nor is it meant to be in this case because the idea is that the performer co-decides the performance, although Cage does not give up authorship of the work for that reason. Rather he authors a setting for the performer to accept and then interpret. Indeed, such musical notations have been called "open works"[62] by Umberto Eco, and they manoeuvre in a space of balance between allowing participation and retaining a more consistent or autonomous character of a work of art. This is relevant because these open works move towards participation in the creation of art works, and thus negotiate authorship and agency. It might be worth noticing this kind of balance when the attempt – as Mario Carpo mentioned – involves working with computational platforms such as Wikipedia in architectural design processes. But this possible relation between open works and open source platforms calls for more research.

Cage's notation is interesting because of its way of structuring an open relationship between notation and performance and because this is done through a diagram that uses both iconic and symbolic signs. It sets the field for a performance, but arranges the performance in an open way, because – being both image and instruction, sketch and score – *BB*'s reading rules do not comply with the image it depicts. In this displacement lies a resistance against musical conventions. The performer must fill in gaps and make decisions that add to Cage's framework, but the performer must also accept Cage's framework as the premise of the performance. Once this premise has been accepted the performance can unfold as a kind of 'sketching act'. The openness in this sort of notation distributes authorship out into the field while also being a work of art. There is a lack of distinctiveness at play in the way the notation gives instructions, which is characteristic of sketches and icons[63] and which becomes productive for the performance. It explores gaps between the maker and the notation, and the notation and the performance by

making what Allen has called a "loose fit"[64] between notation and performance. The sketching act between the notation and the performer is put into focus. The sketch character emerges *not* from a loose or searching way of drawing by hand on Cage's side, but from a mixed use of digital and analogue notation.

Architectural sketch diagrams

Where could something similar be found in architecture? In the essay *The Provisional Work (inspired by Umberto Eco)*[65] Pedersen picks up Umberto Eco's thread from *The Open Work*[66] concerning indeterminate notational and compositional art works, in relation to architecture. Pedersen suggests rethinking what the meaning of openness and uncertainty in the architecture of the 21st century, however, he is not aiming at participatory design as such, but at a balanced relationship between a piece of architecture being an art work as well as being an open, accommodating structure for life.[67] Pedersen points out that similar interests expressed in the open works of music can be retrieved in particular in structuralism, mat-building, megastructures, and metabolism, where architects have challenged "closed forms of composition."[68] Using another term, these -isms have also been called "diagram architecture"[69] by Stan Allen. His diagram architecture operates like a diagram in that its potential is not necessarily to secure and determine a translation of an authorial idea, but just as much to create a *loose fit* between building and program. As an alternative to closed, prescriptive forms of compositions, structuralist architects tried to make buildings and prescriptions more loose, for example by creating kits-of-parts that could be placed provisionally in structures, as in some Archigram projects,[70] or by creating modular building structures that were intended to be reconfigured over time, as known from the concept behind the *Freie Universität* in Berlin by Candilis, Josic and Woods.

Despite this, critique that has been raised against structuralism as being quite the opposite of flexible – and I point this out because the diagrammatic thinking that lies at the heart of this way of creating architecture is now enjoying new attention due to computational algorithmic ways of designing.[71] A quite clear and rational diagram was used to generate the *Freie Universität*. As Candilis, Josic and Woods wrote on their competition plan for the *Freie Universität*:

> Distances and dimension were chosen:
> A./ According to the relation between common and specific university establishments.
> B./ According to the size of the individual faculties.
> C./According to the size of different groups of spaces.
> D./According to the distance between two streets - 1 minute on foot.[72]

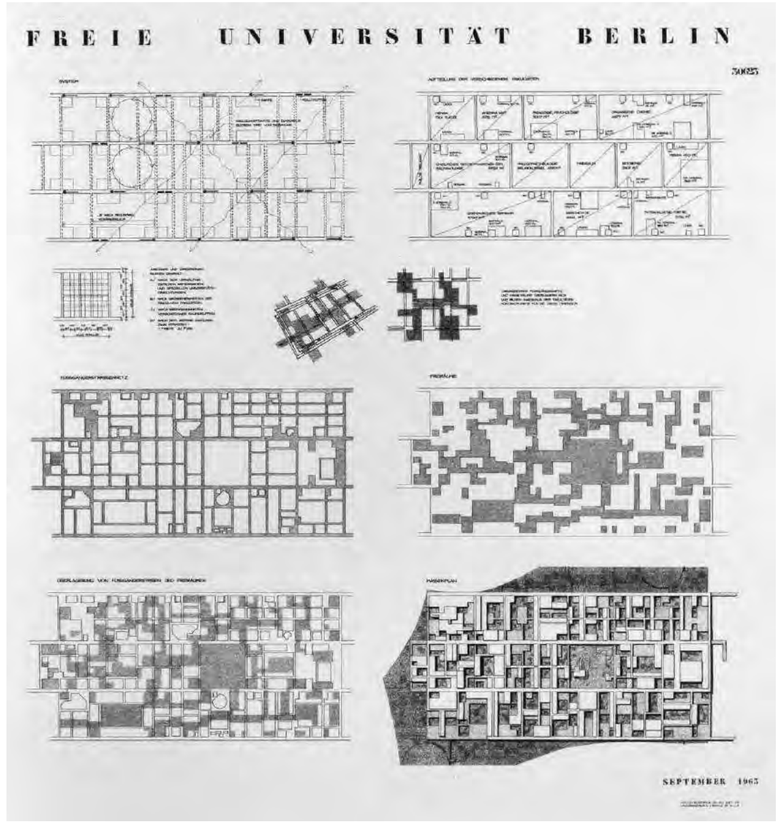


Fig. 11
Competition drawing for Freie Universität in Berlin by Candilis, Josic and Woods, 1963.

This is a rule set written for themselves in relation to the program, but it also generates the spaces, although as rule set for designing it needs interpretation and can be instantiated in different ways. But it is so clear and coherent that with some additional specifications it could be made into a computational, digital diagram which can distribute room sizes automatically in a design suggestion, and let the architects choose amongst a variety of slightly different designs.[73] Interestingly, Josic, Candilis and Woods include a time parameter in order to set out a spatial limit: it should not take longer than one minute to walk from one interior 'street' to another: again an example of an icon (a plan) that works with movement in time. There is a generative trait of diagrammatic thinking here, where *the norm is variety*, leading to a series of works, rather than one singularly composed work. The diagrammatic thinking enhances generativity, both due to the rules of a diagram like the one that Candilis, Josic and Woods formulated which can be instantiated in many ways, and also generativity in that the rules themselves are sketched out.

Junya Ishigami's *Group House* is another example of diagram architecture*:* a home for elderly people with dementia in Japan. Ishigami's idea is to recycle traditional Japanese

wooden houses and building parts collected from all over Japan and place them together in a new structure. The ingenuity of the idea lies in using the tatami convention for measurement that is very strong in Japan, and according to which all traditional houses were originally built, but arranged in new ways.[74] Just as the Renaissance architects were described by Rikke Lyngsø Christensen, Ishigami extracts building components – not directly from ruins, but almost – and arranges them anew, giving them a hyper-modern and yet traditional appearance. The tatami measurements, as a traditional way of laying out houses, are already a 'building system' both embodied in the craftsmen's knowledge and in the houses themselves. It is a quite complex system where all sizes in a house are derived from the tatami mat.[75] However, it is not a unified system but has local specificities, which gives each house a slightly different touch, but which still allows houses or parts of houses from different localities to be easily combined in a new way because of their shared sizes. This facility of combination is retained although one does not know in advance exactly what the result one will get. Moreover, Ishigami's plan diagram uses the convention for drawing and reading plans, but also breaks that convention by not using conventional signatures. The whole complex of houses is drawn as a labyrinth-structure with only the internal and external spaces defined. Ishigami exploits the openness of both architectural drawing and tatami measurement, and combines the two. His move is to reposition traditional houses and he does not need to communicate this very exactly, both because the craftsmen already know the conventions and because the way in which the recycled houses are to be placed together, forming a sort of village or artificial landscape, is intended to have a certain openness. It is supposed to look somewhat compound and informal, although it is also very precise and controlled due to the conventional framework lying behind it. This is also an example of a *loose fit* between building and program generated from a diagrammatic way of thinking with the openness of conventions.

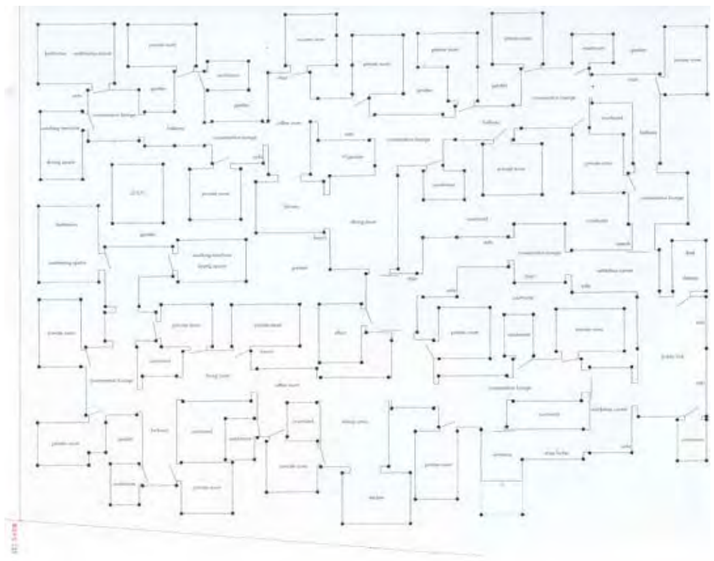


Fig. 12
Plan of Junya Ishigami's Group House

Devices that generate drawing processes

While both the *Freie Universität* and the *Group House* are examples of diagrammatic thinking that point directly towards building, the next work, Bernard Tschumi's *The Manhattan Transcripts*[76] (1976-1981), points only indirectly at building. Nonetheless, the *Transcripts* also take close inspection of the diagrammatic activity between architect and drawing as their theme. In the *Transcripts* Tschumi works with transformational rules in a way that is very compelling for this PhD, where my drawings are relatively theoretical and are related to movement notation and diagrams, as also thematised in Tschumi's work. Tschumi says that the *Transcripts* are a kind of research, a theoretical series of drawings.[77] Not scientific research, but a form of architectural research, with drawing as its epistemic vessel. In the introduction to the *Transcripts* Tschumi says:

> *Books* of *architecture, as opposed to books* about *architecture, develop their own existence and logic. They are not directed at illustrating buildings or cities, but at searching for the ideas that underlie them. Inevitably, their content is given rhythm by the turning of pages, by the time and motion this suggests. The books may read as sequences, but they do not necessarily imply narratives. They can be theoretical projects, abstract endeavours aimed at both exploring the limits of architectural knowledge and at giving readers access to particular forms of research.*[78]

This statement is much in line with what I have argued in the more methodological chapters *DRAWING REASONING*, and which in general I hope to have developed and made accessible in the cooperative play between the drawn and the written parts of this project.

Questioning conventions

The *Transcripts* are an example of how a 'piece of reality'– real and imagined events occurring on the island of Manhattan – is turned into a drawn world of one's own.[79] This is a 'cultural act' of drawing where the 'outer' world is transcribed into a more subjective world of drawing.[80] As Cage does with music, Tschumi questions architectural drawing conventions in order to allow new architecture to be developed and to contain aspects of the world which conventional drawing is not equipped to describe. He states directly his intention to break away from existing conventions:[81]

> The original purpose of the tripartite mode of notation (events, movements, spaces) was to introduce the order of experience, the order of time – moments, intervals, sequences – for all inevitably intervene in the reading of

> the city. It also proceeded from a need to question the modes of representation generally used by architects: plans, sections, axonometrics, perspective. However precise and generative they have been, each implies a logical reduction of architectural thought to what can be shown, at the exclusion of other concerns. They are caught in a sort of prison-house of architectural language, where 'the limits of my language are the limits of my world'. Any attempt to go beyond these limits, to offer another reading of architecture demanded the questioning of these conventions.[82]

The diagram that Tschumi shares in *The Transcripts*, which he calls a "device" and a "tool-in-the-making"[83] can be used by other architects, not as a way of making a copy, but as a way of setting up one's own more or less theoretical drawing game. As an architectural inquest carried out in drawings, Tschumi's drawings are both rationally and sensually generated. He adds *event* and *movement* to the conventional ways of notating space, so that *space, event* and *movement* (S, E, M) make up a structure in a tripartite scheme of four episodes of drawings in a sequential, square format inspired by the Russian filmmaker Sergei Eisenstein's storyboards and his montage theory.[84]

Devices and moves

Tschumi insists that the *Transcripts* are a "device"[85] and a "tool-in-the-making"[86] before they are anything else. Moreover they are a device which cannot be shown, and one which cannot emerge without drawing it. The device itself is captured and sustained in finished drawings, like a set of drawings that play the role of being epistemic artefacts. As 'device' the *Transcripts* are developed and the rules for drawing are changed as the drawing series progresses. Tschumi *questions* conventions but the *Transcripts* are also an *inquest*: here Tschumi is the 'drawing detective' looking into a series of violent and passionate events in New York via drawing, and it seems that he is sketching forth a diagram. He starts abductively by creating relations between clues in the local environment, questioning and guessing, and then step by step the internal rule set of *The Transcripts* becomes increasingly clear, an increasingly coherent diagram. But, interestingly, it also becomes increasingly subjective, at least from the reader's point of view.

Tschumi himself says that the "method"[87] of the drawings became increasingly clear towards the later drawings,[88] although the first and second series of drawings are the easiest for the reader to understand. In that sense they are more conventional and follow presupposed reading rules. In *MT1*, the first series, three squares show space, event, and movement, almost like a comic that follows a story line about a murder in a park. We see a photograph of a running person in one square frame that indicates a drama when read together with the short text that introduces the narrative that a murder has been committed in the park. Then, in two other square frames we see a diagram of the movement and a plan of the park. It is easy to make the connection that this running person is moving in such a way through that park.

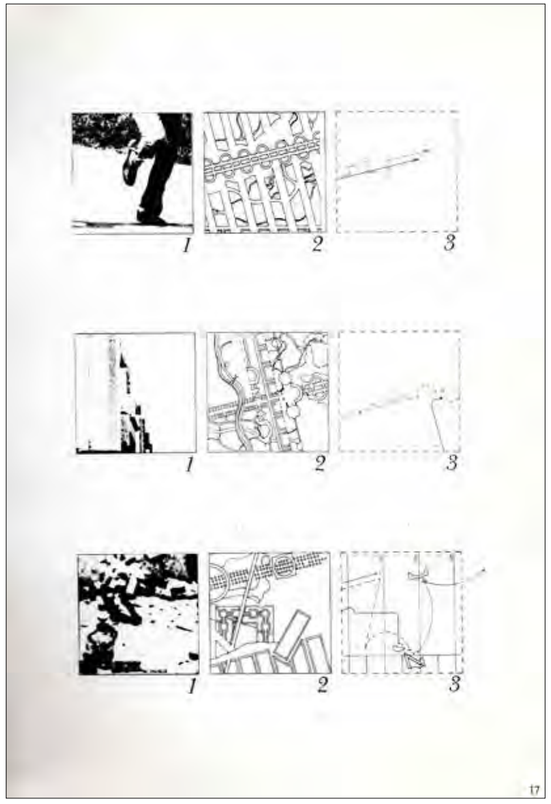


Fig. 13
Bernard Tschumi, *The Manhattan Transcripts*, MT 1, The Park

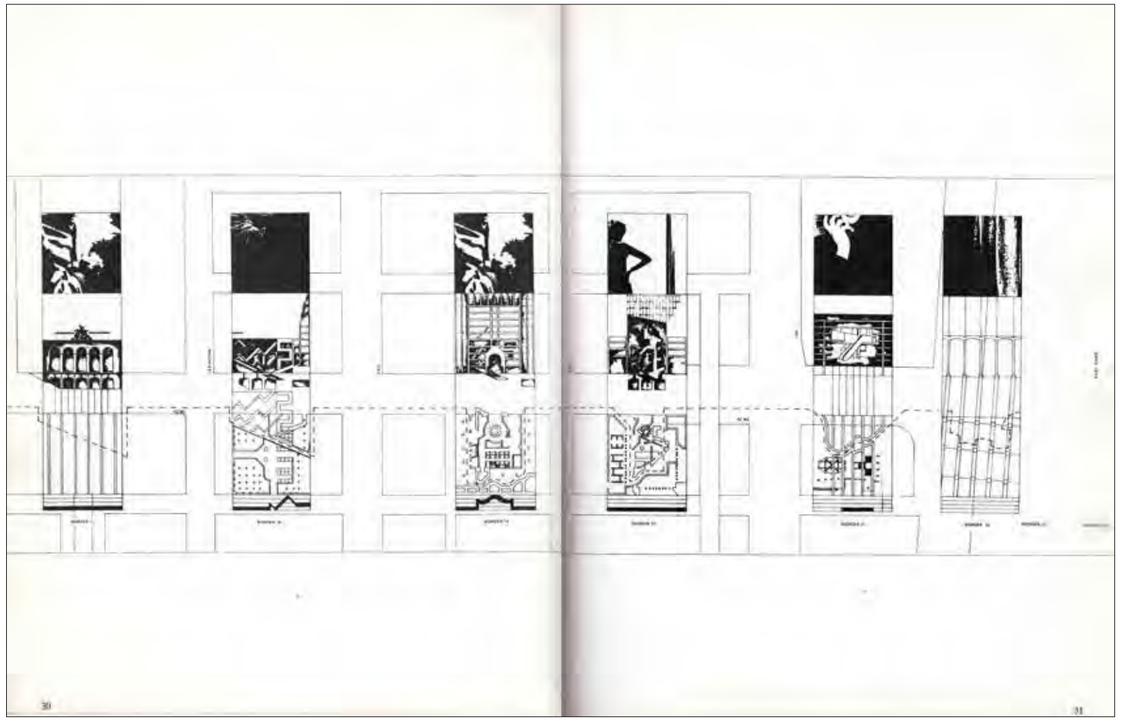


Fig. 14
Bernard Tschumi, *The Manhattan Transcripts*,
MT 2 The Street

In the second series the tripartite scheme – S, E and M – is laid out on a map of Manhattan's 42nd Street. S, E, and M are still indicated, but the drawing also conveys a feeling for the Manhattan grid structure, with the streets running across the entire width of Manhattan Island with high-rises on each side. Here the tripartite squares follow the vertical vector of the city, and are still relatively legible through conventions. But the conventional diagram is then transgressed little by little by "subjective moves" as Tschumi calls it:

> [...] as opposed to logical transformations that proceed from rules inherent in the nature of the object, the Transcripts' sequences often proceed from 'subjective' moves. Although an objective rule is given arbitrarily (compression or superposition, for example), its implementation, articulation, and final form depend upon the person who applies the rule. In other words, such sequences cannot result from a simple cumulative process of logical transformations for which instructions can be given to anyone.[89]

A device in Tschumi's sense is then an objective rule which is carried out in drawing by a subjective move. This is deepened right away.

In the third series, *The Tower*, the high-rise typology is treated along with other Manhattan building typologies: asylums, back-yards, cells, and institutional and domestic buildings. The verticality and drama of the tower is underlined by a falling event. Here S, E, and M is not followed strictly, but a tripartite structure can still be sensed, and the transformational rules of the diagram are developed yet further.

Fig. 15
Bernard Tschumi, *The Manhattan Transcripts*, MT 3 The Tower (the Fall)

Fig. 16
Bernard Tschumi, *The Manhattan Transcripts*,
MT 4 , The Block

In the fourth series there is still a tripartite structure, but movement notation now happens on two levels, both depicted in photographs, but also within the way the drawing is an accumulation of other drawings and photos. The way the device lying behind the drawings 'moves', makes itself legible in the structure, but not so much as narrative. New drawings are generated, where some motives are repeated and cut together like a montage "jump-cut".[90] Emphasis moves from initially being about more free and coincidental movement patterns to being about formalized movement patterns, group movements, teams, players, dancers, etc., and about the system that generated the drawing's composition. Tschumi has set up a transformational drawing game for himself that can challenge previous conventions, because it works with transformational rules: this is what I have called diagram. He explains it as follows:

> 7.0 TRANSFORMATION
> *The sequences of the* Transcripts *are intensified by the use or devices or rules of transformation such as compression, insertion, transference, etc.*
>
> 7.1 DEVICE
> [...]
> Any work on autonomous forms [...] requires the conscious use of *devices*. Devices permit the extreme formal manipulation of the sequence, since the content of congenial frames can be mixed, superimposed, faded in or cut up, giving endless possibilities.[91]

Tschumi's drawing game begins in a more conventional way with a relatively clear device (diagram) with reading rules. But then, as he draws further and develops his device, disjunctions and distortions occur in the initial diagram and little by little it is transformed. In parallel with this the device becomes increasingly clear – not as a conventional reading rule, but as the internal, subjective logic of the drawings; as behind lying structure. Tschumi transforms the initially relatively conventional scheme with its relatively conventional reading rules, and makes a new device. In Stjernfelt's words the diagram is "a formal machine for Gedankenexperimente,"[92] which allows us to go further in our inquiries and to learn more,[93] and Tschumi's device allows the same in his drawing research. But in order for a form of drawing reasoning to happen, the device, so Tschumi, must be instantiated by a subjective move, a subjective drawing action. The idea of the objective device (or rules of transformation as he calls it in the quote above) and the subjective move has strong undertones of playing or gaming, and Tschumi also refers to *The Transcripts* as a sort of drawing game.

> ..., the event's allegorical content can powerfully disturb the neutral logic of the game's successive moves, introducing a purely subjective reading.[94]

The collective of *The Transcripts* thus becomes cumulative of subjective and non-repeatable moves on Tschumi's part, although the game unfolds on the basis of objective rules. While the *Transcripts* begin with a "three-square principle [that] underlies this deadly game of hide and seek,"[95] the game changes towards the end where group movements and architectural elements have been transformed into drawing patterns. As a way to explain this development, Tschumi presents some quite complex formulaic diagrams that allowed him to make manipulations according to these five devices: *repetition*, *disjunction*, *distortion*, *fade-in sequences*, and *insertion*.[96] These

are strategic devices that guide the drawing actions, following Tschumi's formulas.[97] But other *devices* are instructions in discursive language, in a similar way to *superimposition*, which is translated to drawing through a subjective move.[98] As opposed to a game which can be played without any transformation occurring, a device requires interpretative action and transformation. *Superimposition* is not a clear instruction for a drawing action to unfold, but the word does enable a drawing action: it is a guideline but not a law. The device *superimposition* rules some things out of the drawing's repertoire, because not everything drawn can be considered to be superimposed. On the other hand, *superimposition* can be drawn in many different ways, so it also becomes generative of the drawing process.[99] This indeterminacy becomes productive in the gap between Tschumi and the drawing, and between the drawing and the reader, and gives the otherwise highly elaborate and precise drawings a sketch-like quality and an epistemic value. Tschumi puts his devices into a system, and thus, in a quasi-logical way, he systematizes coincidence and events as a way of making his drawings,[100] and cultivate the indeterminacy of the gaps - gaps are bridged from frame to frame, from drawing to drawing, from series to series, and guided along by rules, but slips, slides, and jumps happen between frames, between the "discrete, discontinuous moments"[101] that the drawings embody. Thinking also slips and slides between frames – in what the comic artist Scott McCloud calls "the gutter"[102] – so when Tschumi talks about the drawings as being "discrete moments" this is not discrete digital notation, but jump-cuts between states of actualisation between which the thought flows. As in Cage's composition there are both 'objective' rules of discursive language at play (compression, superimposition etc.) and subjective moves, jumps, flows of thought, and ways of applying the rules in the drawings in order to question conventions. Tschumi made a device – a drawing project – by using devices. Said differently, he has sketched forth a diagram by way of diagrams.

Chance Methods

But why create a set of drawings by means of structuring coincidence and cultivate indeterminacy? Because – and this should remind us of Deleuze's *diagram as motif*, which is a way of destructing clichés – coincidences destruct conventionalized patterns of movement and thoughts. Maybe Tschumi is interested in instantiating an objective rule by a subjective move for the same reasons that interested both Cage and the choreographer, Merce Cunningham, in their work with "chance methods."[103] As theatre and dance theorist Camilla Damkjær explains, more than the everyday coincidence is required in order to put coincidence into play in their artistic process.

> When Merce Cunningham and John Cage start to work with the coincidence, it is an attempt to transgress the limits of the aesthetic subject. In Cunningham's case [it is] a search for new movement and a transgression of the already established body. In Cage's case it is partly a striving to place all sounds on an equal footing and partly a giving up of control over the subject's control of matter. But in order to be able to work with coincidence it must be framed. If we try to do something merely a little coincidentally we risk falling back on old habits. Therefore Cage and Cunningham always deal with *'chance methods'*.[104]

Framing coincidence is also an important trait in *BB* and *The Transcripts*. The frames in *The Transcripts* provide a clear structure, but every drawing that itself consists of frames is also a frame in a larger series. Framing jump-cuts and coincidence is a way to try out new ways of drawing, just as Cage and Cunningham used chance methods to put together new ways of positioning the body in order to open up conventional schemes of movement.[105] It is not improvised, because improvisation could fall back on subconscious conventions, they think, but instead deliberately forces a transgression of conventions. Thus unconventional drawing patterns may come forth, which can reflect the conventional ones and allow them to be seen as presupposed, co-forming structures. The drawings that structure coincidence set up a resistance to conventions by showing what could not have been thought within the convention. Where Cage in *BB* left it to the performer to make the interpretation, Tschumi sets up a game of rational structure and subjective moves with himself as both interpreter and performer. When this interpretative act of drawing then unfolds, it does not lead to one drawing but to a series reflecting the range of combinatorics that emerges from Tschumi's diagram. But this game also reaches beyond itself, as architectural drawings that work with conventions always do, even if they are deliberately questioned as in the *Transcripts*. These drawings offer themselves as a *device*, as a diagram, which famously became the foundation for making *Parc de la Villette*.

Peirce and Stjernfelt's diagram has a double nature which makes it opening and generative, and yet rigid and structuring. When abduction and deduction meet, the abductive source; the direct contact to the world, can disrupt deductive rules and conventions, while also being stabilized and socialized by them. Abductions and deductions 'rub' against each other and set free rifts and jumps in which thought can flow and imagination kick in. The drawing conventions are diagrammatic and therefore fundamentally opening, they can even be transformed themselves. Sketching can take place within the limits of conventional drawing, but can also take place *on* the conventional drawing diagram itself, an epistemic process which might lead to new, more general diagrams, or might simply remain as singular, subjective diagrams. Therefore the conclusion is that diagrammatic reasoning is not merely a structuring form

of reasoning, but a transformative form of reasoning: a trait which is more generative than any technical apparatus or notational form alone.

Algorithmic drawings

This part of the chapter prepares for my last drawings by focusing on sketching with digital diagrams, i.e. a digital computer code. In the first chapter I presented the drawing series *TOWARDS A DIAGRAM* and *TOWARDS AN ANALOGUE DIAGRAM,* and now these final drawings are called *TOWARDS A DIGITAL DIAGRAM*. It continues the thoughts generated from Cage's *BB*, which was a sketch for a diagram, which could be made digital but which was intended to remain a mix between the analogue and the digital – being thus both clear and indeterminate, both rational and poetic.

When writing a digital code one also thinks diagrammatically. The relations the code orchestrates are arranged in an algorithmic way. The term algorithm usually refers to a set of instructions written in computer code. *Processing*, a software and programming language invented by Casey Reas and Ben Fry, is an open source platform which targets artists, architects, and designers and enables using computer code in aesthetic ways more easily. Although Processing is a computer program, Casey Reas and Chandler McWilliams relate it to an algorithmic tradition in visual art, which encompasses art works from before the computer.[106] They say that an algorithm is a "type of code, […], procedure, or program – [that] defines a specific process with enough detail to allow the instruction to be followed. […]. It's just a precise way of explaining how to do something."[107] According to this definition, - of course written for beginners in order to make the difficult code more accessible - an algorithm can be something other than a computer code, such as a recipe for cooking or a knitting pattern. However, they do outline the difference between algorithms conveyed in discursive language and algorithms written in computer code, but point out that the way of thinking in procedures and related steps of actions is in principle the same. In their next step, of course, a high level of technical computer programming knowledge enters the picture and makes the comparison between a computer algorithm and a cooking recipe quite oblique.

It is relevant for this thesis to see algorithmic thinking as a kind of diagrammatic thinking. When you make a *Processing* script *it* makes the drawing, and here I have used simple *Processing* scripts, which Abe Pazos taught me, to generate iconic drawings, which I have subsequently read something into. I have seen the as plans, for instance. Using *Processing* in this way shares the paradox of working poetically with logical structures both with Cage's open musical work, Tschumi's *Transcripts* and with conventional, architectural drawing. Processing can work with random functions, that is, it can work with 'indeterminacy' but in a completely structured way. This was one of the reasons why Reas argued against the idea that computational design is only about determination at the 2012 Yale conference, *Is Drawing Dead?*

The algorithmic tradition in visual art emerged in the 1960s around the same time as structuralism, the experimental music of Cage, and cybernetics. Although cybernetics and structuralism outline separate theoretical tracks, they also shared areas and both influenced architecture around this time.[108] In the visual arts, artists such as Sol LeWitt or Yoko Ono used algorithmis to make art works in an analogue manner, for instance, LeWitt's written instruction for a group of people informing them how they were to make a drawing by repeating certain drawing actions over a defined span of time.[109]

There are also contemporary artists working within this tradition, for instance, the German artist, Nicolaus Gansterer, whom I referred to in relation to my maps of Berlin, or the German artist, Jorinde Voigt. Voigt in particular uses algorithmics in order to generate her drawings. The way Voigt's algorithms are different from the diagrams described above, for instance, for *Freie Universität*, is that they are even more recipe's for carrying out the work. Voigt makes large, handmade drawings that come in long series. Although handmade, they share with computer-generated art the trait that they all differ slightly from one another, but one can still feel the kinship between them. Another consequence of this algorithmic thinking is that the works are presented in series, rather than one singular work being put in focus. Variety is the norm of the algorithm, and one could almost get the impression that the 'Voigt machine' could go on and on. However, one also senses in Voigt's drawings that she allows herself to break the rules and make relatively free choices as to how her algorithm is translated into drawing. Often she publishes the 'algorithm' that she used to make a drawing together with the drawing:

> STAAT/Random (IV)
> [Matrix 4: Algorithmus Alderflug | Strom | Top-100-Popsongs (taktweise) | Elektrische Impulse/doppelte Fraktalsequenz | Puls/ Min. | Standpunkt | Akustisches Feld: doppelte akustische Impulse (Volume in %, Dauer in Sek., Loop | Rotation | Himmelsrichtung | Windrichtung | Windstärke | 2 küssen sich - Aktionsablauf/ Generationen I-II I C4 Detonation | Temperaturverlauf Richtungsansammlungen/Wirbel/Loop I Schlussfeld]
>
> 2008
> Teil der 11-teilige Serie *STAAT/Random*
> Tinte, Bleistift auf Papier I 230 x 115 cm und 67 x 115 cm (Diptychon) [110]

This algorithm has something to do with an eagle flying – the direction of the wind, the direction of the bird against the sky – but is in most aspects quite needy of interpretation. Her algorithm is much like an open work that needs interpretations in order to generate the drawing actions. For instance, one cannot know from this instruction where the drawing starts out on the paper, nor how the different anchoring lines are supposed to be situated on the paper, nor how the curvature of the lines that run between the anchoring lines is to be. Nor do we know which drawing tools are to be used, or what the time indications mean, nor the syntax of the words that are presented together. There is no indication of how her algorithm 'maps' onto the paper. What one can guess and interpret from the instructions she gives herself is very different to how one interprets a digital code and yet it runs along the same lines of thinking in recipes. I would think of Voigt's instructions as an 'analogue algorithm,' as algorithmic thinking which requires poetic translation in closeness to the drawing – just as a painter works directly, analogously on a painting. Voigt's drawings are moving somewhere between an analogue language in the Deleuzian sense, which is sensuously motivated by acts that cannot be translated, and a digital diagram, which can be translated without doubt as in Cage's open work with its mixed notational character. By way of 'analogue algorithms' Voigt inserts a diagram between herself and the drawing and thus cultivates gaps in which translation happens and interpretation is needed in order to be bridged. The diagrammatic structure gives a skeleton-like backbone to the drawing, within which subjective and aesthetically motivated drawing actions can be received.

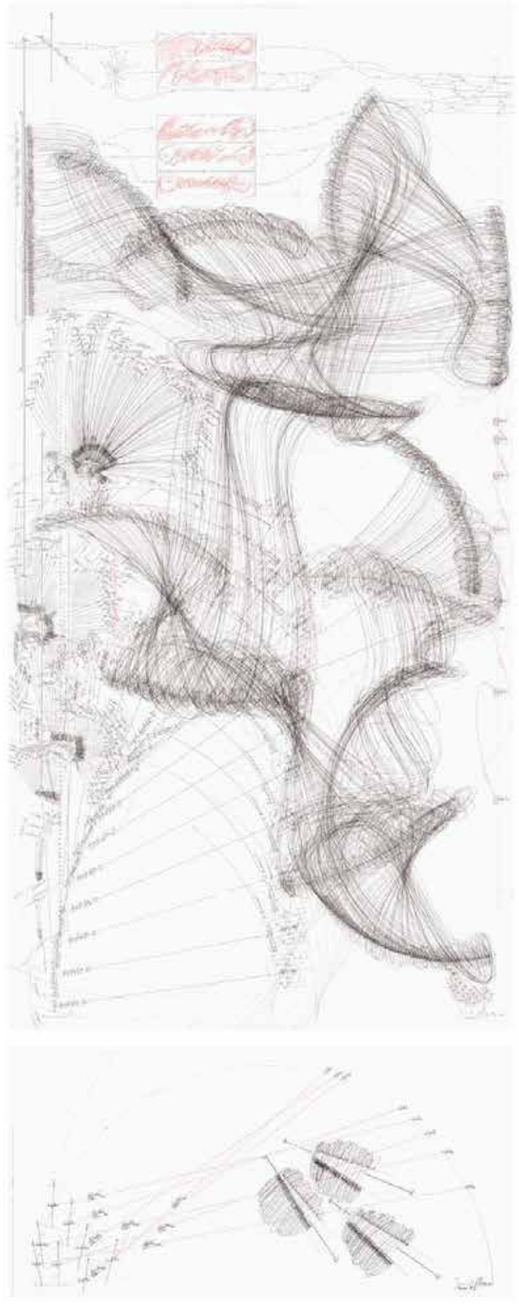
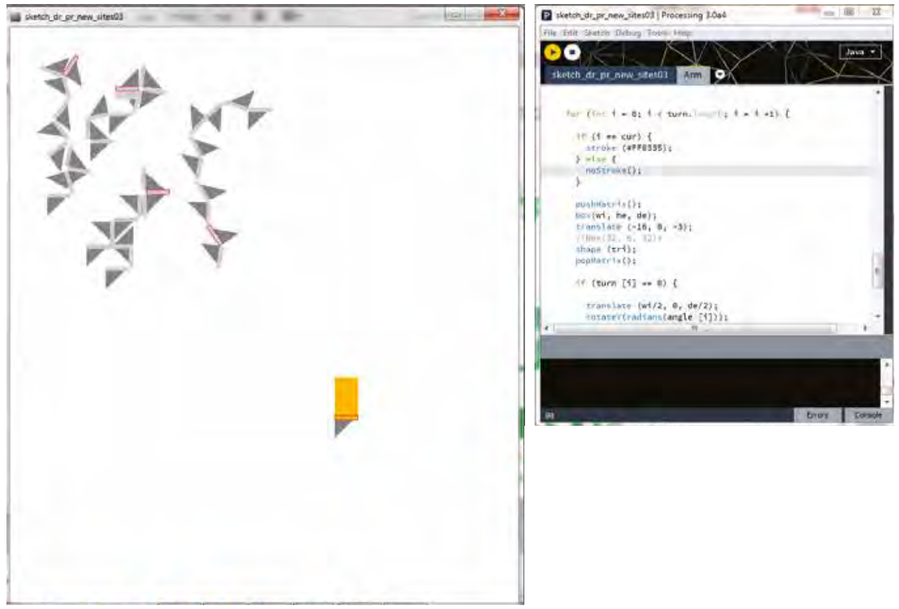


Fig. 17
Jorinde Voigt, STAAT/
Random (IV), 2008.



This script or program can place arms which can rotate around their hinges. Here we see some arms with triangular 'roofs' in plan view.

TOWARDS A DIGITAL DIAGRAM

Playing the non-sense game

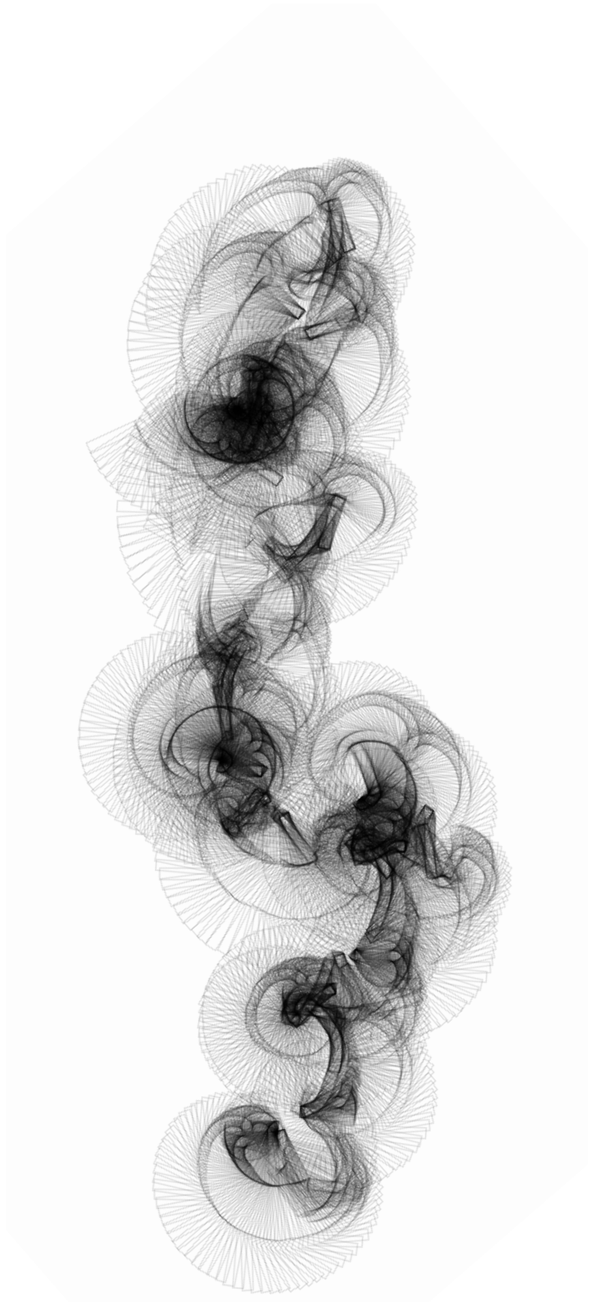
This series of drawings approaches digital computer code. I used simple *Processing* scripts that Abe Pazos (hamoid.com) had helped me make to generate the drawings. This series is related to TOWARDS A DIAGRAM and TOWARDS AN ANALOGUE DIAGRAM in that they have to do with using logical structures and game mechanics as a way of generating the drawings. The drawings themselves are not logical or carry any conventionalized meaning, except that some of them are seen as plans. The snake toy presented in TOWARDS A DIAGRAM played a main role in the *Processing* exercises, because our goal was to simulate its movements. Abe and I did succeed in simulating its geometrical movements (see a screen shot from the script that does this on the opposite page), but not its physical behaviour. The process, however, ramified into all the sketches shown here, which, hence, emerged as exercises on the way to simulate the snake toy. I see them as sketch diagrams that start to hint some spatial qualities.

Seeing drawing in this way – as a way of playing a game – is a metaphor, since playing a game usually leads to a winner or a loser. But when game mechanics are used towards other ends, a game loses its initial sense – to win or lose. It stops being rational, like John Cage mentions, as he tells about how some of his musical compositions were created:

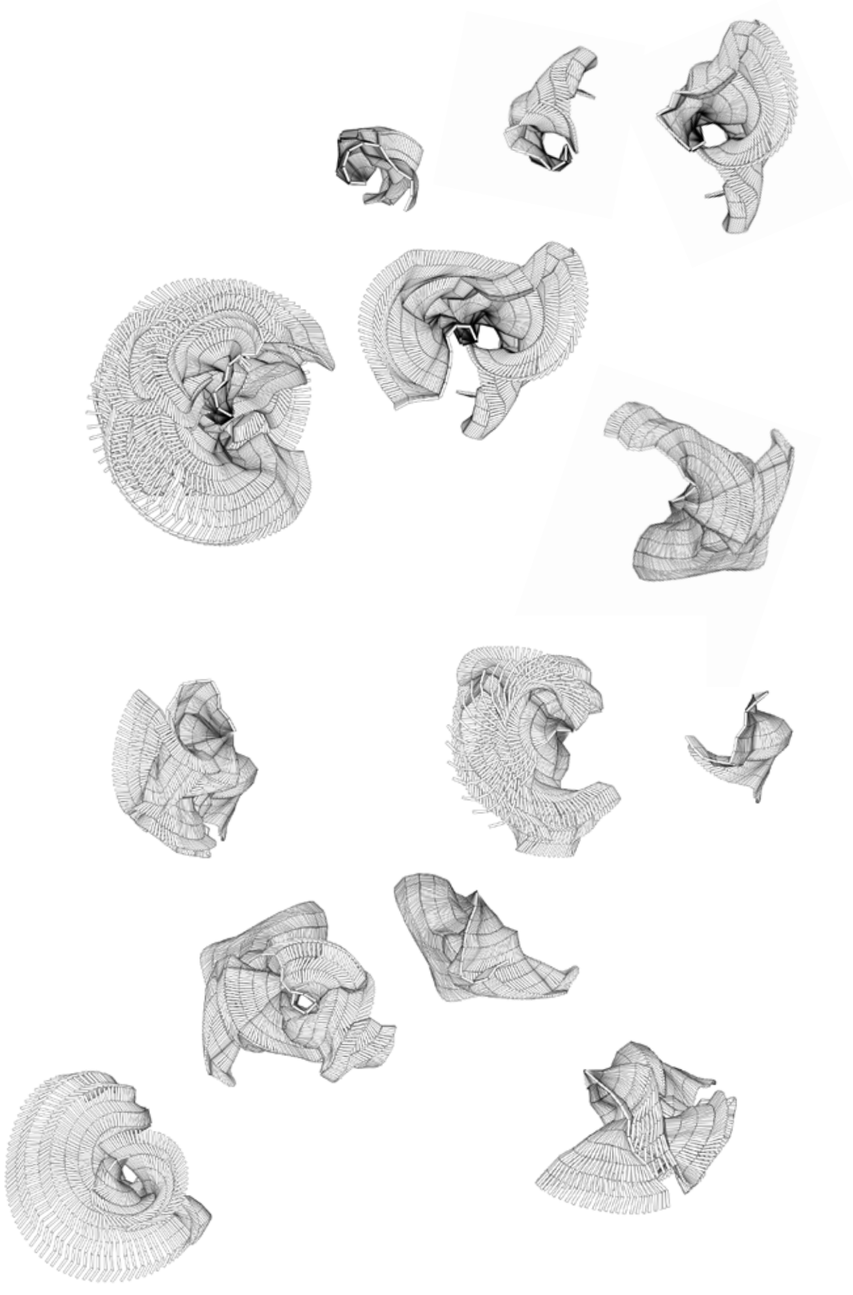
> Yes, the chess game contains a finality in itself, since the object is to win. But if the game is used to distribute sound sources, and therefore to define a global sound system, it has no goal. It is a paradox, purposeful purposelessness.[111]

What Cage outlines is a way of using a logical game structure to generate art, in his case music. This is a paradox that also both conventional drawing diagrams and computational, digital diagrams work with. Remember, for instance, that Evans' talked of signified geometry as being complex geometry used to expressive, artistic ends, as in Le Corbusier's roof for Ronchamp. Where using games or rational structures to expressive, artistic ends could be considered to be absurd, like non-sense, it could also be considered to be a playful way to disrupt ritualized patterns of behaviour, clichés or conventions.[112] But when a game does not function rationally, can it then still be said to be a game? Deleuze thinks it can in this quote about Lewis Carroll's games in *Alice's Adventures in Wonderland*:

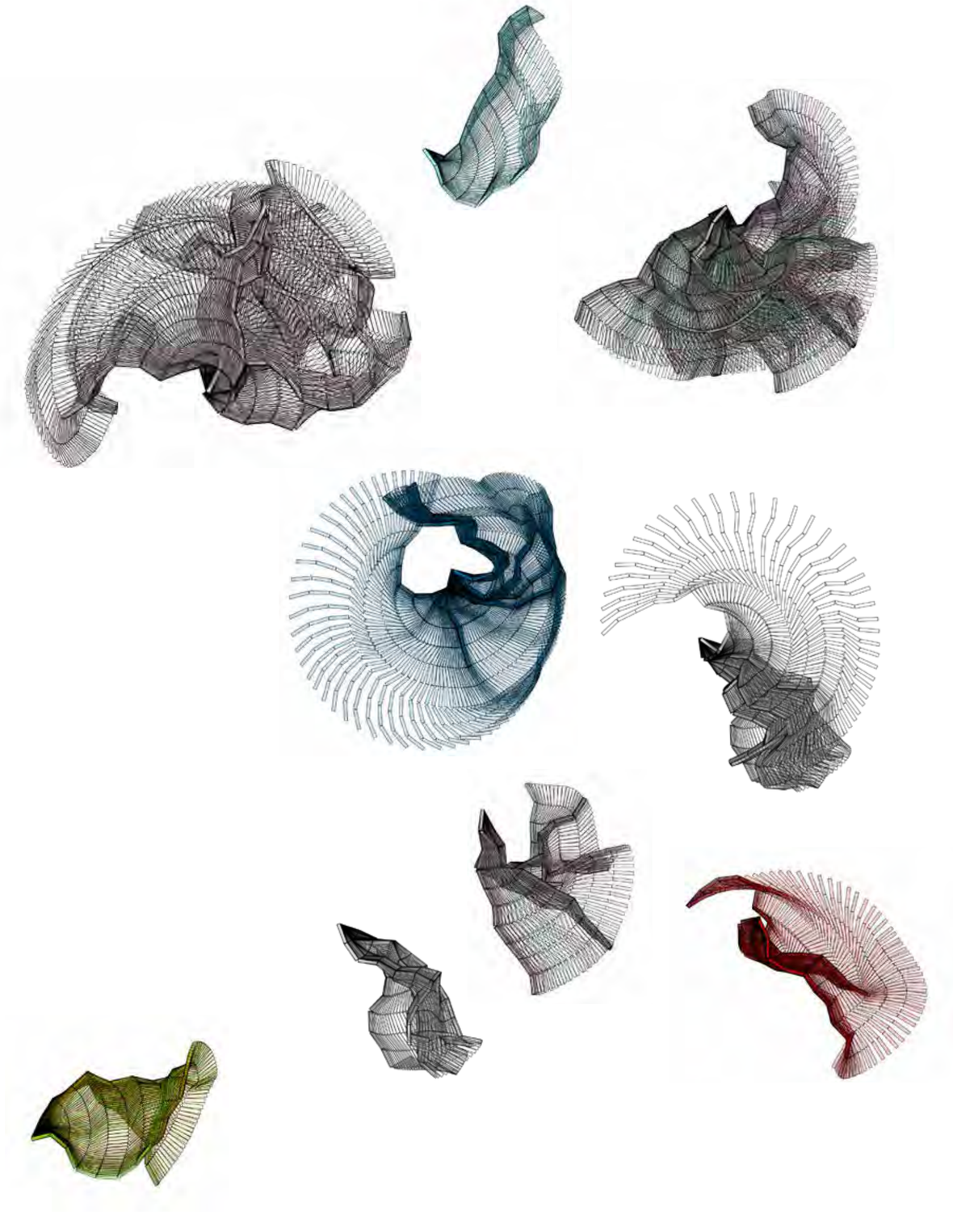
> Not only does Lewis Carroll invent games, or transform the rules of known games (tennis, croquet), but he invokes a sort of ideal game whose meaning and function are at first glance difficult to assess: for example, the caucus-race in Alice, in which one begins when one wishes and stops at will; and the croquet match in which the balls are hedgehogs, the mallets pink flamingos, and the loops soldiers who endlessly displace themselves from one end of the game to the other. These games have the following in common: they have a great deal of movement, they seem to have no precise rules, and they permit neither winner nor looser. […] Such a game – without rules, with neither winner nor loser, without responsibility, a game of innocence, a caucus-race, in which skill and chance are no longer distinguishable – seems to have no reality. […] If one tries to play this game other than in thought, nothing happens; and if one tries to produce a result other than a work of art, nothing is produced. This game is reserved then for thought and art. In it there is nothing but victories for those who know how to play, that is, how to affirm and ramify chance, instead of dividing it in order to dominate it, in order to wager, in order to win. This game, which can only exist in thought and which has no other result than the work of art, is also that by which thought and art are real and disturbing reality, morality, and the economy of the world.[113]

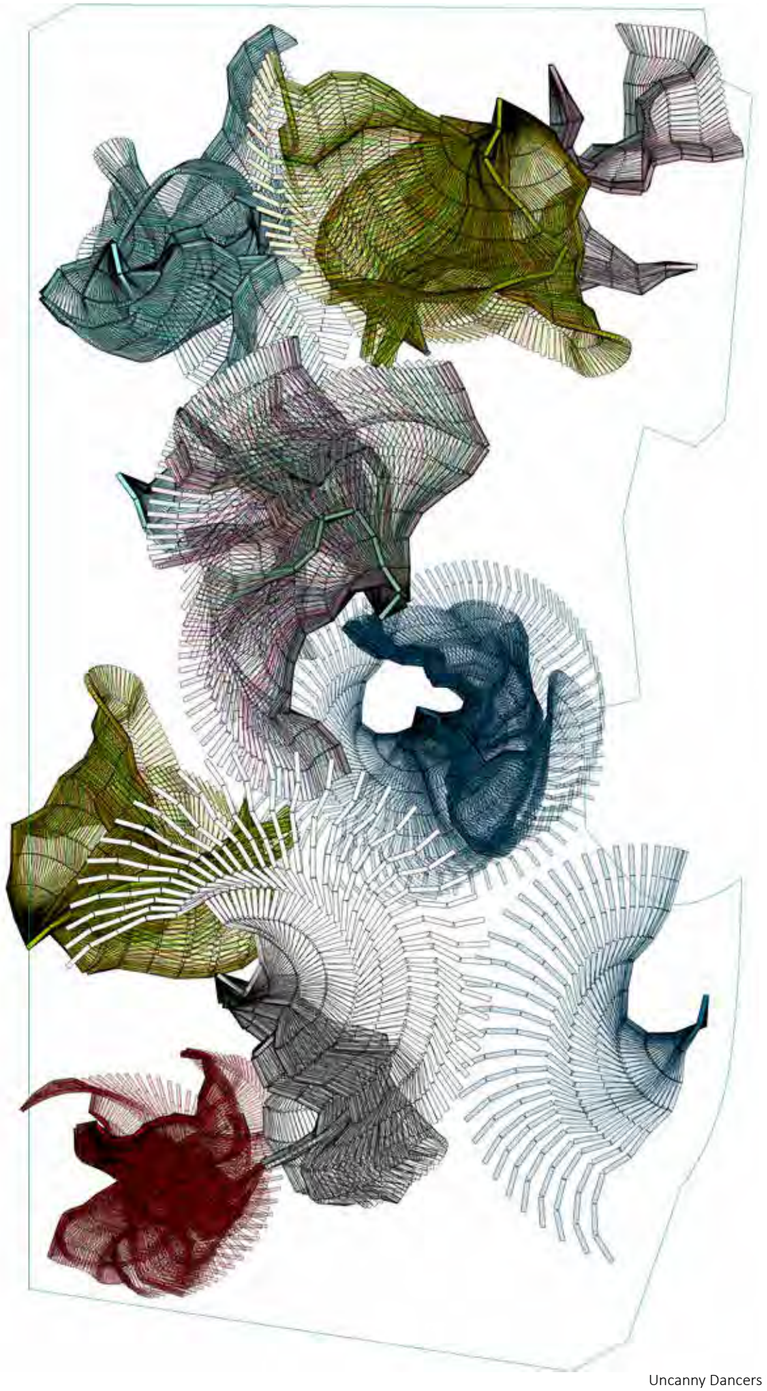


One of the first *Processing* exercises was to make an arm consisting of a row of rectangles (like the snake toy seen from above). The rectangles in this script rotate and follow the cursor so you draw a cursor that spawns a new rotating arm every second. The drawing is hence the record of an animation, recording many key frames of the moving arm in one image.

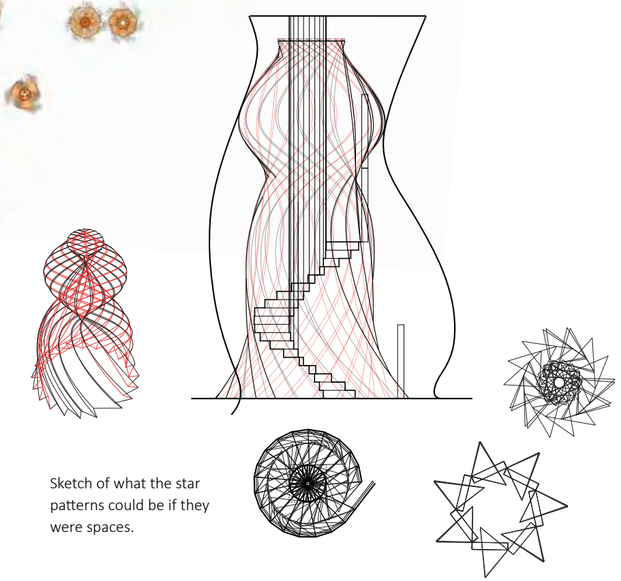


Uncanny Dancers.
These drawings were developed from the same animation-based algorithm as on the opposite page.

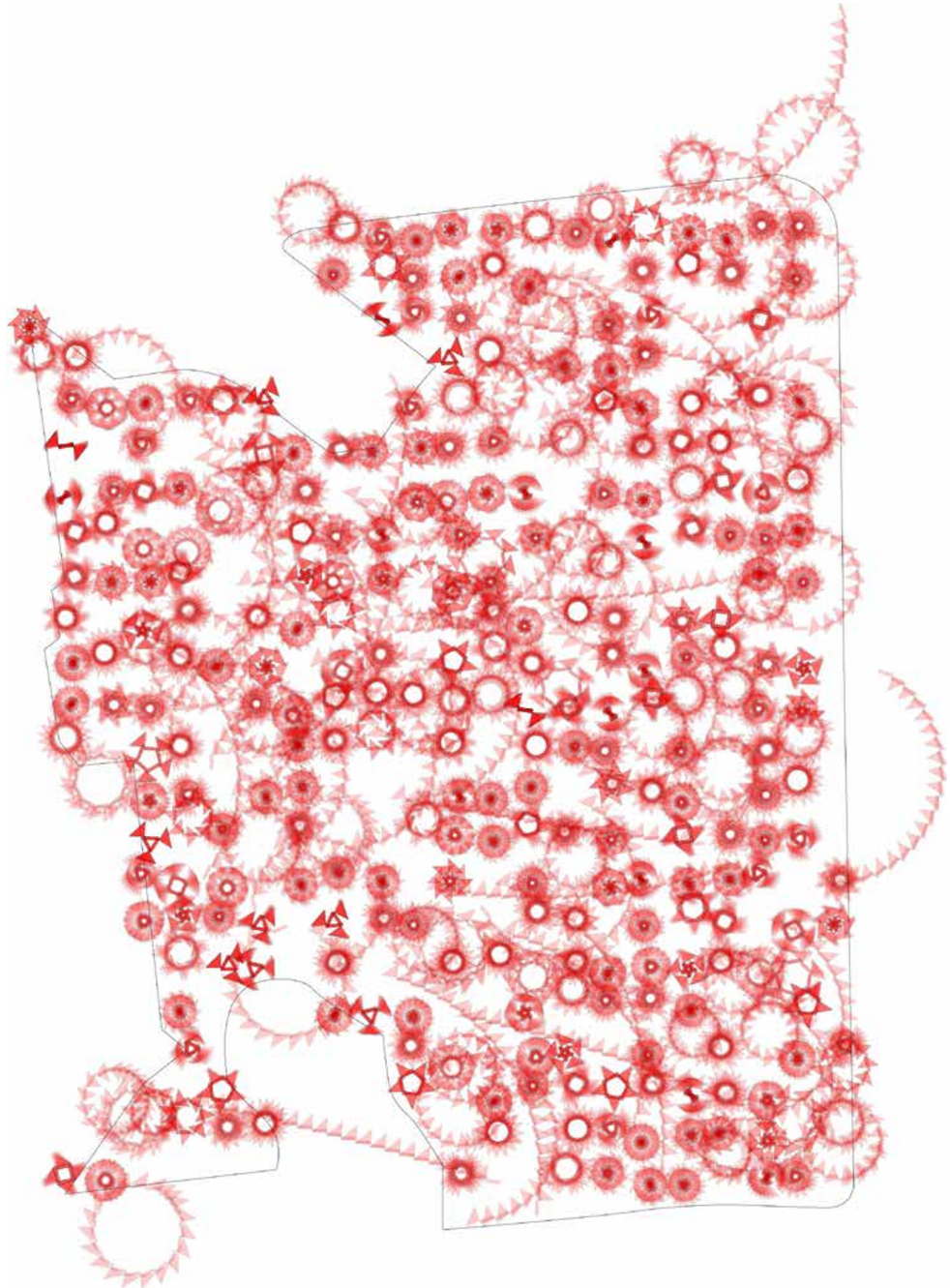




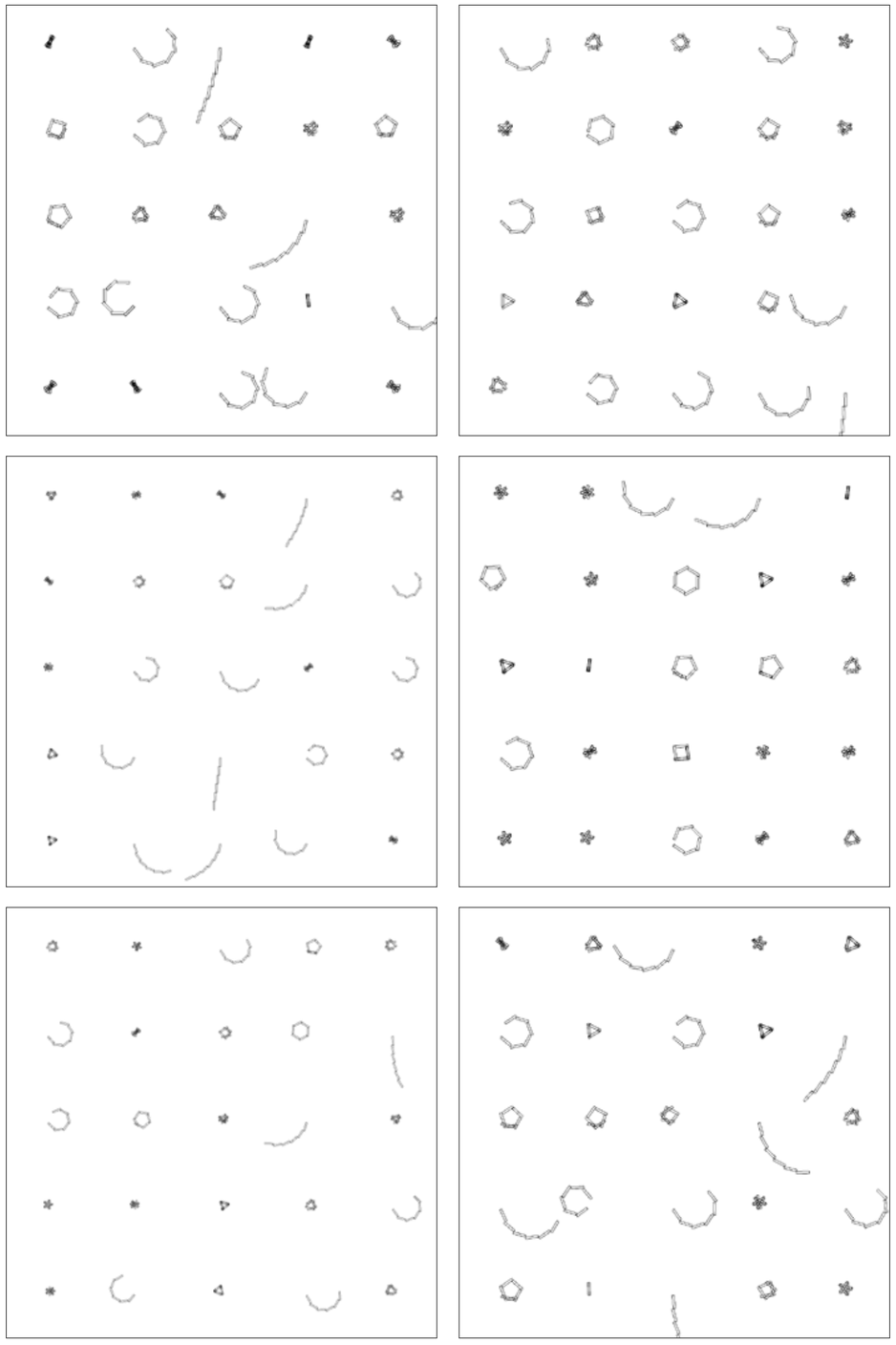
Uncanny Dancers II.
Variation of the same algorithm.
Here I placed some ‘dancers’ on one of the playground sites from the Berlin Hypotheses maps. The site is taken out of context and in a sense made siteless and used as an abstract game board for the uncanny dancers.

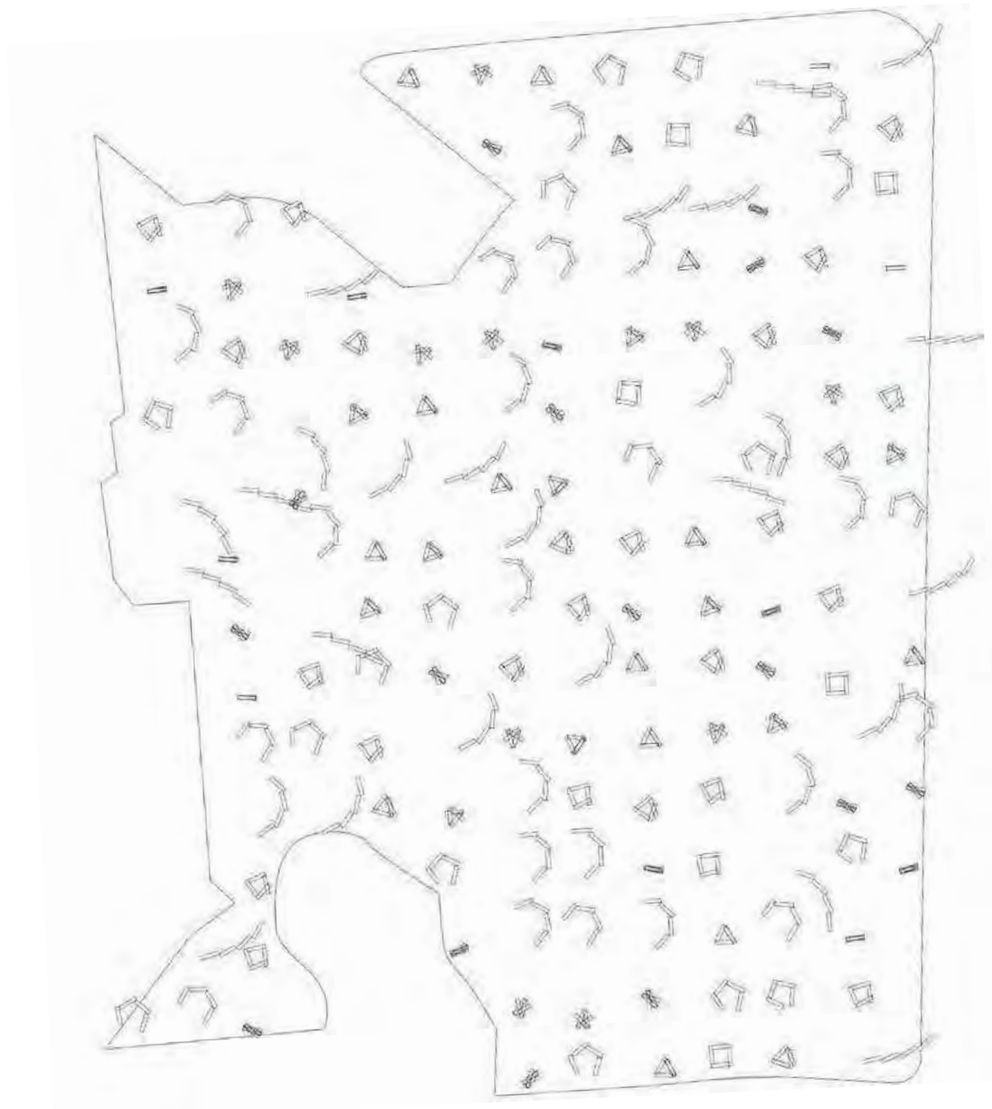


Sketch of what the star patterns could be if they were spaces.

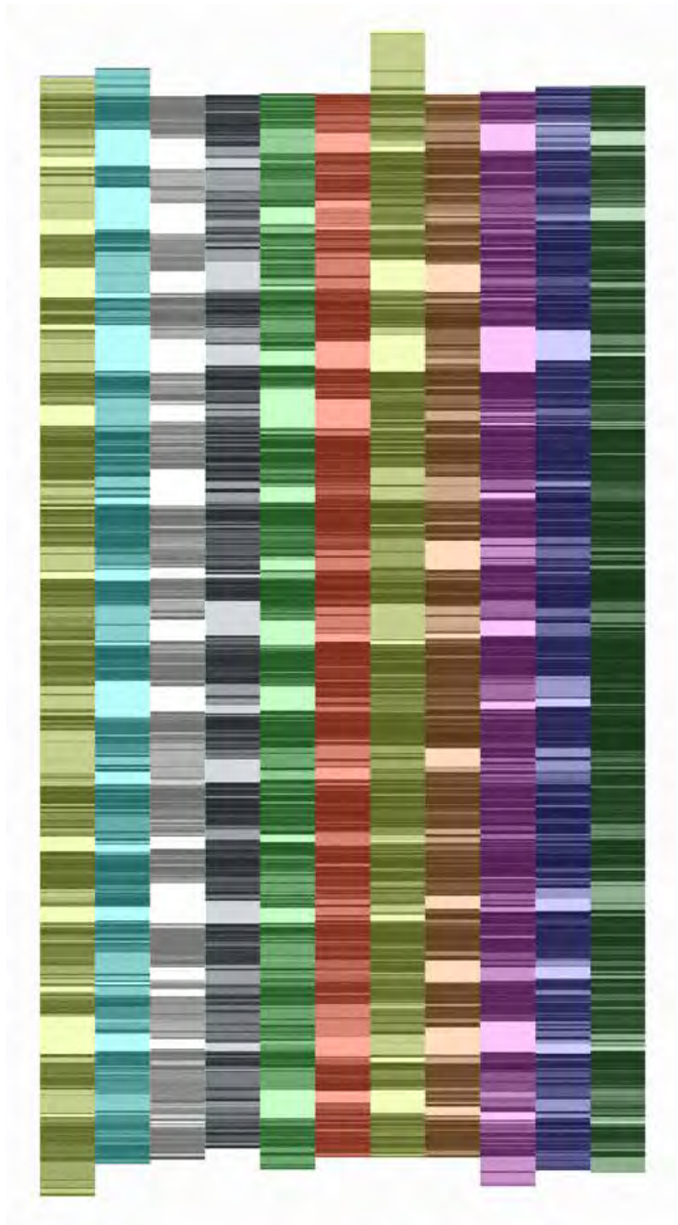


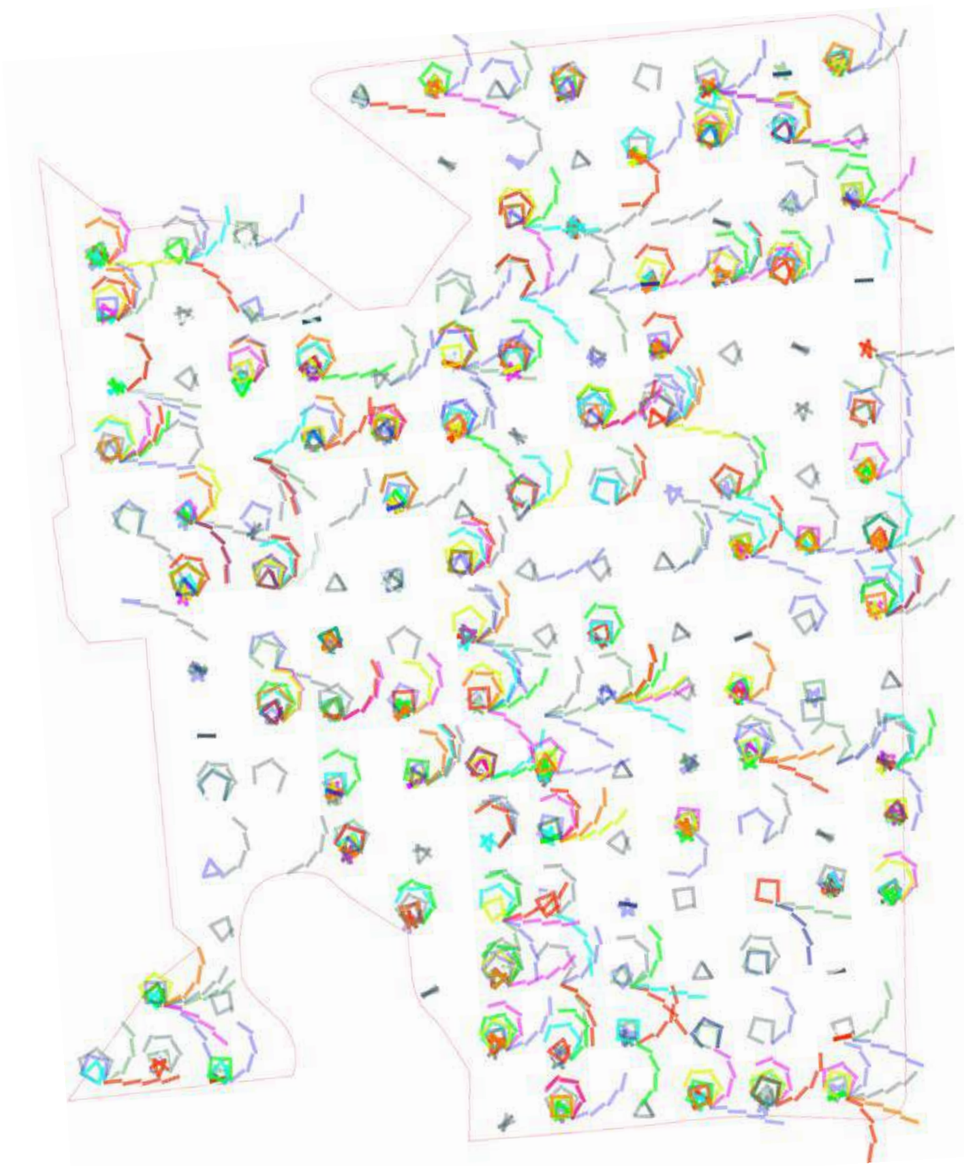
Uncanny Dancers III.
Variation of the same algorithm. Here the organic look of the dancers is reduced and a more angular geometry is achieved, a star or stair-like pattern.

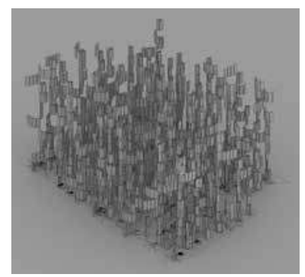




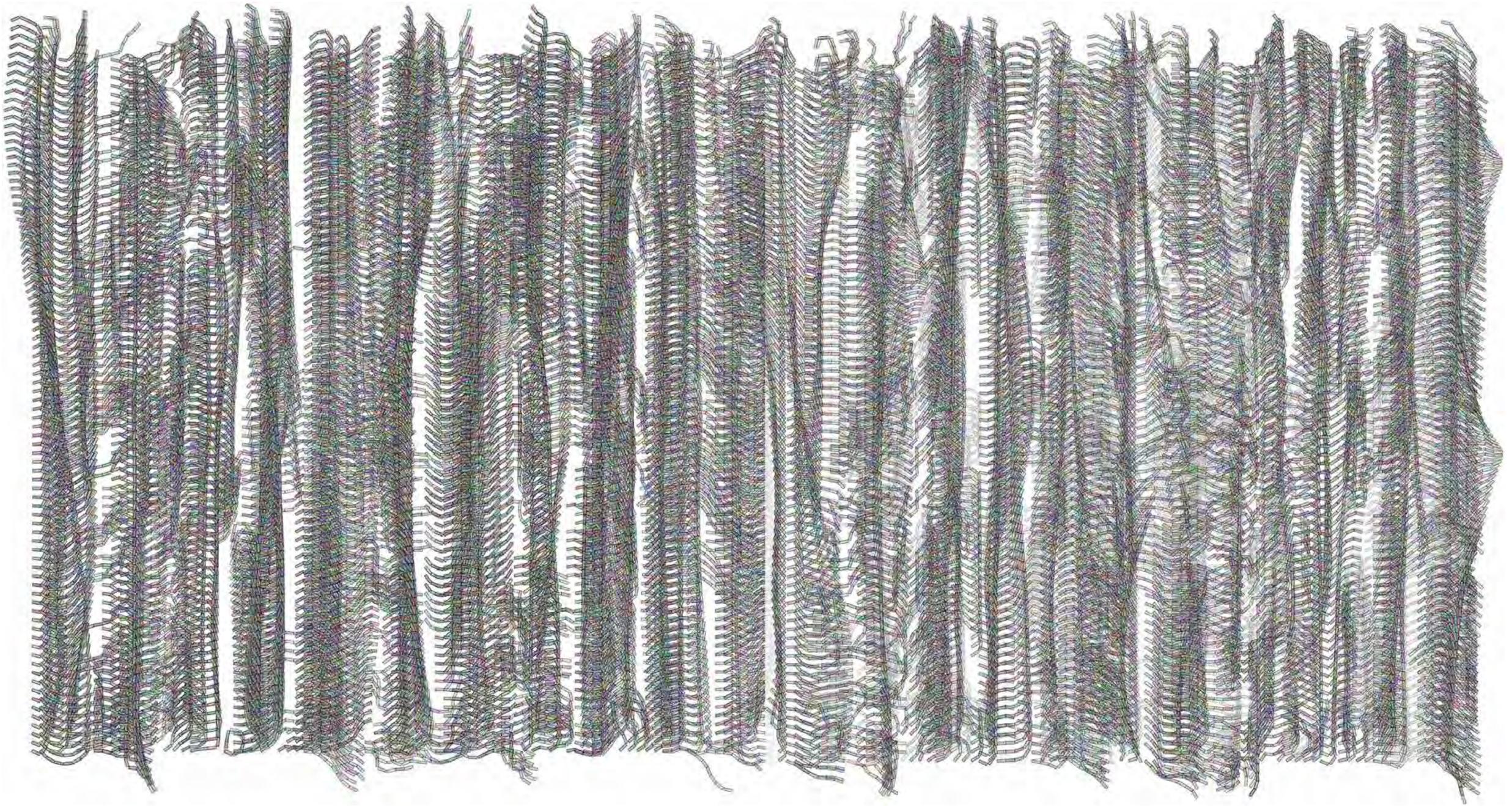
Uncanny Dancers IV. Variation of the same algorithm. As opposed to the other Uncanny Dancer drawings, this drawing only shows one key-frame from the arms movement.





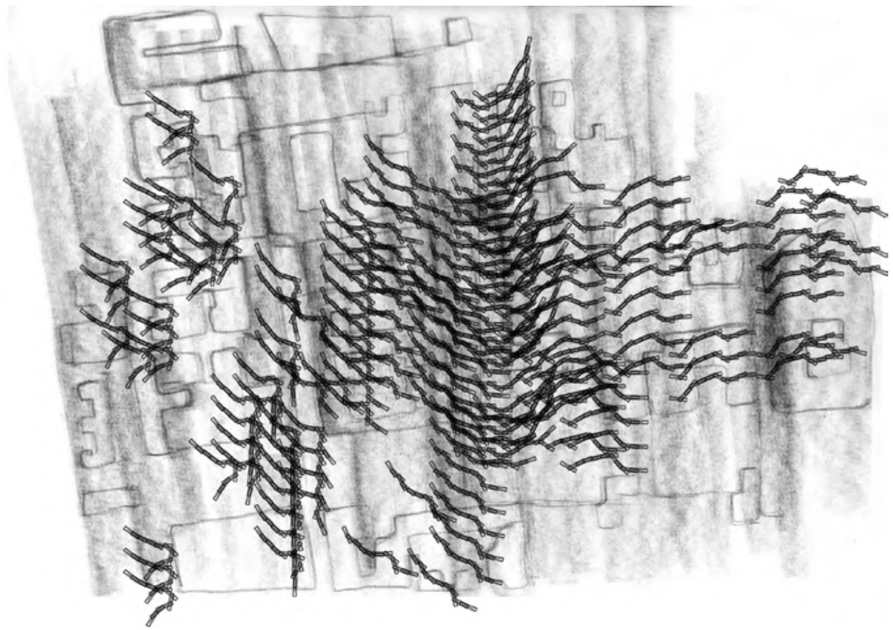


Uncanny Dancers V. Variation of the same algorithm. In this script the dancers consisted of 3D boxes being stacked. On the left page we see plan drawing of several boxes on top of each other, and on the other page an elevation of the boxes.

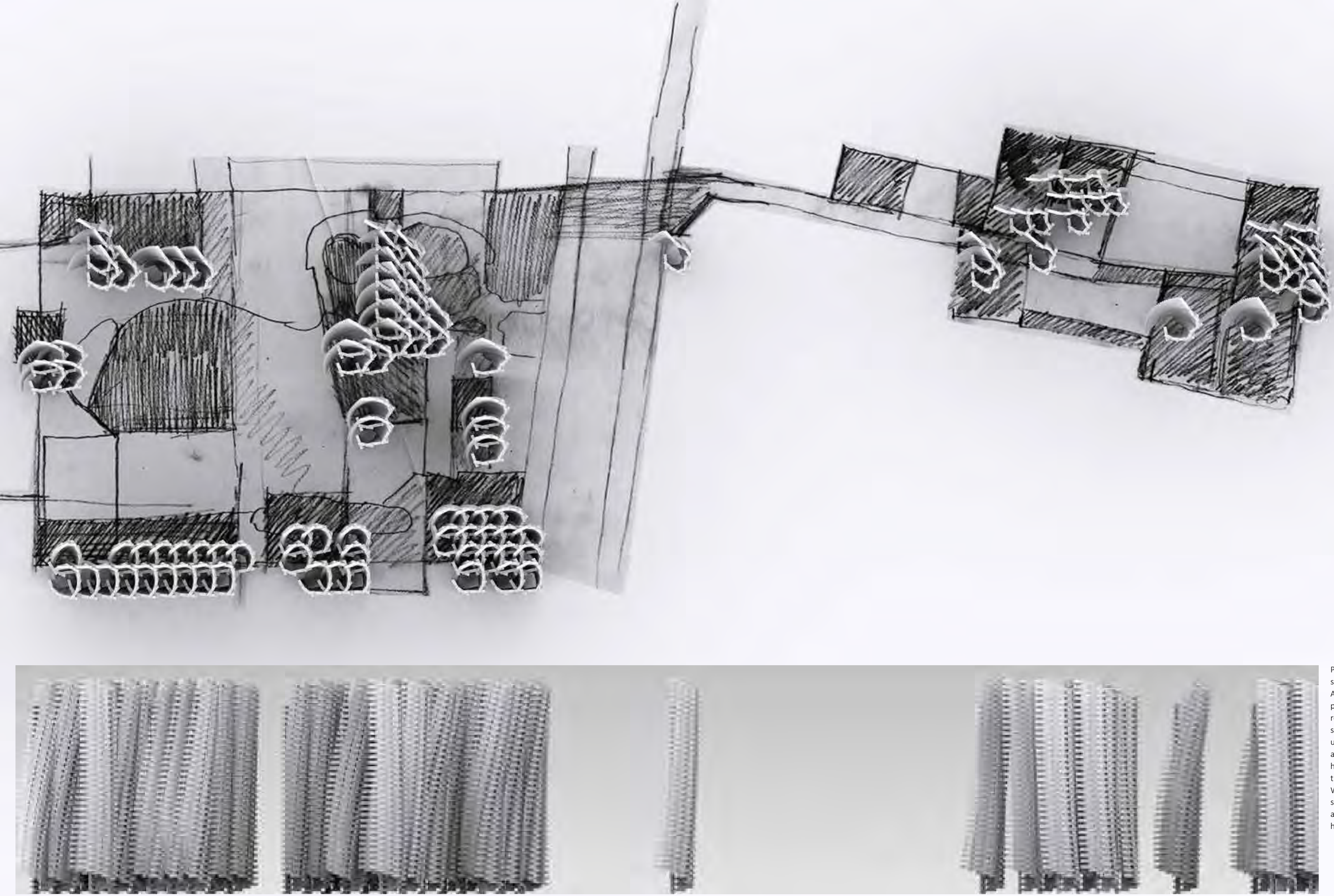


Uncanny Dancers VI.

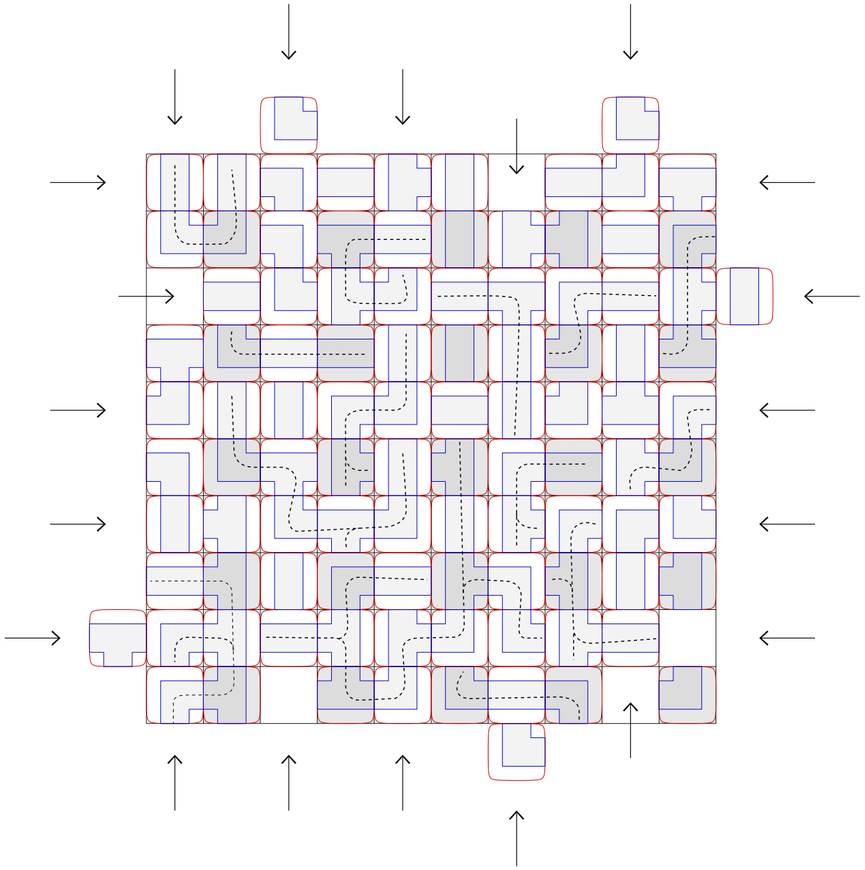
These photos of curtains and sunlight reminded me about some of the Uncanny Dancers drawings.

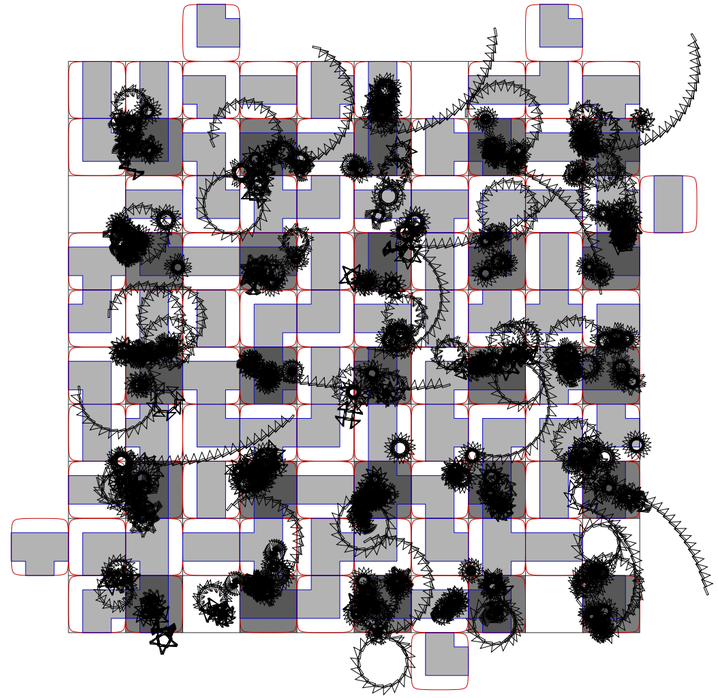


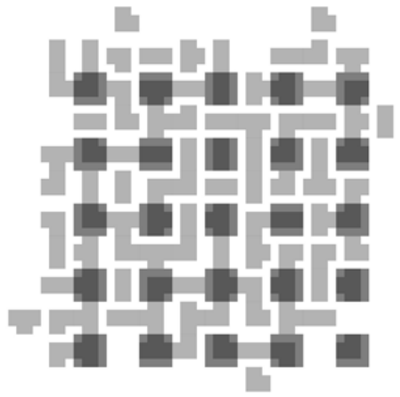
Playing the non-sense game I.
In these drawings the Uncanny Dancers algorithm was developed so it could read the black and white information of an image and place arms in relation to the black and white values. That function became a way to make a hand drawing interact with a digital script, because the darkest areas of the hand drawing are populated most densely with arms. To this adds that the arms still follow some random principles as to how many of them are placed on the darker areas. To return to the metaphor of the non-sense game- if one thinks of the arms as game-pieces that are alive- like the flamingos in Alice's caucus race-, and the hand drawings as game-boards, then the algorithm is the rules of the game, the rules that distribute the game pieces on the game-board.

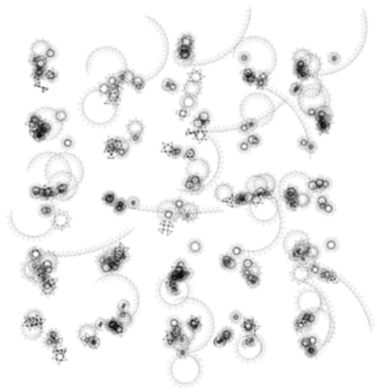


Playing the non-sense game II.
As on the previous pages: the script reads the hand sketch and distributes the arms. The arms of this script, howver, are boxes that are stacked. We therefore also see the stacked arms in elevation here.







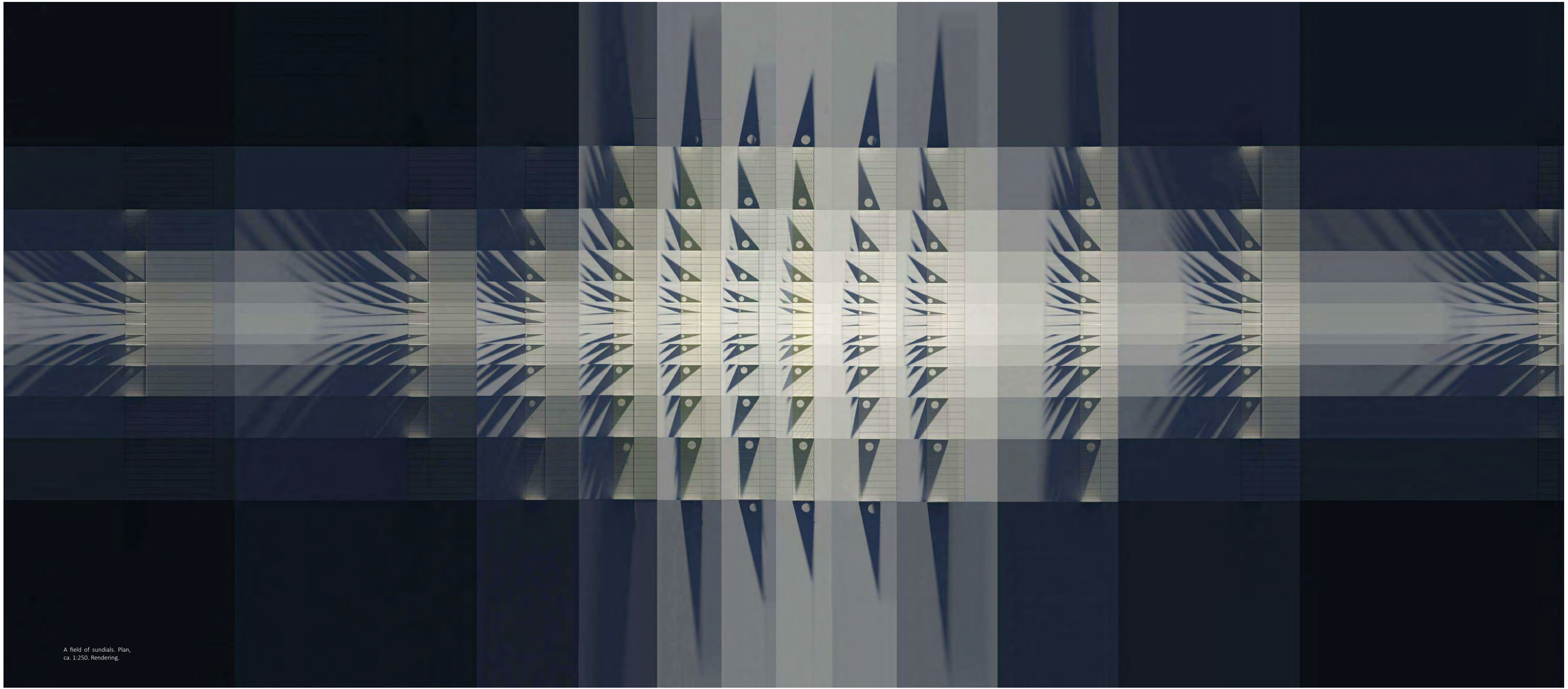


Playing the non-sense game III.
In these drawings I did not use a hand drawing as game-board, but a drawing of the game-board from the children's game *The Magic Labyrinth*. This particular game-board works like a map with roads making up a labyrinth, where some of the pieces can move. In this game it is not just the game-pieces that can move, but also the game-board, since all the connections of the network of streets of the labyrinth change every time a player has her turn. Turn after turn different routes through the labyringh emerge on which the game pieces can wander according to the rules of the game and the choices of the players.

[1] Sections of this chapter are currently being published by the KADK as part of a publication on artistic research.
[2] Goodman, *Languages*, 221.
[3] Cf. Søberg's understanding of sketches.
[4] I discuss this in the next part of the chapter.
[5] Allen, *Practice*, 64-67.
[6] Ingold, *Lines*, 40. Ingold quotes Alberti, *De Pictura* (1435, 1972), 37-38.
[7] Allen, *Practice,* 41-49. Allen refers to Goodman, *Languages of Art*.
[8] Ingold, *Lines*, 39.
[9] Ibid., 3.
[10] Ibid., 74, his emphasis.
[11] Ibid.,152-60.
[12] "Writing is still drawing. But it is the special case of drawing in which what is drawn comprises the elements of a notation."Ingold, *Lines*, 122.
[13] "Drawing the letters of the alphabet, recognizing their shapes and learning to tell them apart are exercises in notation. Spelling, however, is an exercise in script."Ibid., 121-22.
[14] Ibid., 125.
[15] Allen, *Practice*, 64-66.
[16] Will be deepened in next parts of this chapter.
[17] Allen, *Practice*, 49.
[18] "Notation belongs to—and to some degree anticipates—the digital computer. In projection, by contrast, there may be geometric transformation, but something of the structure of the original sketch is preserved throughout the process…. Notation shortcircuits this retrospective gaze, and shifts attention to the performance of building in the world, necessarily cut off from its author, working in and among the world of things." Ibid.
[19] Ibid., 48
[20] Ibid., 48, 64-66.
[21] "These issues gain urgency at a time when architects work on the computer and almost all architectural representation is filtered through digital media. Notation belongs to—and to some degree anticipates—the digital computer. In projection, by contrast, there may be geometric transformation, but something of the structure of the original sketch is preserved throughout the process. […]. Notation shortcircuits this retrospective gaze, and shifts attention to the performance of building in the world, necessarily cut off from its author, working in and among the world of things. For Goodman, it is precisely this character of being "discontinuous throughout" that distinguishes the digital from the analog. To work with notations and diagrams therefore implies giving up ideas of depth, authorship and intent, betting instead on immediacy and presence." Ibid., 49.
[22] Ibid., 81, 240.
[23] Goodman, *Languages*, 221.
[24] "To be digital a system must be not merely discontinuous but **differentiated** throughout, syntactically and semantically." Goodman, *Languages,* 161. His emphasis.
[25] Ibid., 121, 160.
[26] Ibid., 170.
[27] Ibid.
[28] Ibid.
[29] Carpo, *Alphabet*, 123.
[30] Evans, *Translations*, 173-80.
[31] Goodman, *Languages,* 219.
[32] Ibid., 170, his emphasis.
[33] Ibid., 170-1.
[34] Ibid., 231.
[35] Ibid., 221
[36] Ibid., 219.
[37] Ibid., 221.
[38] Ibid.
[39] Allen, *Practice*, 5.
[40] Perhaps musical notations for experimental music are particularly relevant here, as for example, one finds presented in John Cage, *Notations* (New York: Something Else Press, Inc., 1969).
[41] Goodman, *Languages*, 218.
[42] Ibid., 219.
[43] Ibid., 221.
[44] "Many diagrams in topology, for example, need only the right number of dots or junctures connected by lines in the right pattern, the size and location of the dots and the length and shape of the lines being irrelevant. Plainly, the dots and lines here function as characters in a notational language; and these diagrams, as well as most diagrams for electrical circuits, are purely digital. The more we are startled by this, because we think of such diagrams as rather schematized pictures, the more strongly are we reminded that the significant distinction between the digital or notational and the non-notational including the analog, turns not upon some loose notion of analogy or resemblance but upon the grounded technical requirements for a notational language." Ibid., 170-1.
[45] Carpo, *Alphabet.*
[46] Cf. Evans, *Translations*, 173-80. The example with Philibert de l'Orme's dome.
[47] Goodman, *Languages*, 221.
[48] Ibid.
[49] Evans, *Translations,* 163.
[50] Evans, "Architectural Projection," 30.
[51] Ibid., 29-30.
[52] Cf. Goodman, *Languages*, 161-2.
[53] Ibid., 157-60.
[54] Belardi, *Why Architects still draw*, 107, refers to Venturi Robert, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas revised edition* (Cambridge, Massachusetts, and London, England: The MIT Press, 1977).
[55] "Traditional geometry cannot be used [these architects think] because it has an inherent autonomy, which determines the space at the expense of living a free life." Pedersen sees examples of this in the works of Scharoun, Hugo Häring, and Frederick Kiesler. Claus Peder Pedersen, *Arkitekturens Dynamiske Formdannelser* (Århus: AAA, 1998), 165. My translation.
[56] https://de.wikipedia.org/wiki/Neue_Musik (accessed 30.01.2016).
[57] Goodman, *Languages,* 190.
[58] Ibid.
[59] Ibid., 192-93.
[60] Helms, Hans G., John Cage, "Reflections of a Progressive Composer on a Damaged Society," *October* vol. 82 (Autumn, 1997): 78. Retrieved from http://www.jstor.org/stable/779001,1972/1974/1997 (accessed 19/20/2014)
[61] Goodman, *Languages,* 187-89.
[62] Umberto Eco, *The Open Work*, trans. by Anna Cancogni with an introduction by David Robey (Cambridge, Massachusetts: Harvard University Press, 1989).
[63] Cf. Boehm, "Indeterminacy," 219-20.
[64] Allen, *Practice*, 240.

[65] Claus Peder Pedersen, "The 'Provisional Work' (inspired by Umberto Eco)," in *Cartography, Morphology, Topology*, ed. Cort Ross Dinesen (Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009), 34-37.
[66] Eco, *The Open Work*.
[67] Pedersen, "Provisional," 37.
[68] Ibid., 34.
[69] Allen, *Practice*, 53.
[70] See for instance the project *FEATURES MONTE CARLO* in Peter Cook, ed., *Archigram* (New York: Princeton Architectural Press, 1999), 102-9.
[71] Cf. Tomás Valena, Tom Avermaete, and Georg Vrachliotis, *Structuralism Reloaded – Rule-Based Design in Architecture and Urbanism* (Stuttgart/London: Edition Axel Menges, 2011).
[72] Text from the competition drawing exhibited in the Berlinische Galerie, October 2015. My translation.
[73] Cf. Deborah Domingo Calabuig, Raúl Castellanos Gomez, and Ana Abalos Ramos, "The Strategies of Mat-building," *The Architectural Review* (13th of August, 2013). See also Ludger Hovestadt, *Beyond the Grid - Architecture and Information Technology, Applications of a Digital Architectonic* (Basel, Boston, Berlin: Birkhäuser, 2010).
[74] Anh-Linh Ngo et al., "Group House Seniorenwohnheim," *ARCH +* 208 (August 2012): 132.
[75] Heino Engel, *Measure and Construction of the Japanese House* (Boston, Rutland, Vermont, Japan: Tuttle Publishing, 1985), 40-1.
[76] Bernard Tschumi, *The Manhattan Transcripts* (London: Academy Editions, 1994 expanded 2.nd edition).
[77] "Without pretending to fuse the intuitions of the drawing board with the certainties of abstract thought, this index attempts to point out the essential directions of a mode of research." Tschumi, Bernard, *Architecture Concepts – Red is not a Color* (New York: Rizzoli, 2012), 106.
[78] Tschumi, *Transcripts,* 6, his emphasis. (most of the original text bit is emphasized)
[79] Ibid., 8.
[80] Robbins, *Why*.
[81] Tschumi, *Transcripts*, 9.
[82] Ibid.
[83] Ibid., 6.
[84] Tschumi, *Red Is Not A Color*, 24-25.
[85] "Even if the *Transcripts* become a self-contained set of drawings, with its own internal coherence, they are first a device." Tschumi, *Transcripts*, 7.
[86] Ibid., 6.
[87] Ibid., 9.
[88] Ibid.
[89] Tschumi, *Transcripts*, 12.
[90] Ibid.
[91] Tschumi, *Red Is Not A Color*, 108. His emphasis.
[92] Stjernfelt, *Diagrammatology*, 99.
[93] Ibid., 49-88.
[94] Tschumi, *Transcripts*, 10.
[95] Ibid., 8.
[96] Ibid., 11.
[97] Ibid., 12.
[98] Ibid.
[99] Tschumi, *Red Is Not A Color*, 108.
[100] Tschumi, *Transcripts*, 12.
[101] Ibid., 10.
[102] Scott McCloud, *Understanding Comics - the invisible art* (New York: Harper Perennial, 1994), 66.

[103] Camilla Damkjær, "Tilfældighed i Bevægelse," in *Bevægelsens Poetik - om den æstetiske dimension i bevægelse*, ed. Lis Engel, Helle Rønholt, Charlotte Svendler Nielsen, Helle Winther (Copenhagen: Museum Tusculanums Forlag, 2006), 152-3.
[104] Damkjær, "Tilfældighed," 152-3. My translation, her emphasis.
[105] Ibid., 152-54.
[106] Casey Reas and Chandler McWilliams, *Form + Code in design, art and architecture* (New York: LUST, Princeton Architectural Press, 2010).
[107] Ibid., 13.
[108] ed. Valena, Avermaete, and Vrachliotis, *Structuralism Reloaded*.
[109] Reas, McWilliams, *Form*, 21.
[110] Jorinde Voigt, *NOW,* ed. Julia Klüser and Hans-Peter Wipplinger (Kunst Halle Krems, Verlag der Buchhandlung Walther König, 2015), 64.
[111] Damkjær, "Tilfældighed," 151. Damkjær quotes Cage: John Cage and Daniel Charles, *For the birds - John Cage in conversation with Daniel Charles* (1981), 168.
[112] Evans, *Cast*, 273-320.
[113] "Patterns make reality, and media patterns – like the circuits on a computer chip, the divisions on a map, the fields in a database, the sections of a Wikipedia page, and the mechanics of a game – shape reality by providing the templates by which we exchange meaning with one another. Games are fundamental building blocks for designers because they ritualize behaviour. But playfulness is even more important because it disrupts ritual patterns and reconfigures reality." Janet Murray, *Inventing the Medium – principles of interaction design as a cultural practice* (Cambridge, Massachusetts and London, England: The MIT Press, 2012), 405.
[114] Gilles Deleuze, *The Logic of Sense*, trans. Mark Lester with Charles Stivale (London and New York: Continuum, 2004), 69.
[115] Ibid., 71.



A field of sundials. Plan,
ca. 1:250. Rendering.

CONCLUSION

The thesis has pointed out new possibilities for understanding drawing in the context of the computer, and raises awareness of how drawing as a projective agency of observation continues to co-produce architecture, as opposed to what some theorists and architects argue. The thesis has argued that conventional drawing provides architectural design with reading rules and is a shared architectural, social, and cultural convention. A shared, general diagram used as working medium. However, when the general medium is destabilized and new possibilities emerge, the patterns of which media to use and how to use them are opened up and the media field becomes more complex and offers less direction, as discussed in the state of the art chapter. On the plus side this initiates rich possibilities to change both media use and socio-cultural conventions, including, for instance, those that were previously limiting. But on the other hand, there is also a fear of loss of those qualities that are characteristic of the convention, such as, for instance, the fear of losing the critical, generative hand sketch. In relation to this problematic, this thesis has argued that architects are not faced with a simple 'either conventional drawing or computational design' situation, as the conventional drawing still plays too important a role to be discarded by architects or in the software that architects use. Moreover there might be ways of sketching which are not necessarily bound to the hand but are more general and diagrammatic, and which are permeated with mixed media use. On this basis the last chapter, *MEDIA MUTATIONS III,* outlined an overlap between sketches and diagrams where analogue and digital notation are used together in ways that work deliberately with indeterminacy and coincidence while aiming at becoming generative but also remaining structured. Goodman argued that conventional drawing already relies upon a mixed use of analogue and digital notation, which gives it its double nature: its ability to be used in both rational and sensuous, logical and poetic, scientific and artistic ways, spanning the whole way through a design process.

With Peirce and Stjernfelt, conventional drawing was considered to be a diagram that works with both completely conventionalized, symbolic reading rules, but can also be in close, intuitive contact with the world as it is sensed. This ability of the diagram offered an interaction between conventional reading and thinking rules and subjective invention, and was seen as a good way to describe the dual nature of conventional drawing, which can pass on completely clear instructions for building but also be an epistemic artefact used to invent architecture in the first place.
Sketching with diagrams was considered as having to do with indeterminacy becoming productive of more than could be imagined at the outset of a design process. This was an attempt to emphasize some qualities of sketching which do not have to do with hand

drawing per se, but which nonetheless works with indeterminacy as a productive and fertile aspect, as hand drawing can do. Moreover it has been indicated that the paradoxes that drawing brings with it, being both a sketching medium and an instructive medium, probably persist in computational media practices, and in relation hereto, the paradox of being able *to close* the gaps of translation in the design process, as well as being able to open gaps for creative contemplation or participation is seen as highly relevant, indeed calling for more research. Interestingly, like with conventional drawing it is exactly the conventional nature of digital notation which causes this ability – to close or open gaps.

Aligning myself with Carpo, I have argued that it was already an affordance of the digital notation of conventional drawing to create identicality between the drawn and the built, but I have, as opposed to Carpo, argued that even though digital, notational affordances are 'heightened' due to digital technology, analogue aspects persist too, for instance the closeness between an architect and her working medium, and in the sensuous ways media is used in highly subjective practices. I would say that the *paradox* that always existed in the conventional drawing is heightened when architects design with computers. That is different from saying, as Carpo does, that there is one primary working practice which is better, and that architecture's working media has reached a state of being fully digital. To this I must add that conventional drawing still permeates architectural ways of looking – especially in the projective geometry often used when looking at design objects. Projection is neither analogue nor digital, but diagrammatic and continuously mutating into new media practices.

In addition to this it was pointed out that speculative architectural drawings, for instance, breed from computational affordances and it was argued that, despite the fact that 3D fabrication machines bring the building, the model, and the prototype closer to the architect, it is still the medium – and the whole diagrammatic set-up of the medium – which is closest to the architect, rather than the building. Therefore I would hesitate to say that architects will become builders as they were before the Renaissance because of computational affordances, as Carpo has argued, and would rather say that architects are still designers in close, sensuous contact with their medium, which today moves 3D production, but not the building site, closer to the architect.

The proposition of sketching with diagrams was a way to seek for a concept of sketching which is not bound to hand drawing, but which is rather a way of making one's own working medium by focussing on the nodes of translation in the medium. In John Cage's open work he had made a sketch for a performance, which he nonetheless considered to be a finished work. He had deliberately not prescribed completely how a performer was to translate the work into a performance. It was intended that the performer interpret the work before he could carry it out. I took this as an example of a way of sketching that comes from cultivating indeterminacy in translation, while not giving up authorial control completely, nor giving up a high degree of finish in the graphical expression. I also took it as an example of a musical notation which did the same as some of my drawings do – that is, supplying the receiver with some reading rules, while lacking others.

Structuring coincidences or combining objective rules with subjective moves, as Tschumi claimed to do in *The Transcripts,* was then approached in my last drawings with *Processing* that structured randomness. The paradox of structuring randomness and working with completely rational sorts of notation in artistic ways was deliberately intended to make the creative process generative, and to question and open up conventions. Such a sketch condition could emerge from the way a medium is put together, and this was conceptualized as sketch diagramming.

The potential of diagrammatic reasoning

The diagram has been taken as a methodological leitmotif both in relation to how this thesis is made, and how conventional, architectural drawing is changing because of the computer. This argument started with the observation that Peirce's diagrammatic reasoning could be a relevant concept for understanding conventional drawing, since Peirce's diagram has the potential to open thinking up with symbols and icons in combination. This could lead to a leap of thought – the imaginary moment – which is a moment of epistemic force where a new idea emerges. The diagram was understood as a map of relations which could be used to create subjective, possible worlds or new general, universal concepts. The diagrammatic double nature of conventional drawing in a research context is pithy, because drawing is a device for both artistic, architectural reasoning and rational reasoning, and which could easily be part of scientific practice. However, in this thesis more series of drawings have been placed throughout the thesis as if they were intruders in the discursive text; this was not for its potential as a rational map of relations but more for its potential to question existing conventions and to suggest possible, subjective worlds forming part of the theoretical practice. Investigating conventional drawing in a research context has put into focus that drawing in architecture is itself a non-neutral construction that carries with it its own agenda; however it has the characteristics that when looking through drawing, the world is viewed orthogonally. This has been compared with the way theorists of knowledge have presented experiments in natural science (Rheinberger, Barad), and how, paradoxically, known, conventional frameworks have provided a kind of basis for receiving the new, for handling epistemic artefacts.

The relevance of diagrammatic reasoning with conventional drawing was developed further approaching drawing with the computer via Karen Barad's apparatus theory on

agencies of observation and Goodman's diagram, which can be both analogue and digital. Through holding these theories together, the diagram shows itself as a generative device in its capacity to work with both digital and analogue notation, while also describing a reasoning form, as Peirce and Stjernfelt described it. Therefore it was suggested that *making a medium* has a diagrammatic level of reasoning that is more basic than any technical developments, but is not for that reason unaffected by technical developments, nor by subjective moves and sensations. In that way the same affordances that drawing offers as medium – its double nature – persist with computational design. However, because technical equipment and notational forms are not neutral, the digital affordances are heightened. Here the diagram and the sketch diagram offer awareness that the paradoxes themselves are also heightened. This means that it is not that the double nature of conventional drawing disappears when drawing with the computer, but rather that this double nature is enhanced at the extremes.

On the role of my drawings - short reflection in hindsight

A reader might ask: why make a PhD thesis about conventional, architectural drawing as artistic research? A PhD project about this could have been done in many other ways. Making a PhD about a subject within which you have a practice probably cannot help being influenced by that practice. Artistic research methodology has therefore been a way of using my own drawing practice as an even more decisive agent to form the thesis. My own practice has been setting the tone in relation to which other drawings I have analysed, in relation to choices of theory of knowledge, and the discussions of the theories about drawing too. Working in this way has then become a way to pose the question to which degree conventional architectural drawing can be used as another format of reasoning in a PhD. Had the art form had been another – for instance painting or video art maybe – artistic research methodology would have probably been working in other ways. Not just because the practice is different, but because conventional drawing is specifically incisive in that the notational system of conventional drawing is already map- and theory-like, and can be used scientifically. My drawings are more artistic in the sense that they are indeterminate with regard to meaning. Although they 'take place' within the conventionalized system for drawing they still cannot be explained in any one unambiguous way, and this pointed out the double nature of architectural drawing; that it can span between a scientific/symbolic domain and an artistic/iconic one. When looking at the drawings that form part of the thesis, the two map series, firstly the one of Berlin and secondly the one of the world, show well, I think, the way that maps can cross over the difference between making art and making science. I think they also show that drawings can be speculative, conceptional and theoretical while also keeping a door open to building practice simply via the conventional way of reading the drawings, which presupposes building. The *field of sundials* drawings are about how the notational system of conventional drawing mixes analogue and digital notation - the analogue gnomon and the digital dial give meaning to each other, - and both projection and notation form part of this double nature. The three drawing series called *towards a diagram, towards an analogue diagram,* and *towards a digital* diagram also deal with mix forms of analogue and digital notation, but thematise the analogue as more related to the hand and the digital to computer code. These three series seen together also work in relation to the idea derived from Goodman and Allen that diagrams can be both analogue and digital. They are generated from patterns of playing and gaming as a way to break down clichés and disrupt habitual patterns of thinking and moving. These drawing series also work with the paradox of using rational structures in poetic ways. The *origami drawings* and the *developed surface drawings* thematise a drawing as a diagram ingrained in the paper it is made on, where everything can be folded. While flexibility is an interest that this drawing series shares with some of the structuralist drawings, my drawings are more about how the medium of drawing can be animate in another way than when one talks about animation in relation to a building.

While making the thesis the drawings sometimes 'ran ahead' and had their own dynamic, but they have been organised in such a way that they should help understand the theory and vice versa. Sometimes the drawings exemplify the theory, or the drawing experience has influenced the way theoretical concepts were chosen – assessed for their ability to conceptualize what happened in the drawing process. That was, for instance, the case with Peirce's concepts abduction and diagrammatic reasoning. In that way, I think, that the two practices have actually been made to play together, and given each other frames for understanding, which has produced new insight.

My drawings are serial and process oriented, rather than what could be called work oriented. A work can of course be a series, but if one thinks of work as a finished, architectural project, these drawings are more procedural and keep on ramifying. This maybe has to do with the diagrammatic constitution of the drawings, since diagrams are essentially generative, so series and variations over the same theme may be a consequence of working like this. Diagrammatic reasoning does not necessarily lead to closure.

Perspectives

Further research could be channeled into the continuous development of artistic research methodology.

It could also be channeled into teaching along the lines of understanding drawing diagrammatically, as it has been developed in the thesis. Then drawing is understood less as a pen and paper activity and more as a projective agency of observation with mixed analogue and digital affordances, and puts focus on how nodes of translation are bridged in more or less defined ways. This is also a hypothetical theory that has been posed by the thesis, and it could involve more direct testing, for instance, through case studies comparing buildings with their drawings, taking up Evans' thread; or investigating design process and media usage, taking up Robbins' thread. Working with anthropological methods might be a way to assess more precisely the tendencies of different media usages. For instance, if it is true that computational design has the possibility to both determine translation to an even greater extent, and also open it even more up. This would be an attempt to try and see 'how much' suggestiveness there is in different media uses, and how they deal with determination and indeterminacy. Moreover, the thesis' concept of the diagram as a mode of sketching, which has less to do with hand drawing and more to do with mediated ways of translating, and this concept could be made sharper through and a deeper background research concerning the relationship between, for instance, open works and architectural drawings and buildings. This could be relevant because it holds a promise of a needed new understanding of sketching which includes computational media. Moreover, an deeper investigation of open works and architectural works could provide more knowledge of how a balance between an artistic work and a social space can become better integrated. The germ for these themes - open works, open source, participation and art works - already lies in this project, but could be developed even further and perhaps combined with social media uses, open source software development, and collective drawing/design processes, all in all collective processes of making media and sketching architectural works forth. This would be an investigation into and concretion of the dream of an animate architecture, reaching beyond speculative, animate drawing.

TEXT APPENDIX

Firstness, Secondness and Thirdness in Peirce

According to Peirce, processes of signification always work as a relation of three: a sign (also called *first*) stands instead of something that it represents, namely an object or phenomenon (also called *second*). Between the first and the second, the sign and the object of signification is a link, also called the representation, interpretant or *third*. The third (interpretant /representation) is the mental effect that the sign conveys to a receiver,[1] that is, the general meaning of the sign. All communication, - and we should take communication in a broad sense here including drawing that includes sensations and ideas that cannot be represented through language -, relies on the co-play of these three parts.

Peirce orders things and phenomena in the world according to his categories firstness, secondness or thirdness, which describe three modes of being.[2] Phenomena of firstness are expressed through the group of signs called icons and work by abduction. Phenomena of secondness are expressed through the group of signs called indexes and work by induction, and phenomena of thirdness are expressed through the group of signs called symbols and work by deduction. Firstness describes phenomena of sensation and ideas. Phenomena of firstness are pure qualities, such as feelings and thoughts which are merely possible. Phenomena of firstness are originary and by definition vague and indeterminate,[3] because they stand alone without relation to anything else. Such relation would introduce secondness.[4]

> The idea of First is predominant in the ideas of freshness, life, freedom. The free is that which has not another behind it, determining its actions; but so far as the idea of the negation of another enters, the idea of another enters; and such negative idea must be put in the background, or else we cannot say that the Firstness is predominant. Freedom can only manifest itself in unlimited and uncontrolled variety and multiplicity; and thus the first becomes predominant in the ideas of measureless variety and multiplicity.[5]

Phenomena of secondness are existing facts and material things in the world, which offer resistance to the phenomena of firstness. The hard facts of secondness cannot help being in a relation of resistance to the phenomena of possibility and sensation; phenomena of firstness and secondness therefore are in a tense relationship. Matter causes resistance to pure possibility.[6] Take the relation between an architect and a drawing. The architect has ideas and sensations that she tries to transfer and make visible in the drawing. A drawing on paper is itself a material thing that together with pencils, rulers etc. are haptic in another way than the architect's imagination of what the

drawing might be. The drawing tools and materials give resistance to sensations and thoughts; they do not just transmit them without alteration. It is a matter of training to become familiar with this exchange between what Peirce describes as modalities of being first and second. Said differently, it becomes easier to make sensations and ideas visible in the drawing when one has gained experience, but this never happens in a one-directional or seamless way. It is not like the architect simply "delivers" his ideas to the drawing. Rather, the drawing renders something visible which was not in the mind or senses before the act of drawing began. Maybe, this is why architects sometimes say that the drawing is smarter than they are.

The resistance between phenomena of firstness and secondness can be productive in a positive way (restraints can heighten creation), but maybe it suffices to say that there is a spontaneous impact between architects, ideas and drawings no matter what, just because of the drawing's material character which differ from ideas and sense qualities. In Peirce this resistance is given before the *third*, which links that the first and the second in a stable relation to each other. Peirce calls the relations of the third habit or convention. But there is not any stable relation between the first and the second in the outset, just effect or impact.[7] It is between the first and the second, however, in the orchestration between these modes of being, that diagrams play an important role. Thus Peirce thinks of different kinds of reasoning as linking to different kinds of signs that describe different kinds of phenomena.

Phenomena:	Firstness	Secondness	Thirdness
Reasoning:	Abduction	Induction	Deduction
Signs:	Icons	Indexes	Symbols
works by:	Instinct/guess	Empirics	Habit/law

Drawing and the Body

Where projection is an aspect of conventional drawing, which has moved comfortable in with the computer, there are other aspects of drawing which feel better at home in 'pen and paper surroundings'. These other aspects have to do with the human body and direct, haptic ways of sensing a drawing. The body is the direct and indirect 'reference point' of architecture: Just as buildings are made to be inhabited by bodies, the projective systems of drawing point to the body. In perspective drawing this is very obvious; we look through an eye-height through an imagined, invisible body. In orthogonal projection scale is also read through the body, - you develop a bodily feeling for how a 1:50 drawing differs from a 1:1000 drawing by looking directly at the drawing. With pen and paper the drawing is 'called forth' in a fixed ratio to the body, and it is well-known that drawing on the computer screen can confuse this feeling for sizes, which is trained more directly when the drawing is a physical thing right in front of you. The whole material feeling that a traditional drawing situation has, has changed with computer drawing as Jean Gardner and Brian McGrath show:

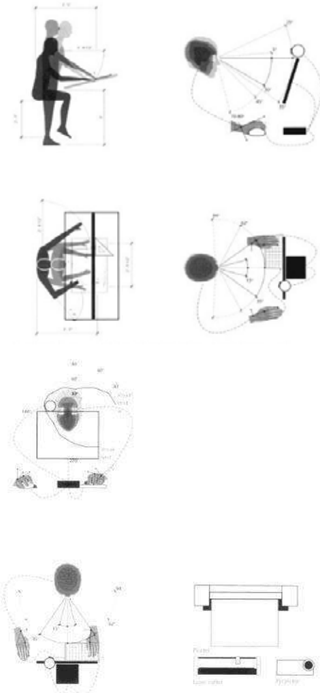


Illustration from *Cinemetrics - Architectural drawing today* by Jean Gardner and Brian McGrath.

Here it is shown how the human body moves in relation to the drawing table with paper, parallel ruler, square etc. Then a human is shown using a computer and a printer, which changes the way the body moves in the drawing situation, but also displaces the relation between the body and the drawing, because of the extra mediating chains and dependencies that the input-output situation with the computer involves. But this, of

course, concerns *miming* conventional drawing space as a pen and paper activity, where the clue in many computational design practices is exactly to not do that, because the output is not on a paper but managed by 3D fabrication machines. However, often times the expected outcome is visualised beforehand in some sort of projection.

The Digital Sundial

A sundial called *The digital sundial* was invented by Hans Scharstein, Daniel Scharstein, Werner Krotz-Vogel and Felix Scharstein in 1998.[8] It combines a scanimation drawing technique with a sundial. *The digital sundial* has no moving parts and yet the display image, which shows local solar time written in numbers, continuously changes during a day like a very slow animation. The image changes due to a high resolution scanimation drawing combined with the movement of the sun and the earth.

A digital sundial

> The principle underlying the digital sundial is amazingly simple. Two photographic masks are separated by a thin sheet of plexiglas. The first mask is a regular array of thin vertical slits, casting a striped pattern of light onto the second mask. This second mask contains all the numbers to be displayed during the day, cut into vertical stripes, and interleaved in such a way that only a single number's stripes are illuminated at a time. As the sun moves through the sky, the illuminated numbers change to indicate the current time. During transition times, two hours will be visible simultaneously.[9]

Like any sundial *the digital sundial* always differs from mean time, but is locally exact.[10] With the sundial as metaphor for a mixed form of analogue and digital notation, and the digital sundial as adding the scanimation technique to the working nexus, I made some drawings with a 3D modelled sundial in 3D Studio Max's sunlight simulation system.

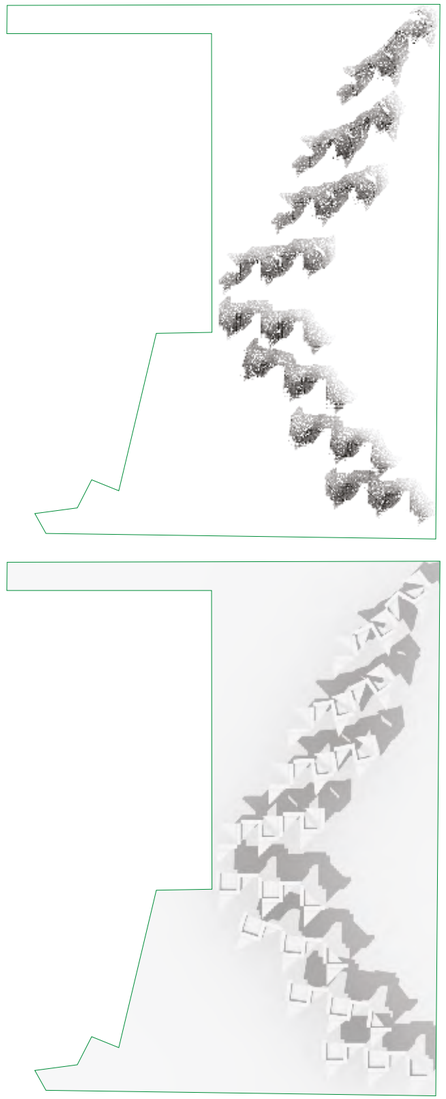
After having tried different things with the world map scanimation and the sundial in combination, I started to notate circles, instead of an image of the world. In that way some of the narrative character that a scanimation makes possible was removed, and by just notating circles a simpler but more distinct notational character was gained, where a full circle notates a full hour. The sundial structure became like a big clock and calender, a built calculative framework notating different points in time with light and shadow in the form of circles and triangles. The opening aspect of working with the sundials is that projection (shadow tracing) *notates* time, and hence the distinction between notation and projection, which both Ingold and Allen make, is transgressed. Projection takes part in a notation performance and vice versa.

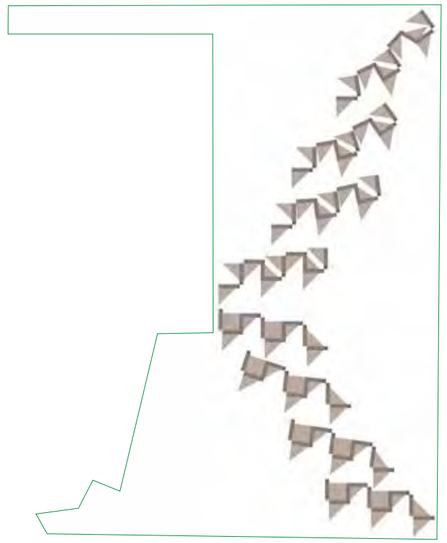
Notes - Appendix

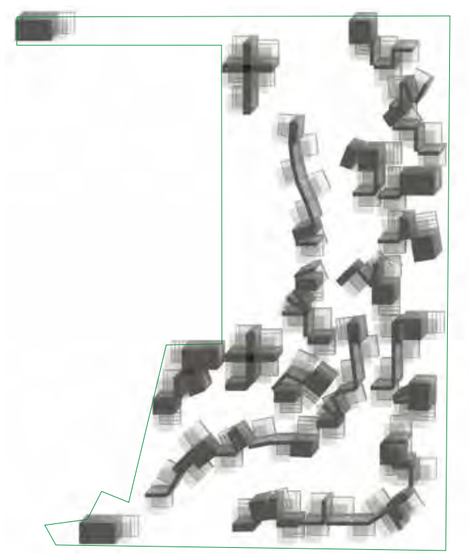
[1] "A representation is that character of a thing by virtue of which, for the production of a certain mental effect, it may stand in place of another thing. The thing having this character I term a *representamen [later he replaces the word representamen with sign]*, the mental effect, or thought, its *interpretant*, the thing for which it stands, its *object*."
http://www.commens.org/dictionary/term/representamen (accessed 14.12.2014) "That Categorical and Hypothetical Propositions are one in essence, with some connected matters", 1899, Collected Papers, 1.564.
[2] Peirce, *Semiotik*, 136.
[3] Ibid., 29-30, 41.
[4] Ibid., 14–15.
[5] http://www.commens.org/dictionary/term/firstness (accessed 14.12.2014) "The List of Categories: A Second Essay" (ca. 1894), in Charles Hartshorne and Paul Weiss (eds.), *Collected Papers of Charles Sanders Peirce*, 8 vols. (Cambridge, MA: Harvard University Press, 1931), vol 1, 302.
[6] Peirce, *Semiotik*, 30.
[7] Ibid., 51.
[8] invented in 1994 and now patented, http://www.digitalsundial.com/product.html
[9] http://www.digitalsundial.com/Instructions.pdf (accessed
[10] "Solar time and standard time differ by varying amounts during the course of a year. … This difference is called the "equation of time", … : On January 1, for example, a sundial will run about 3 minutes slow; on October 15, it will be about 14 minutes fast compared to a clock showing standard time." http://www.digitalsundial.com/Instructions.pdf (accessed 28.02.2016).

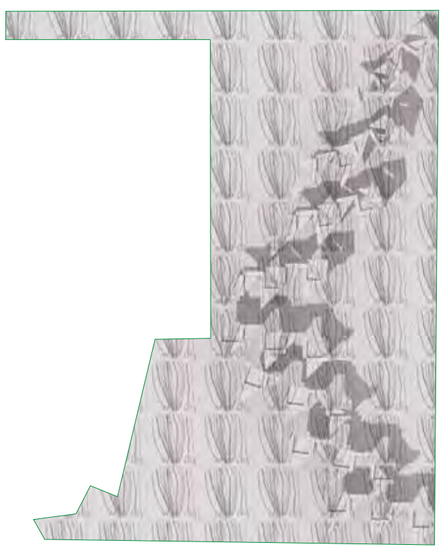
DRAWING APPENDIX

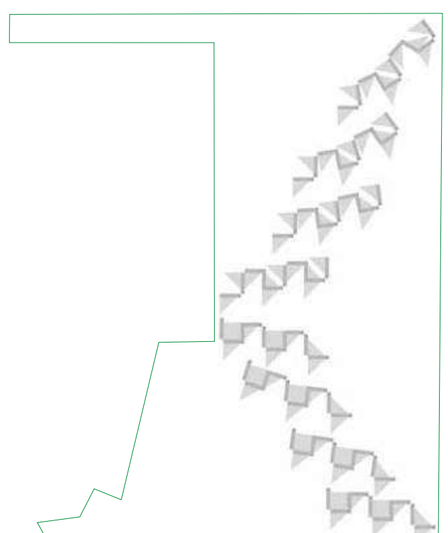
Not all the drawings that I made in relation to the project fitted into the main work. I have arranged those that did not fit in here as an appendix of drawings and sketches. Here the drawings make up a world of their own unaccompanied by words.
Here both process drawings that were steps on the way are shown, together with more finished drawings that were made as a kind of ‘side effect’ of the process, but fall outside the way the drawings were grouped in relation to the texts. The drawings in this appendix follow the same chronology as in the main work, and offer some extra information if one wishes to see more drawings related to a drawing chapter.

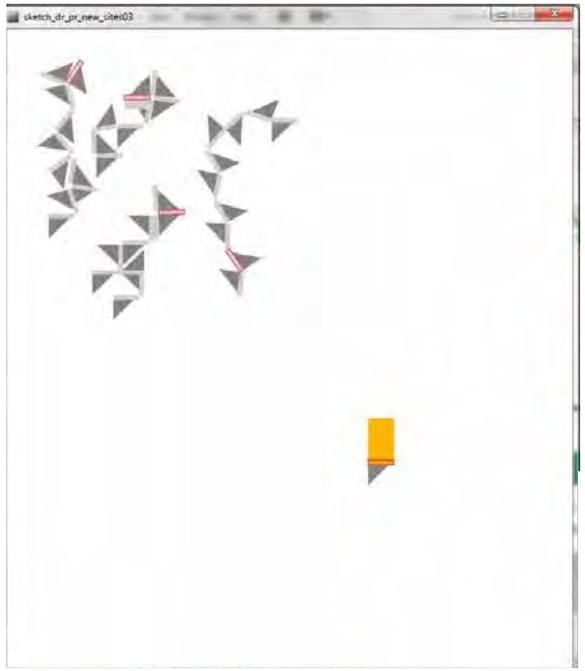




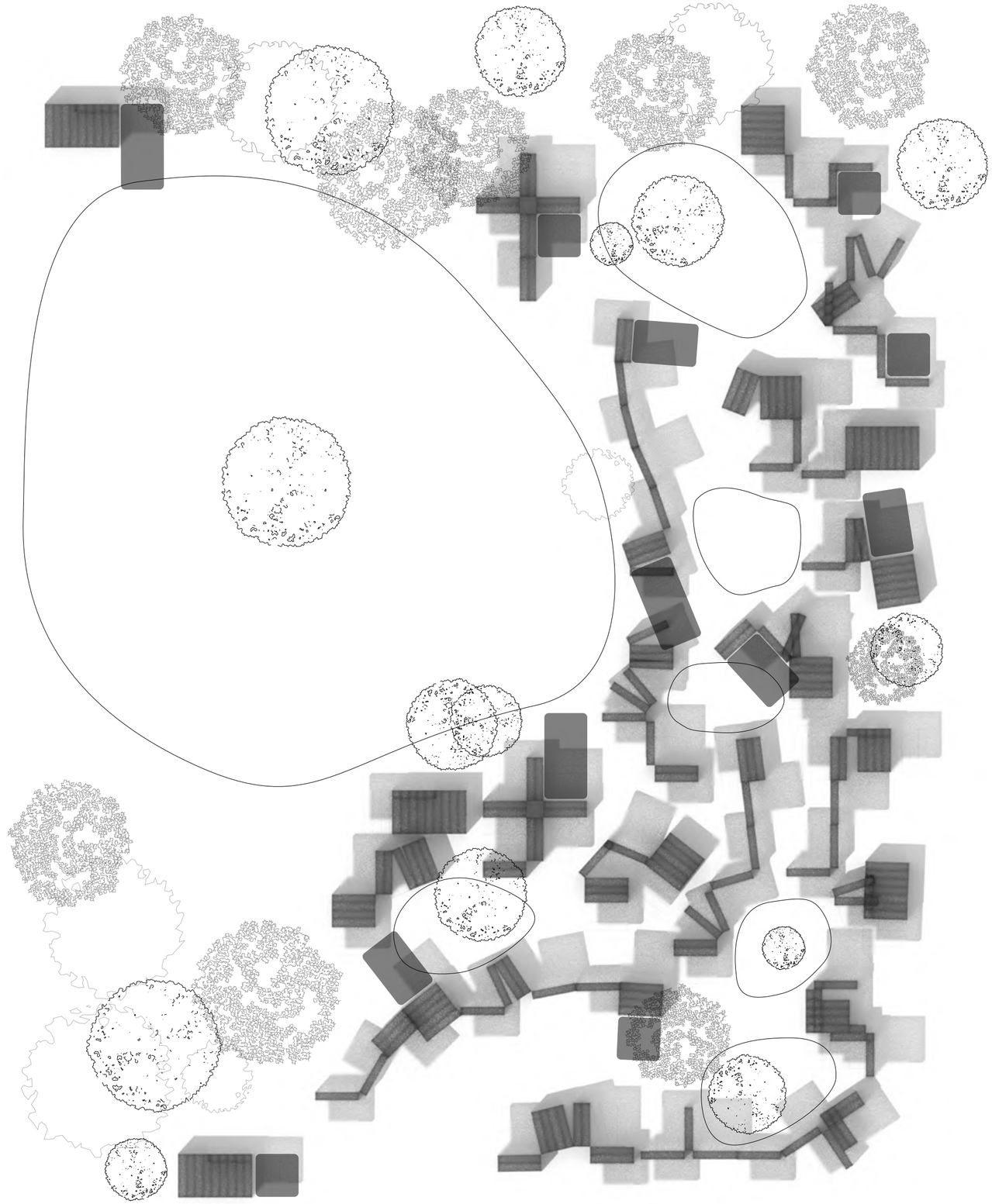


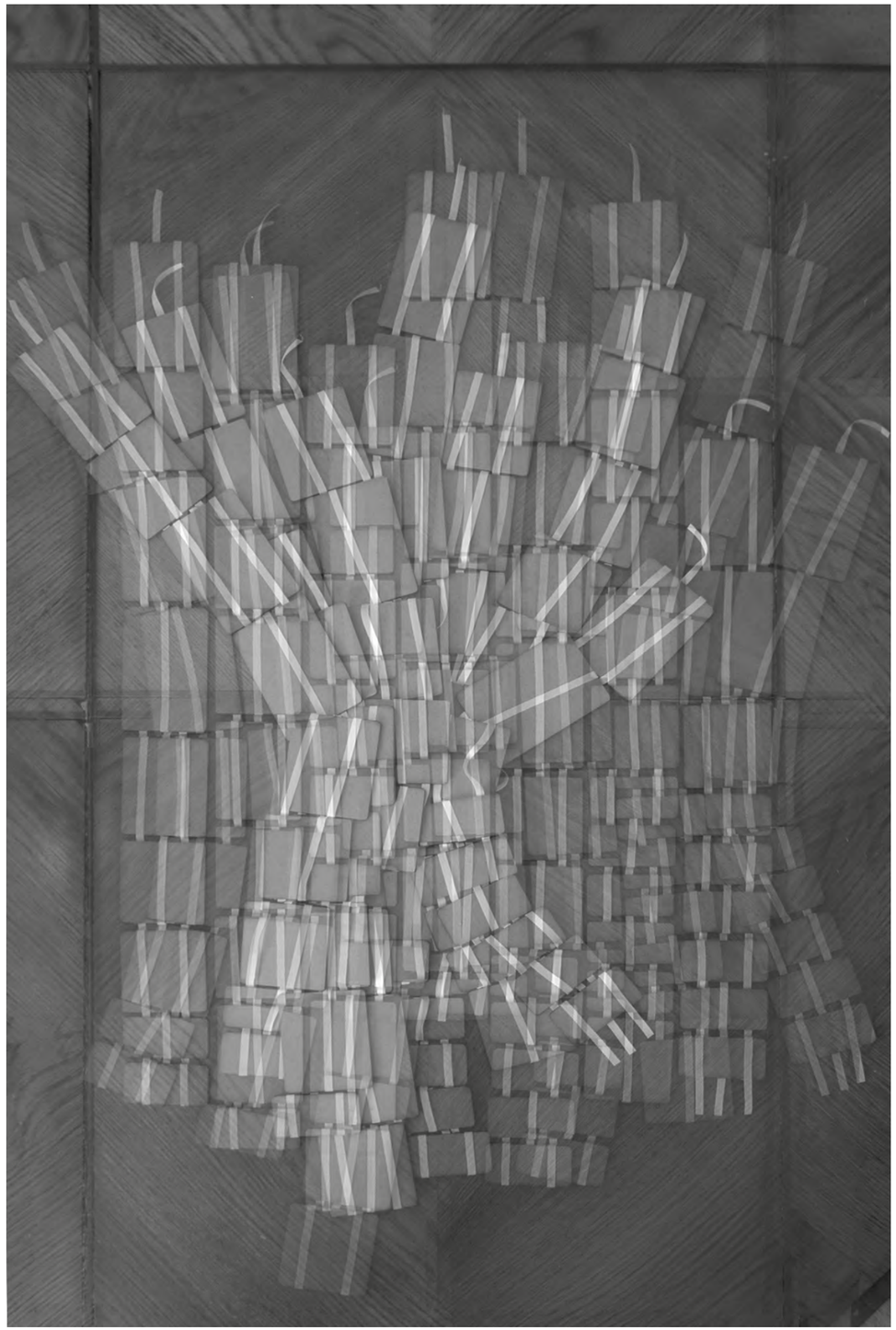


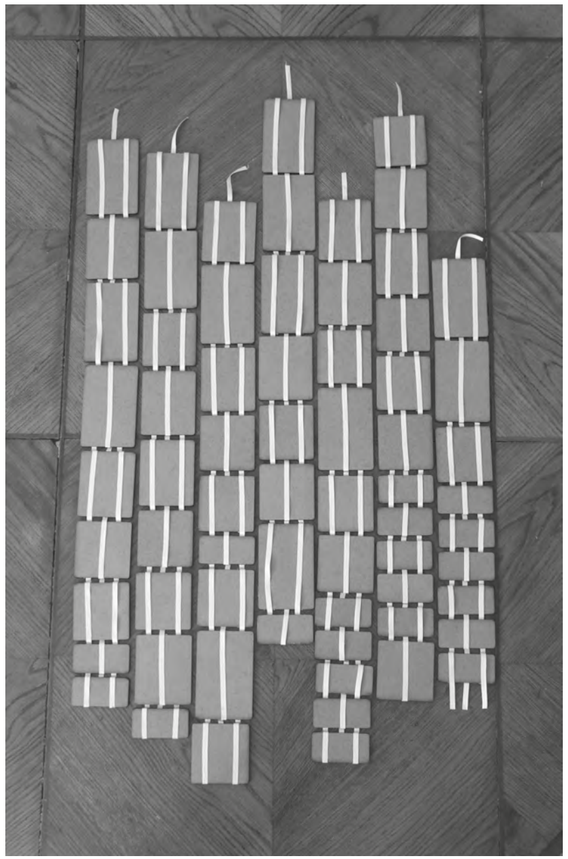


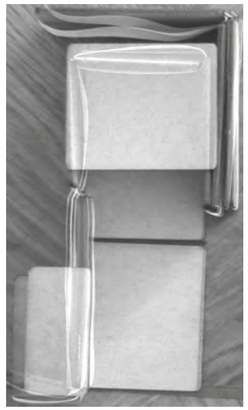

sketch_dr_pr_new_sites03

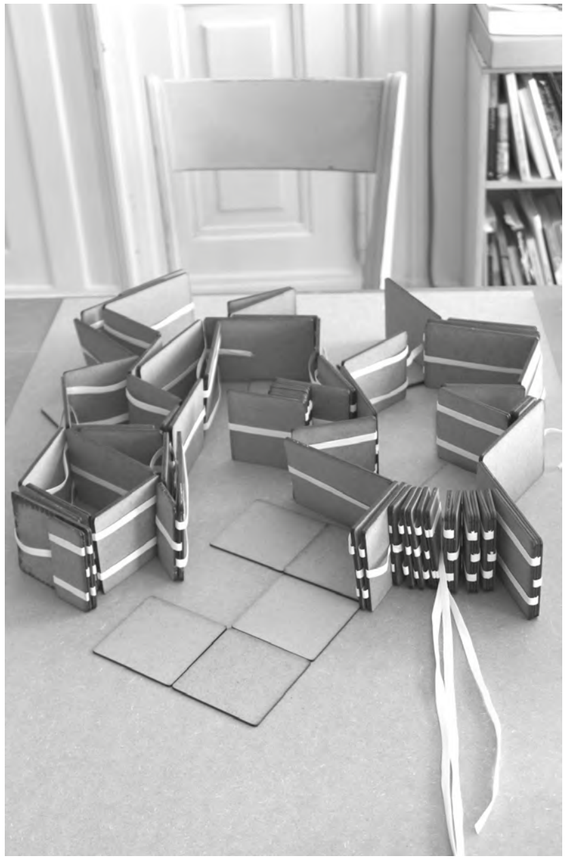

sketch_dr_pr_new_sites03 | Processing 3.0a4
File Edit Sketch Debug Tools Help
Java
sketch_dr_pr_new_sites03
Arm
for (int i = 0; i < turn.length; i = i +1) {
if (i == cur) {
stroke (#FF0335);
} else {
noStroke();
}
pushMatrix();
box(wi, he, de);
translate (-16, 0, -3);
//box(32, 6, 32);
shape (tr1);
popMatrix();
if (turn [i] == 0) {
translate (wi/2, 0, de/2);
rotateY(radians(angle [i]));
Errors
Console

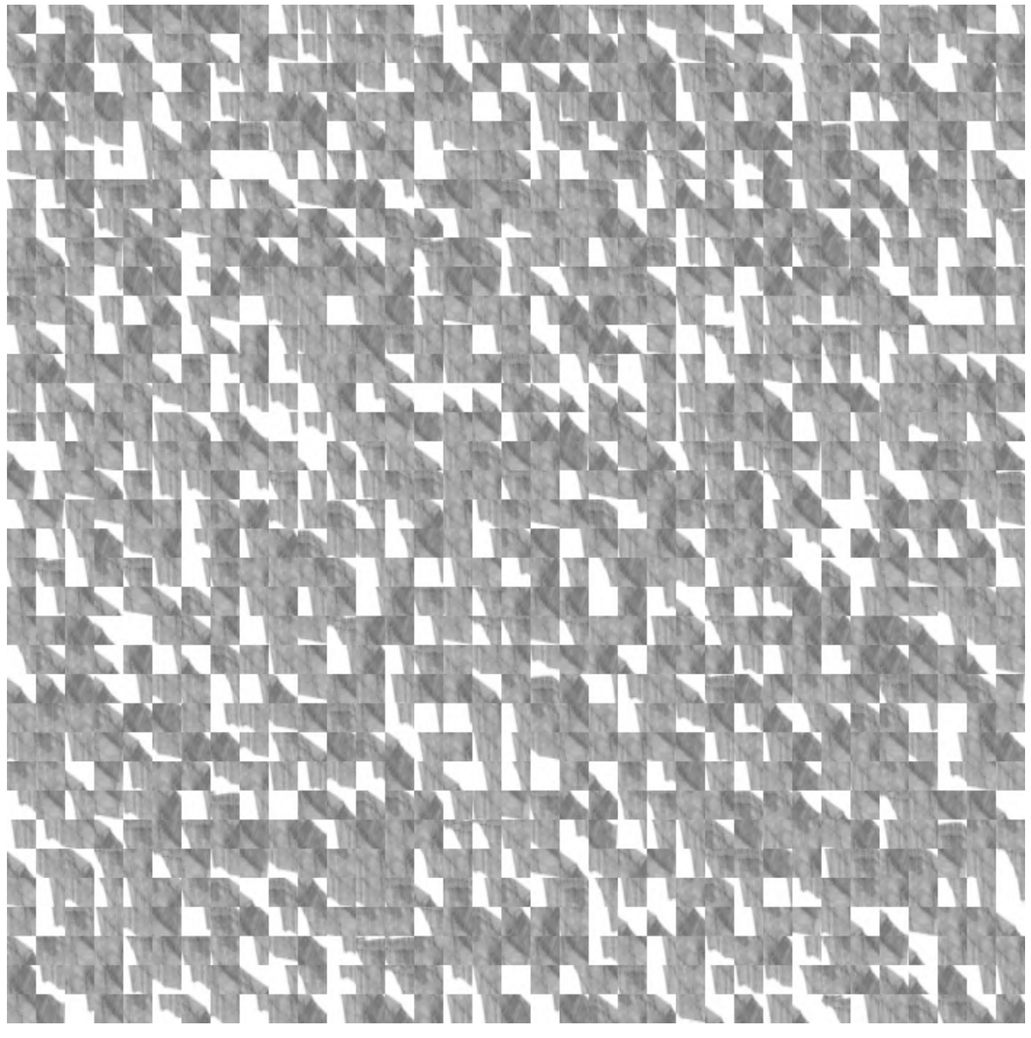


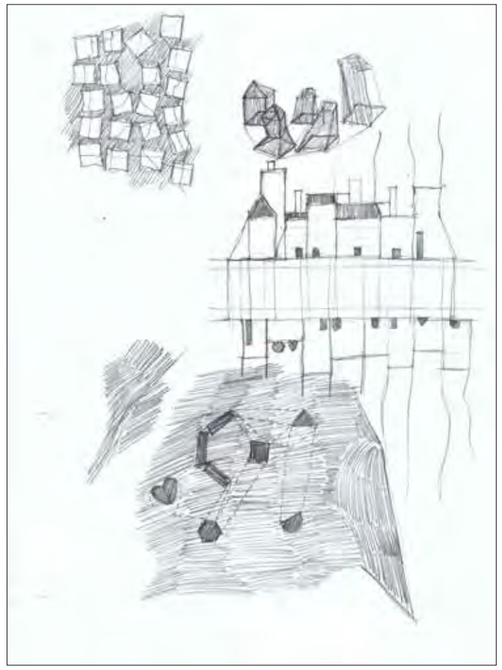


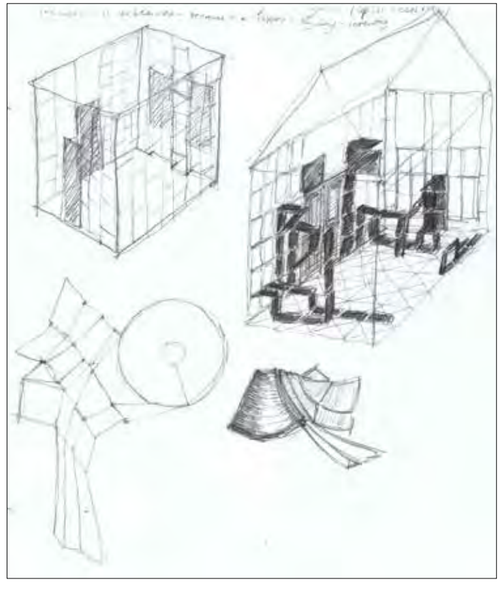


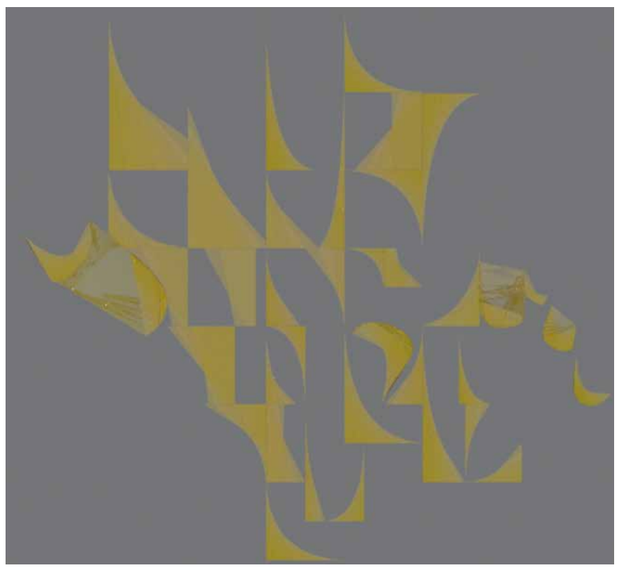


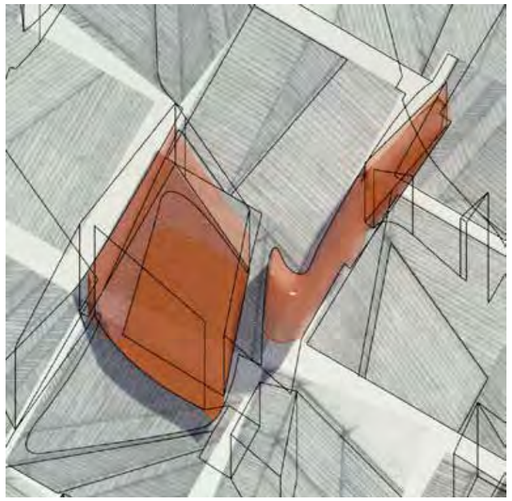


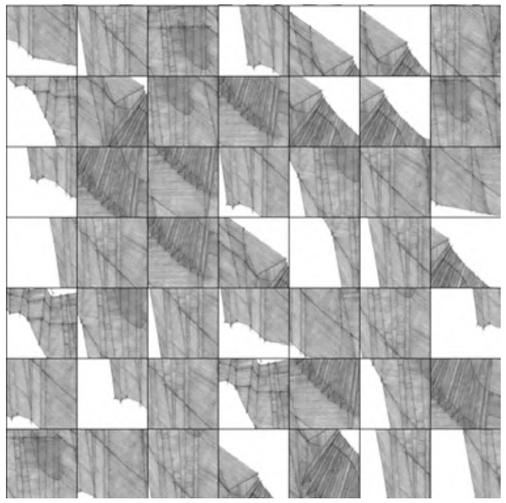


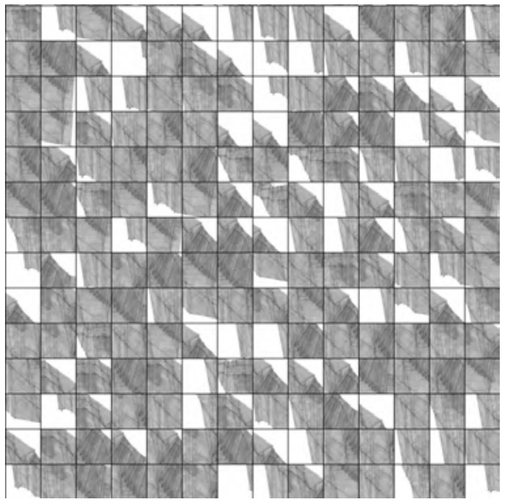


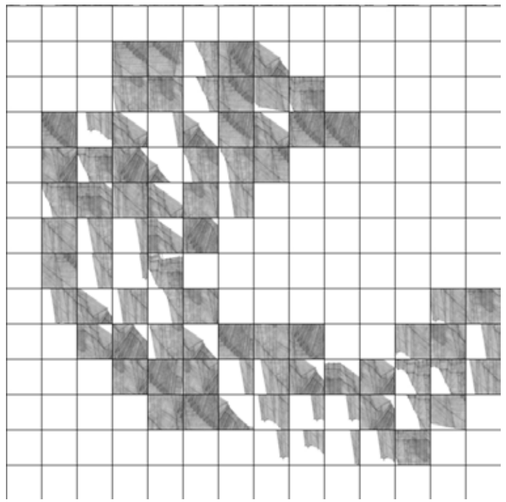


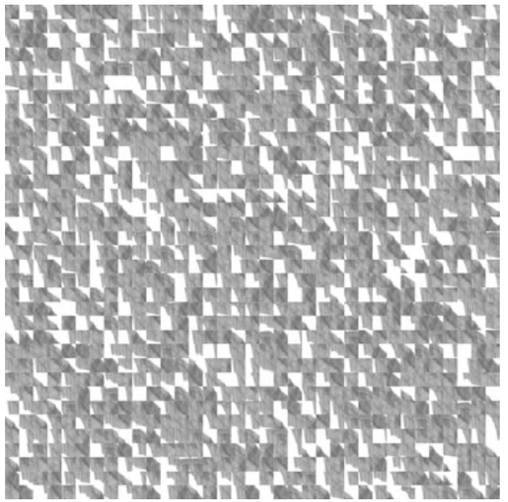


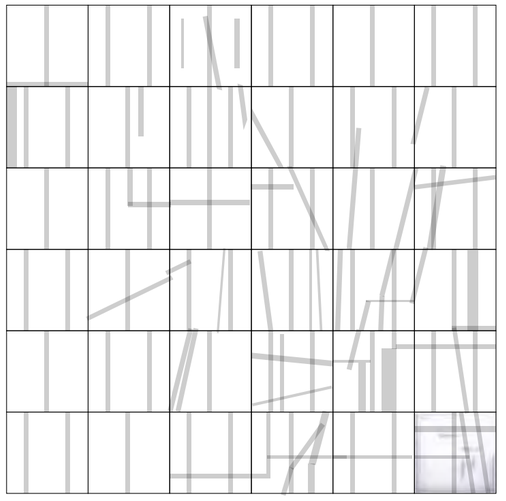


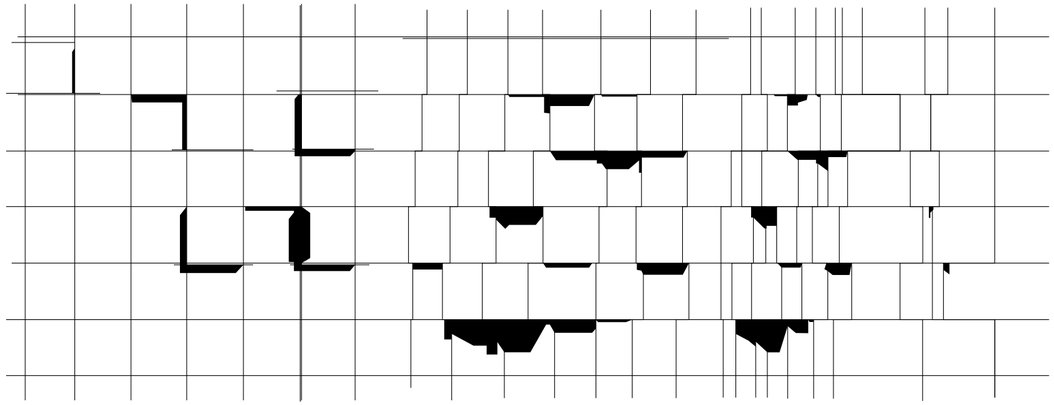


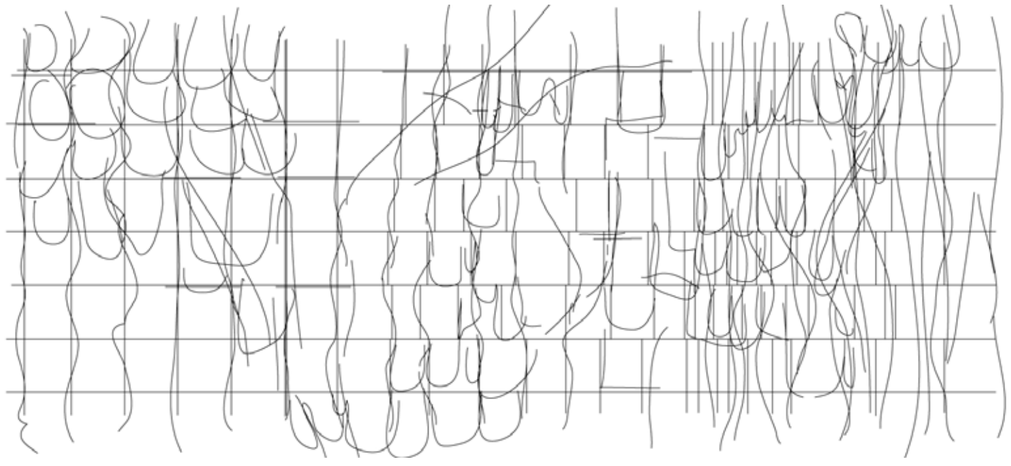


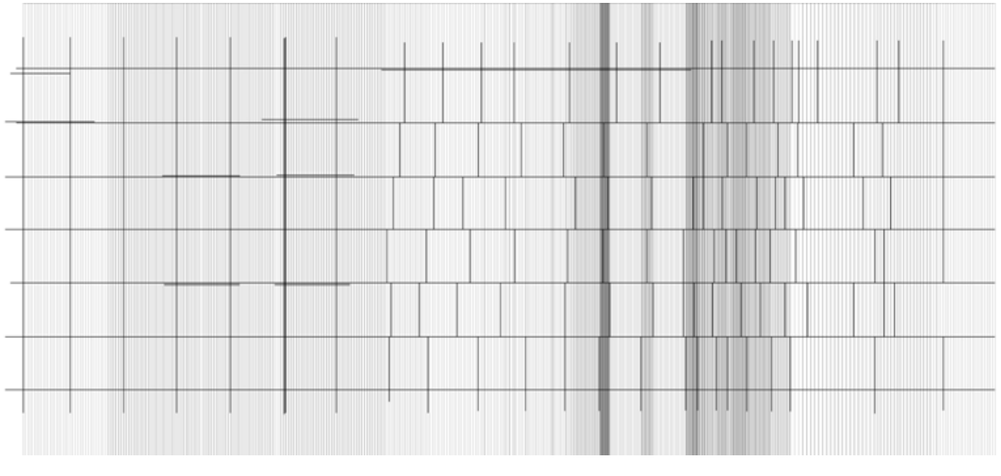


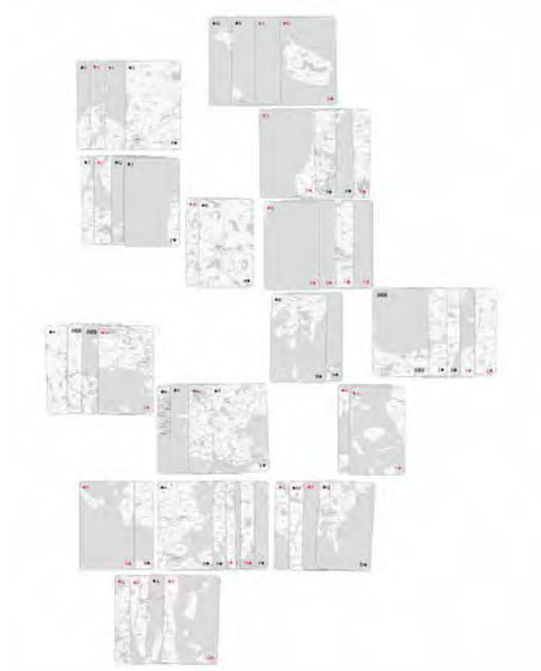


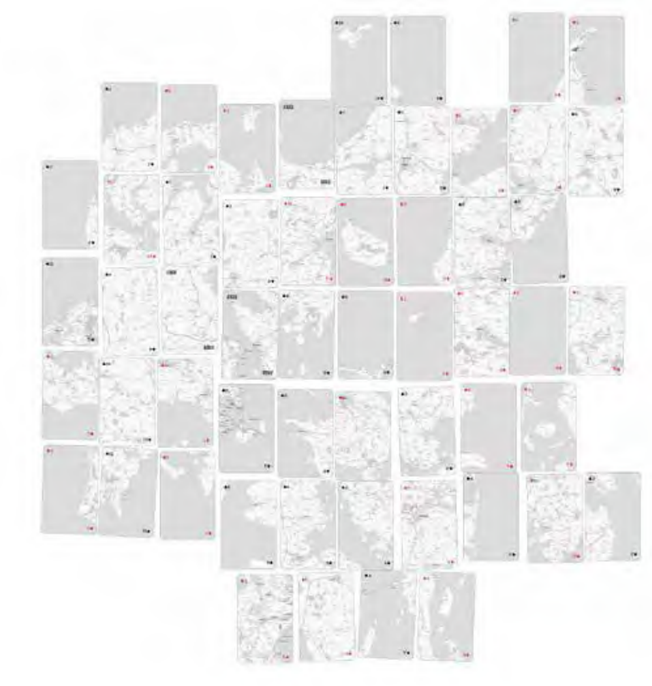


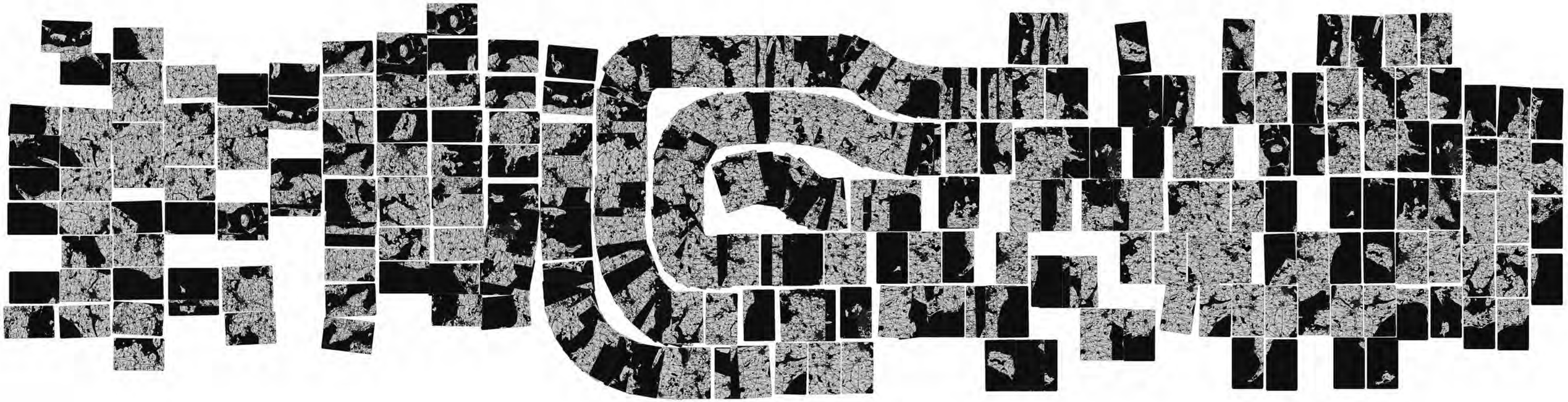


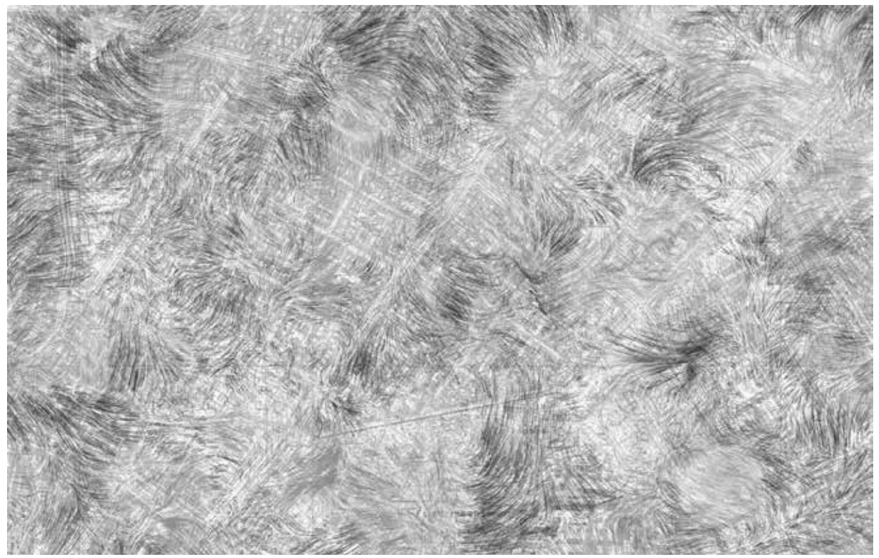


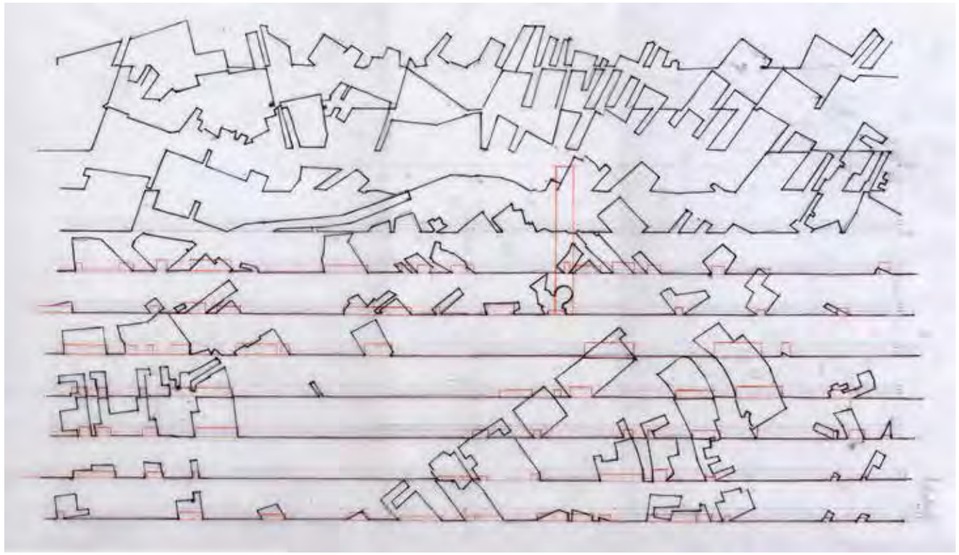


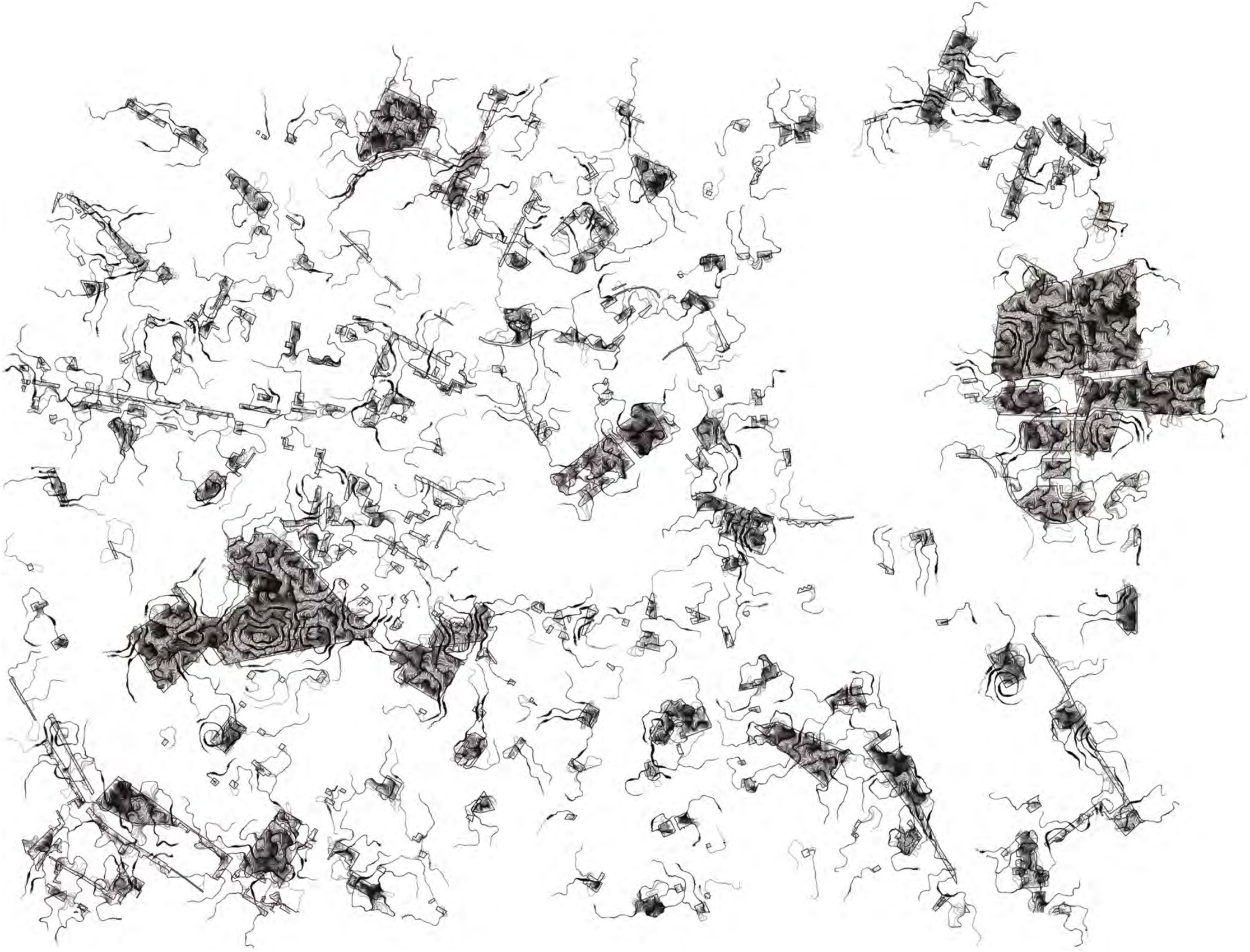


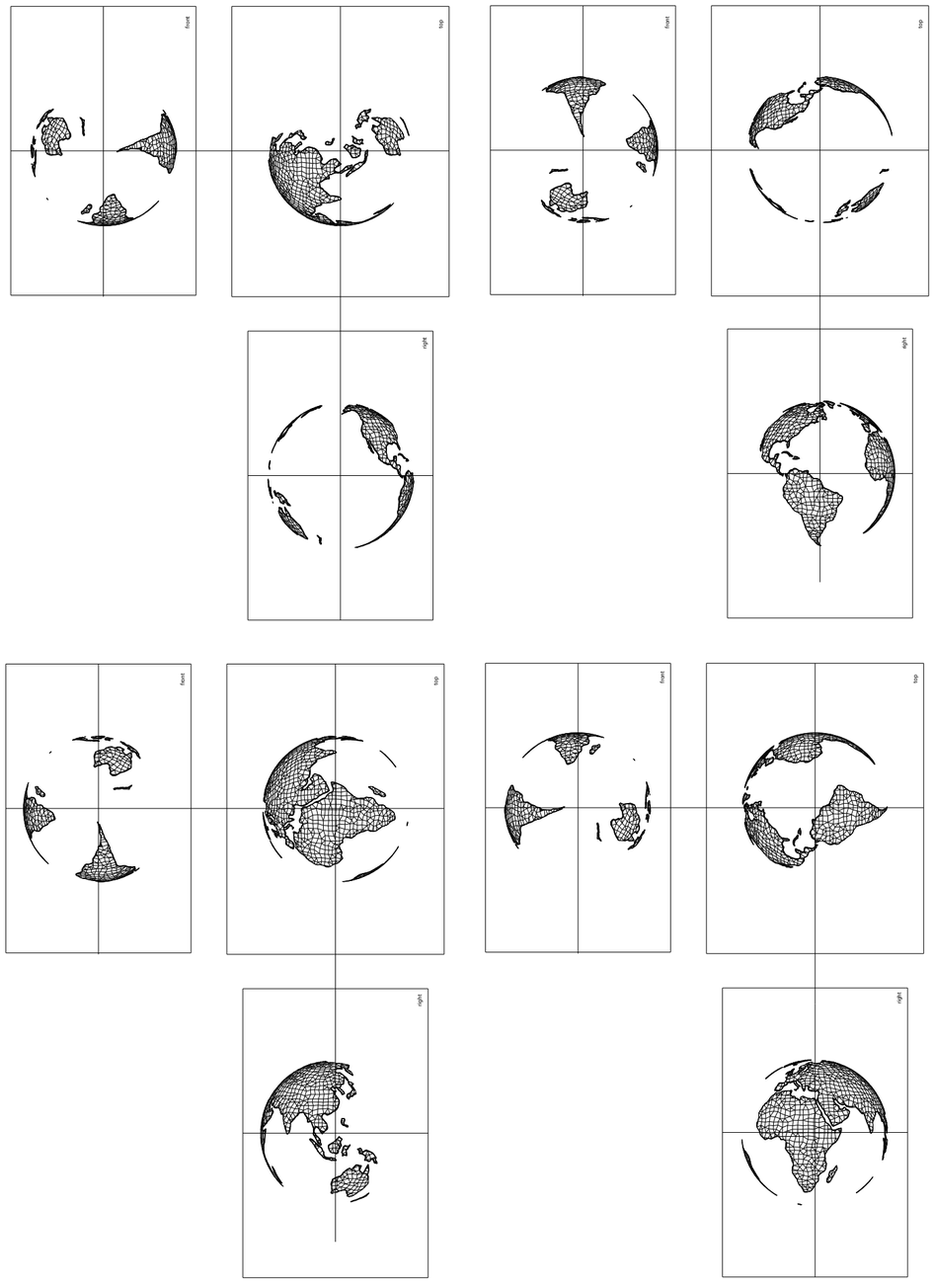




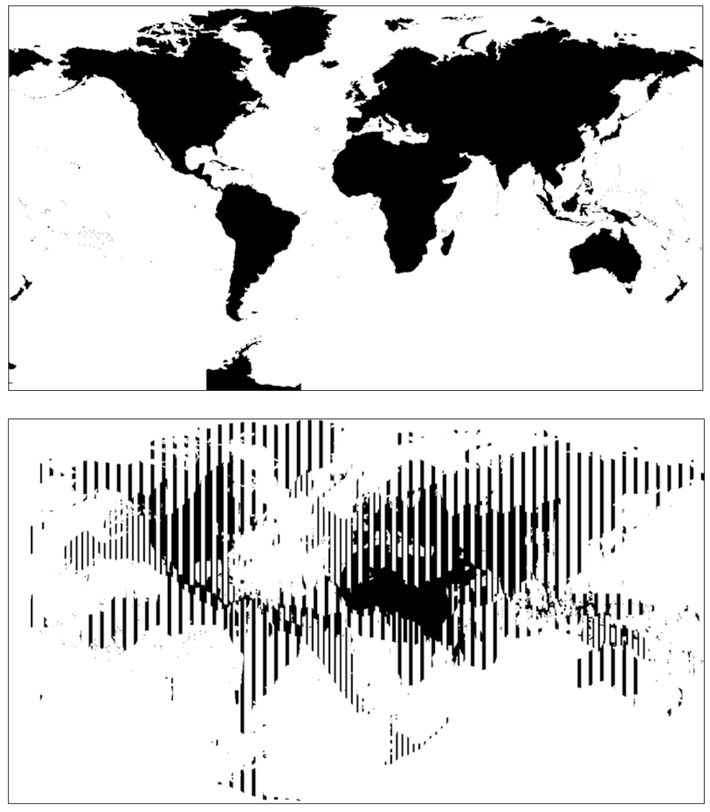


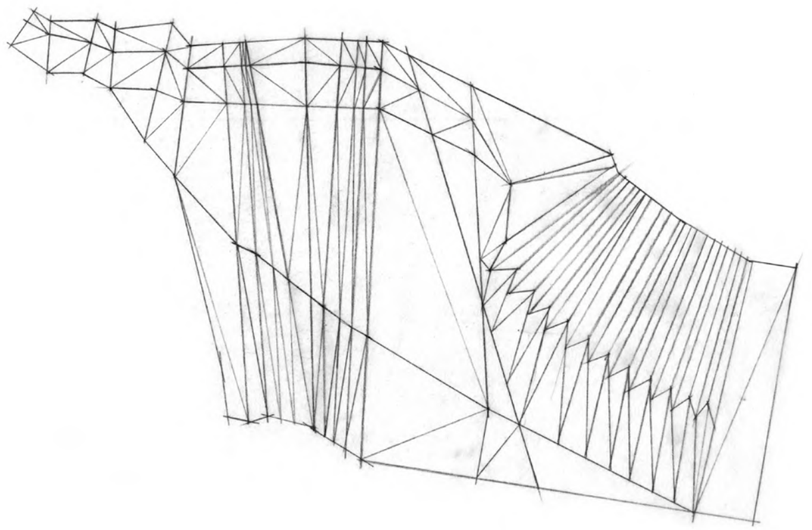


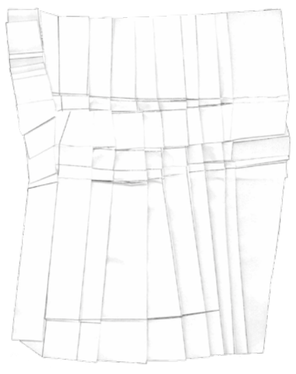


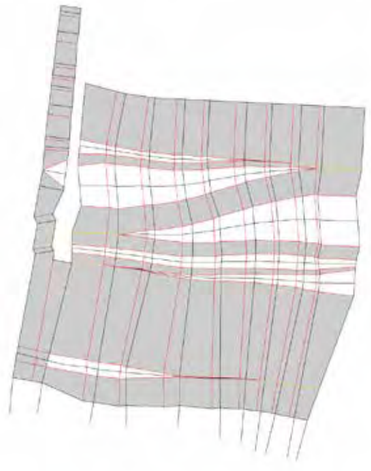


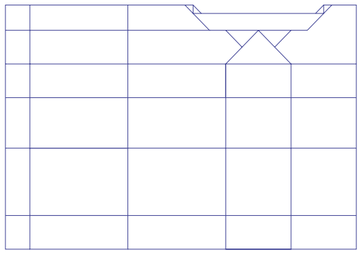
The earth seen in orthogonal projection

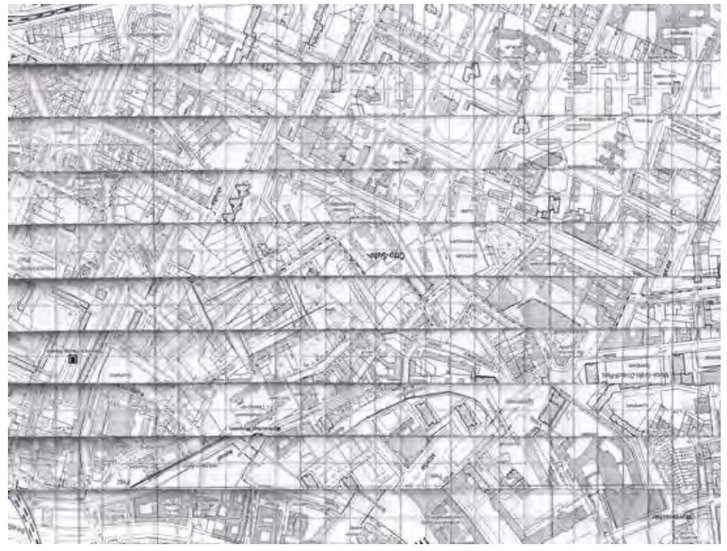


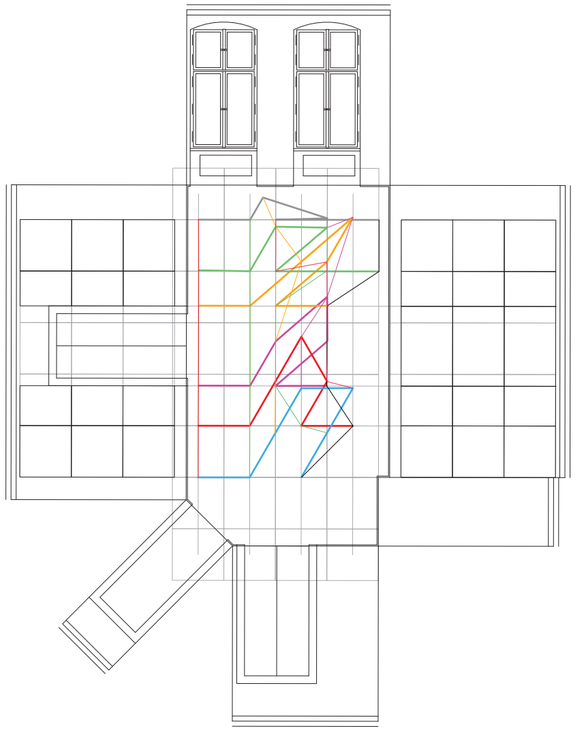


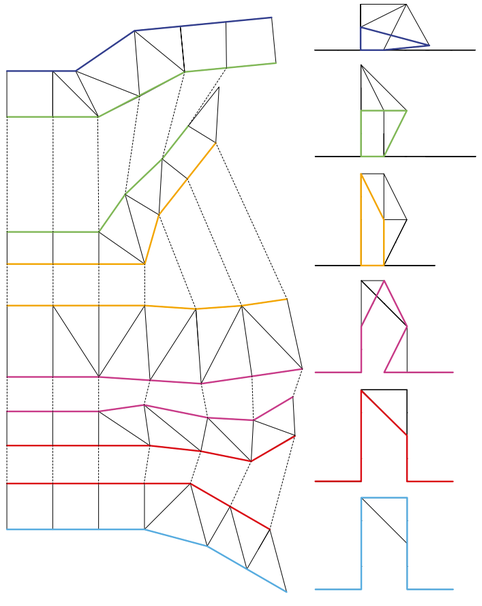


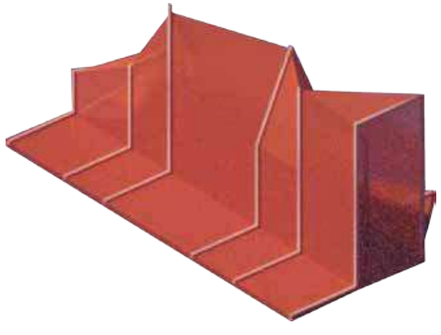


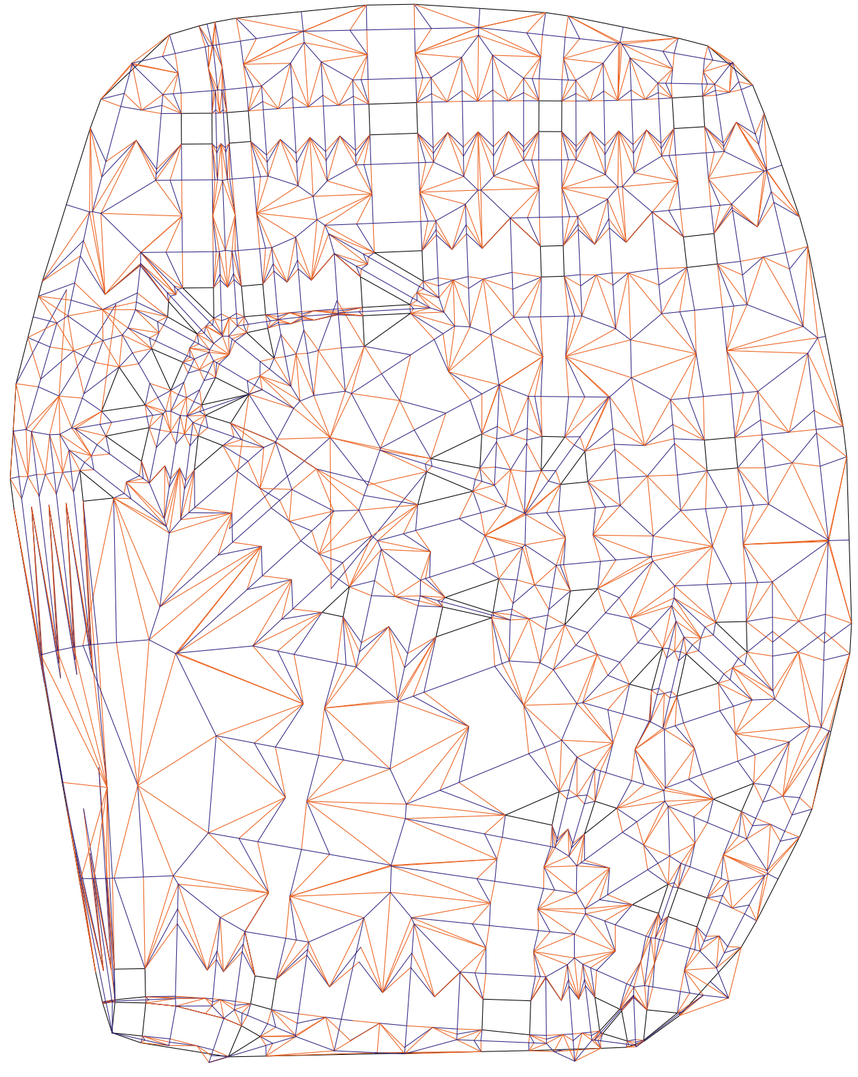




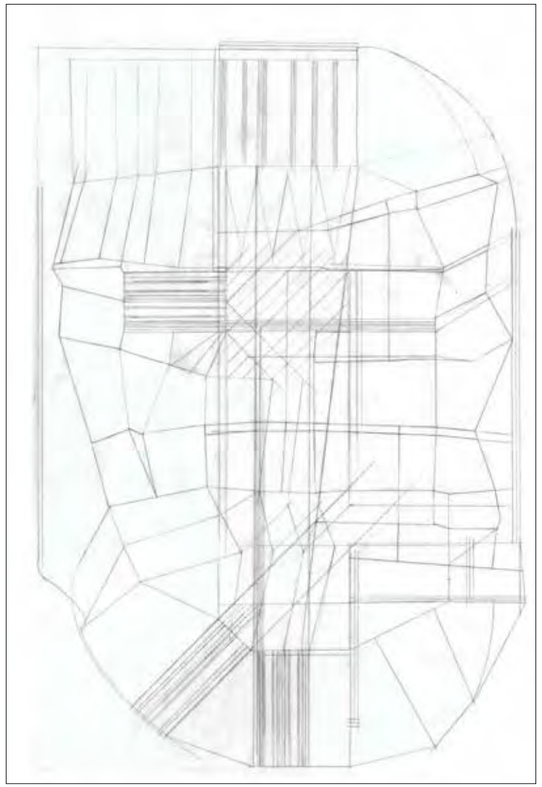


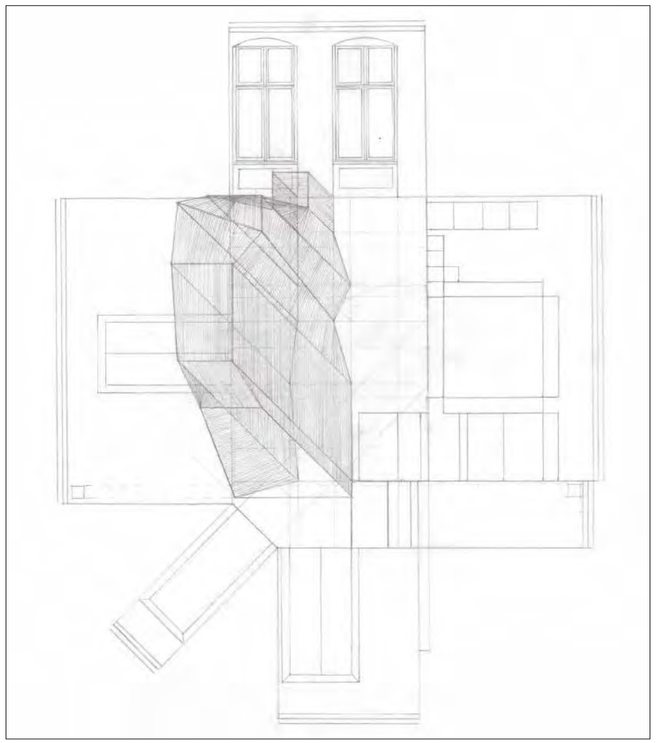


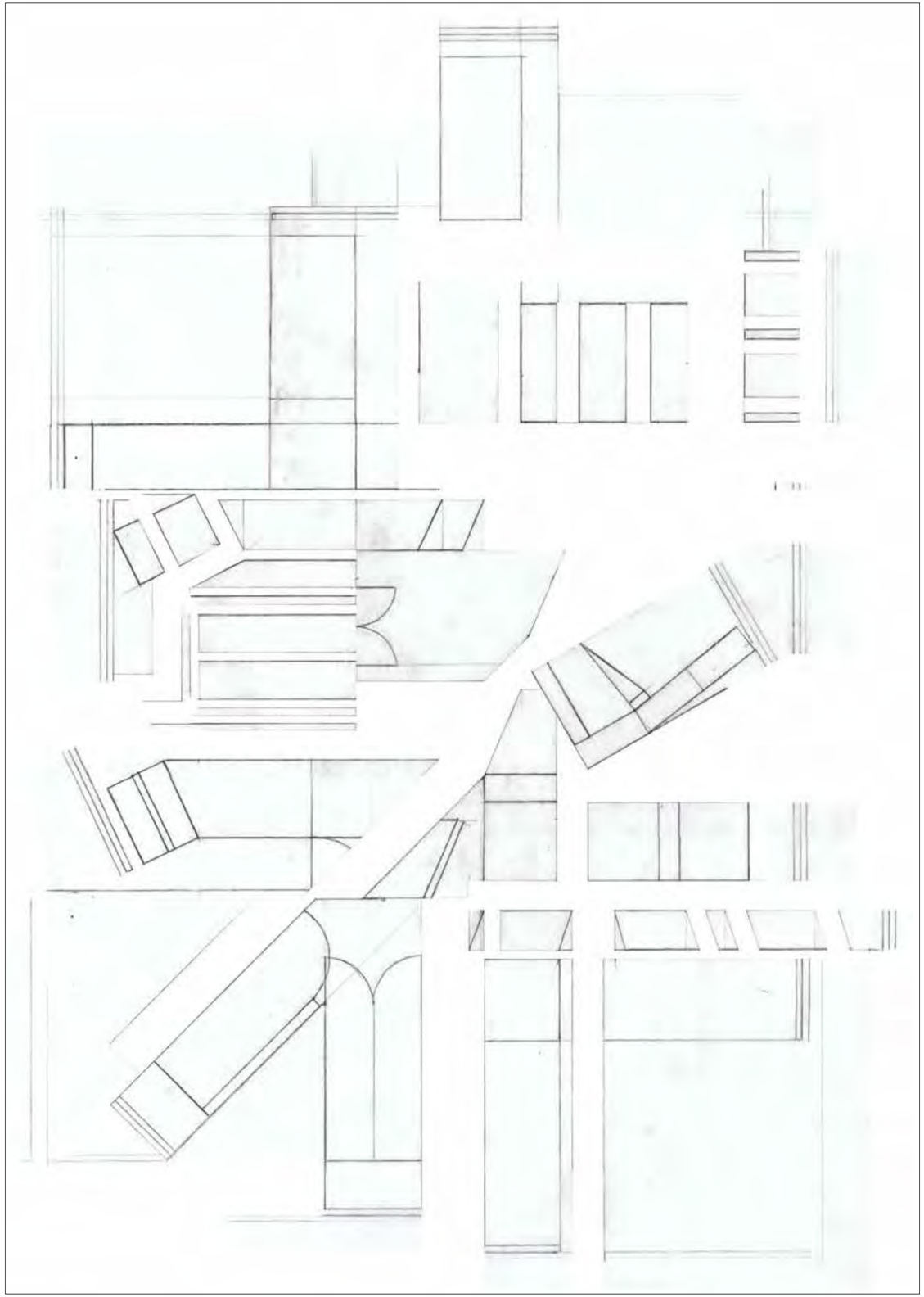


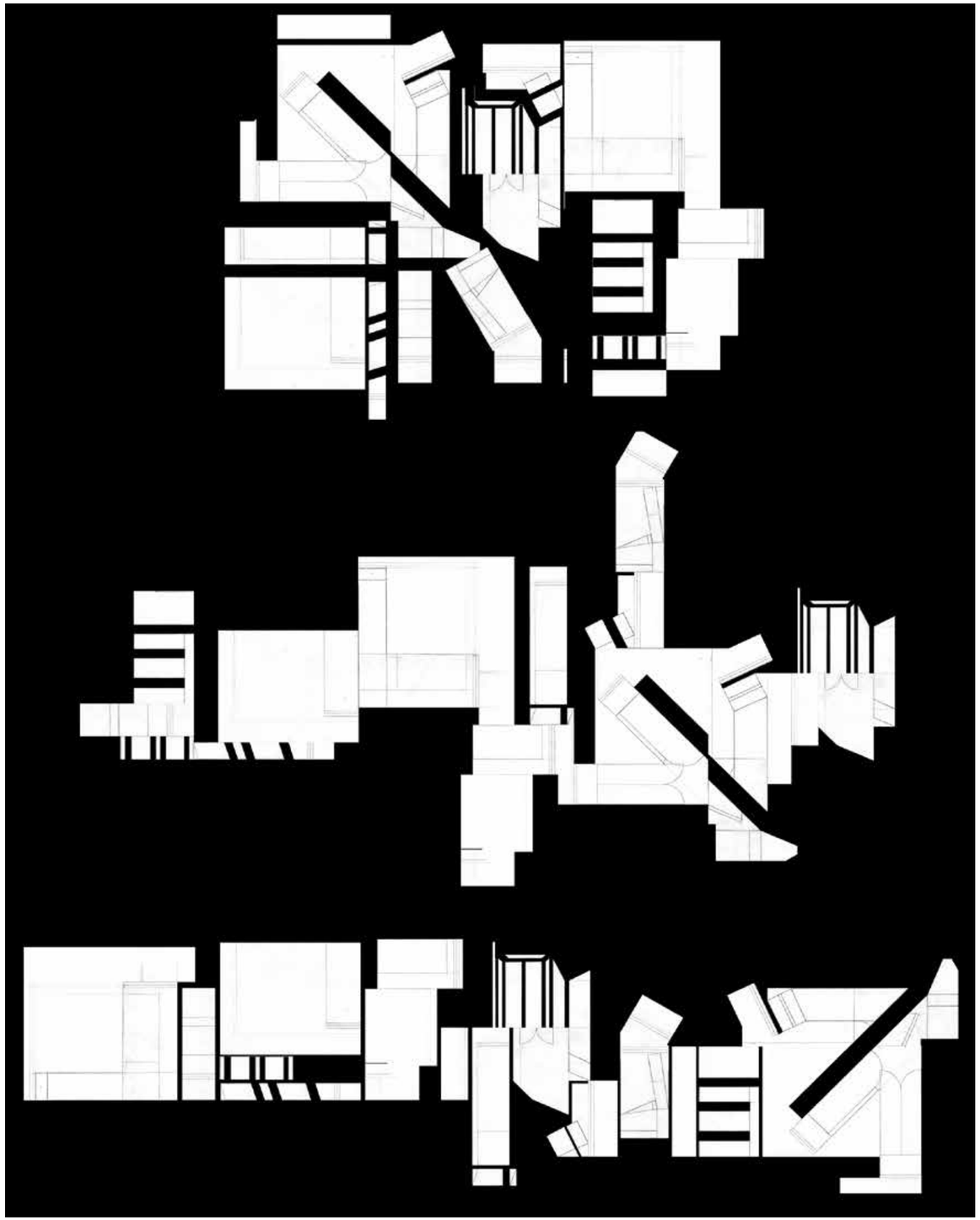


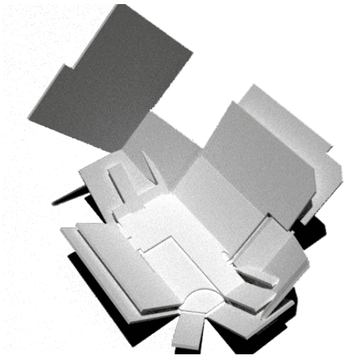
Folding pattern made with Tomohiro Tachi's *Origamizer*.

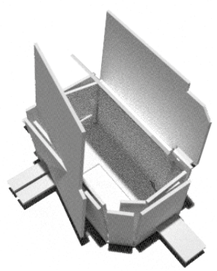


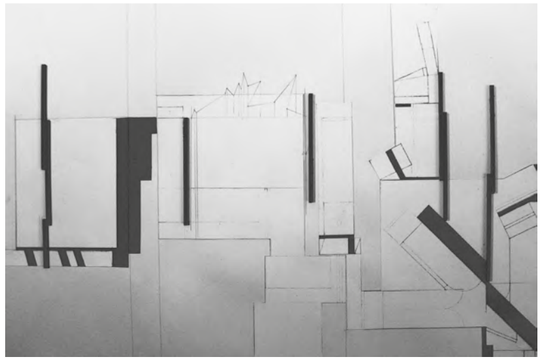


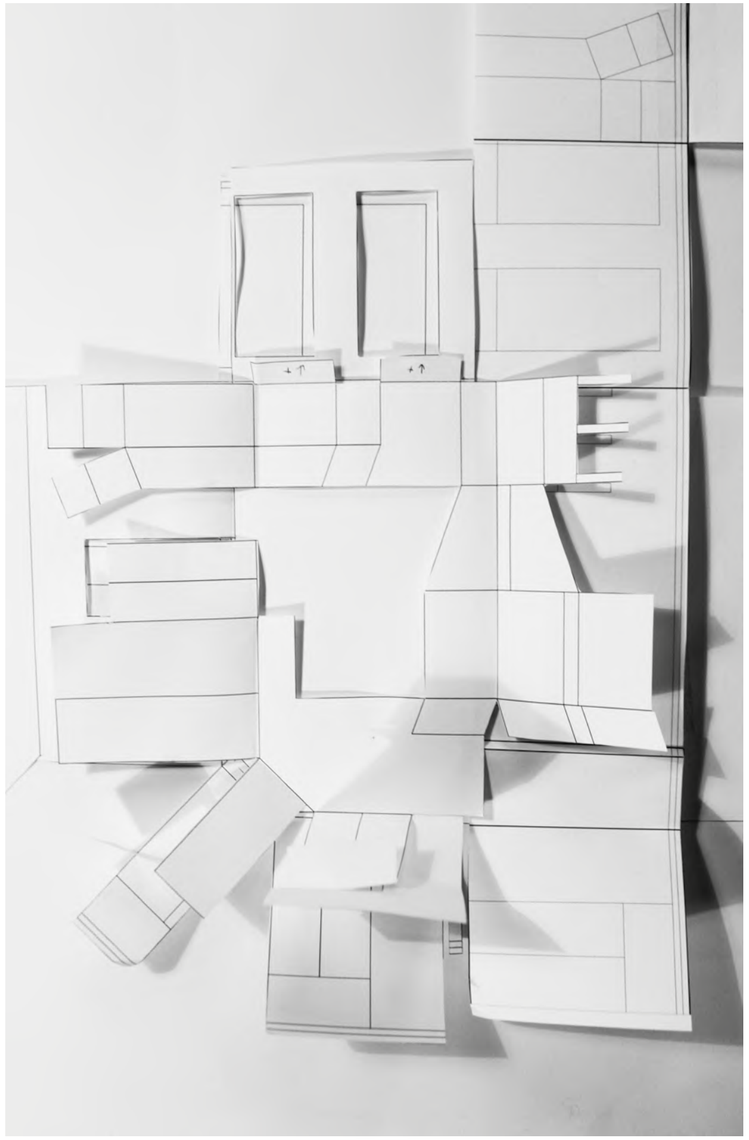


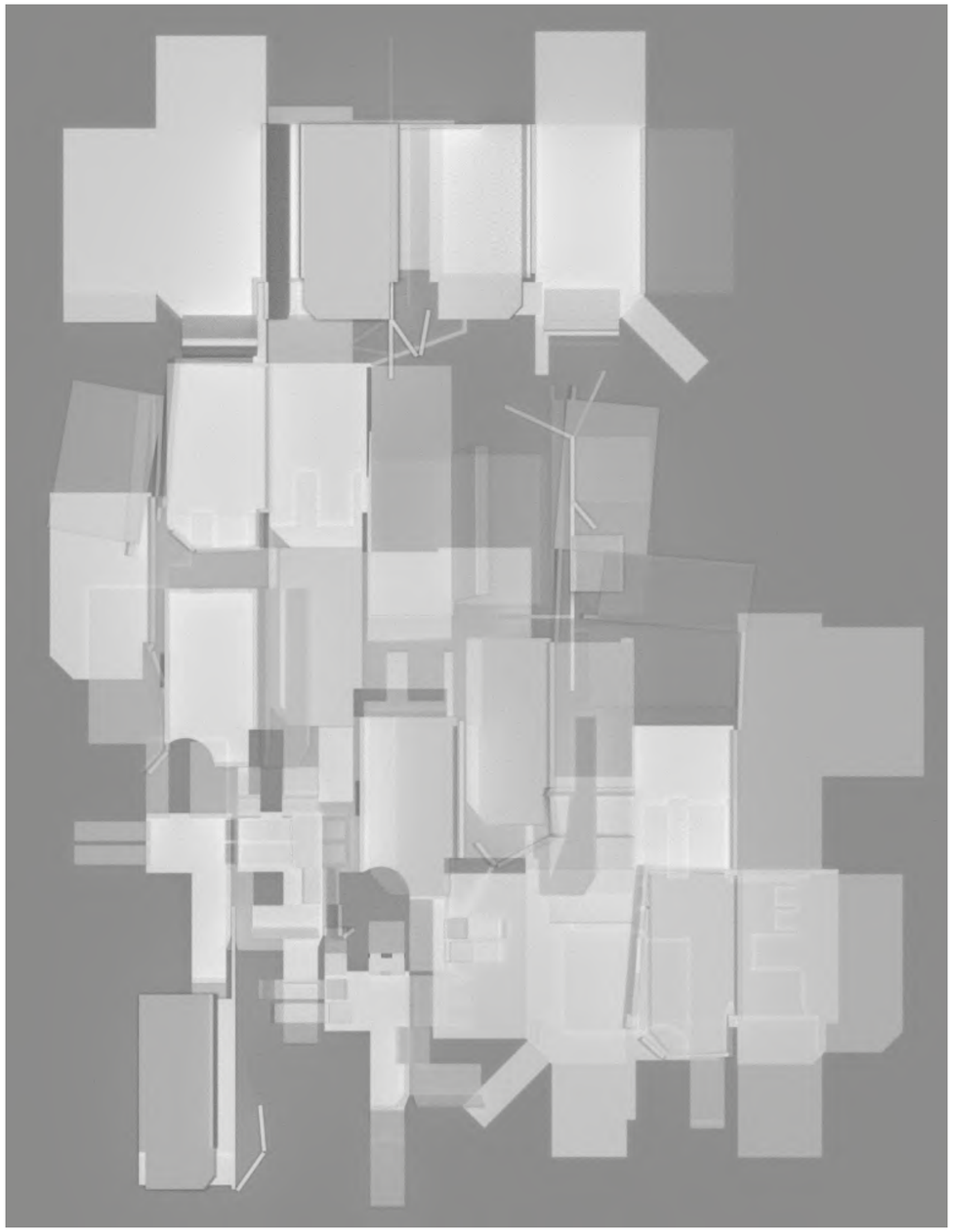


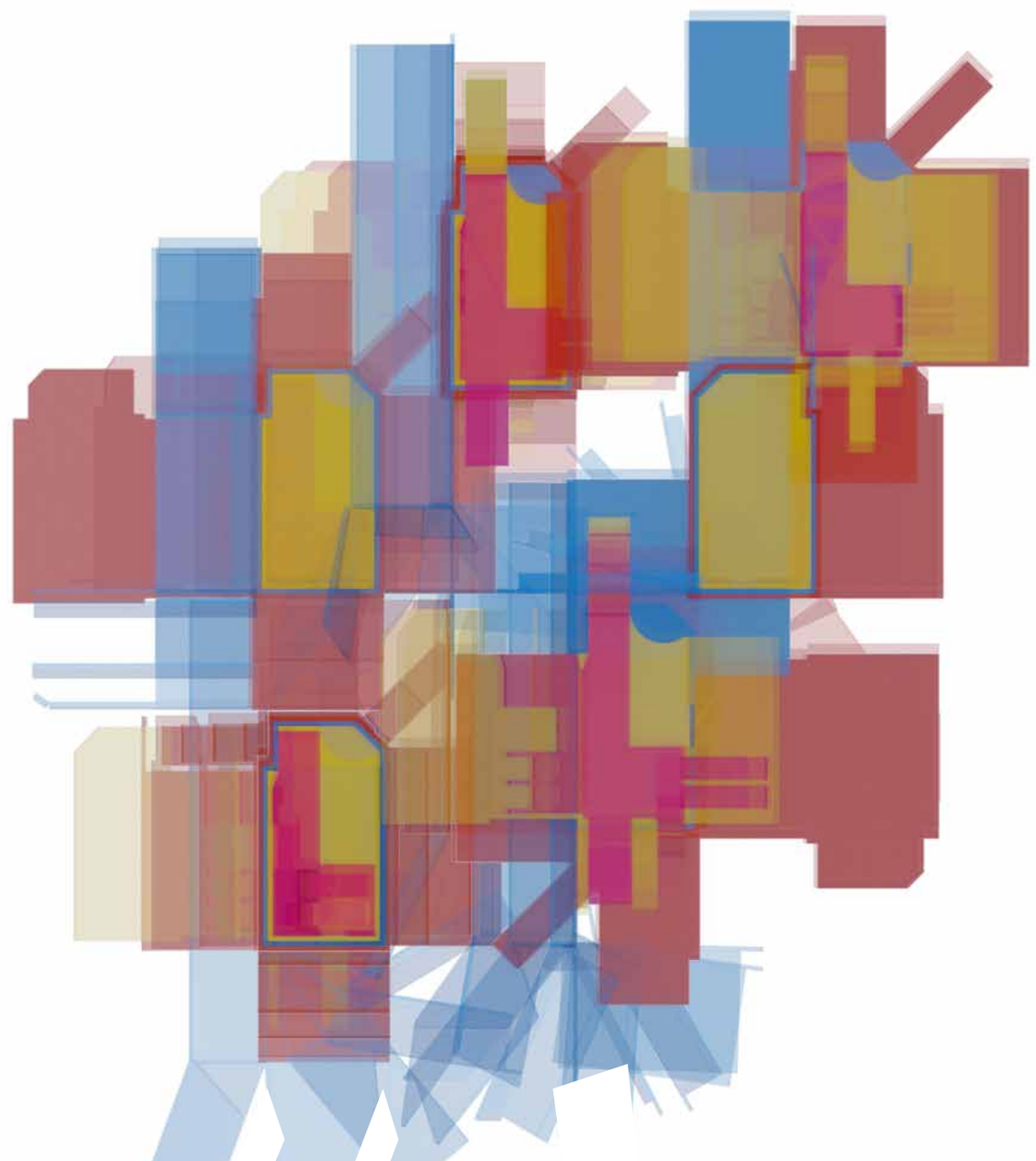


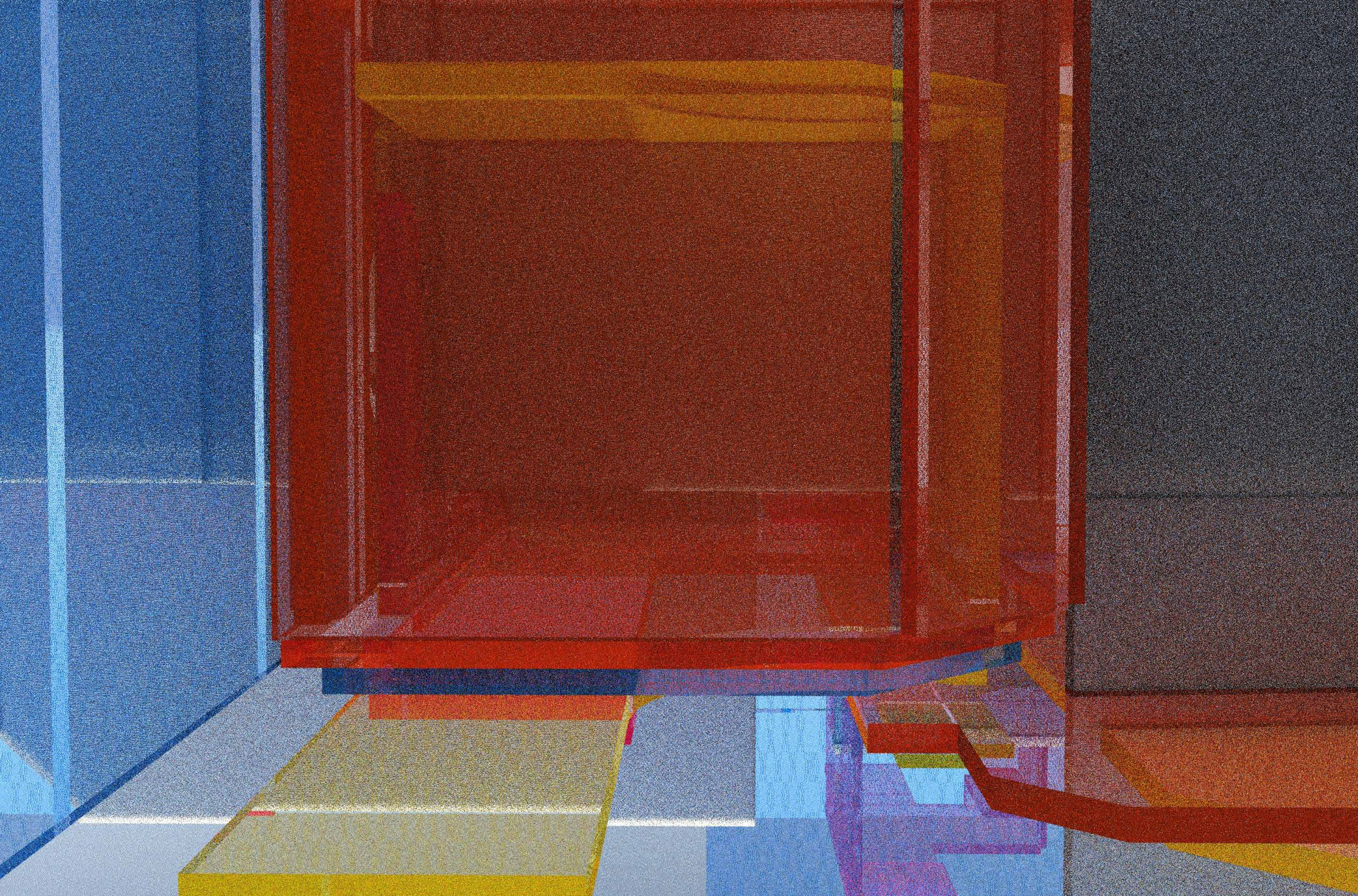


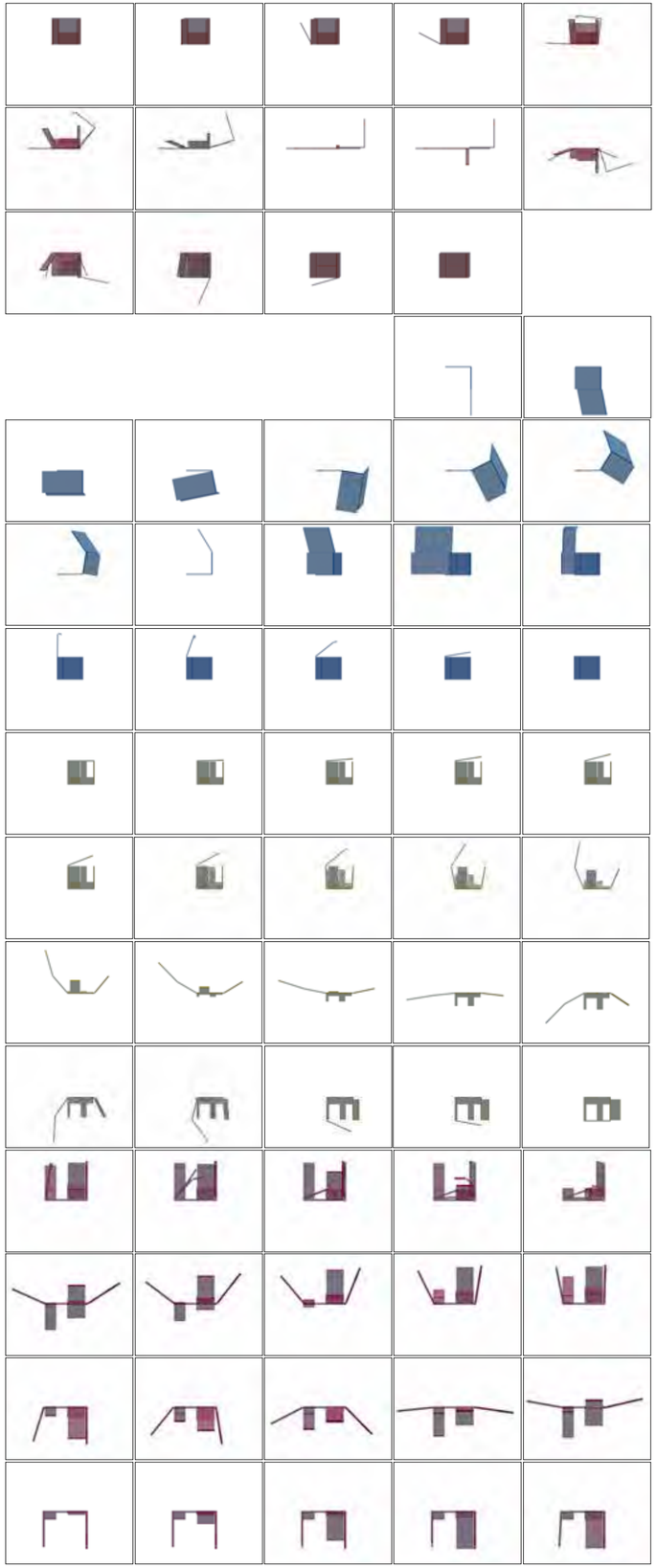












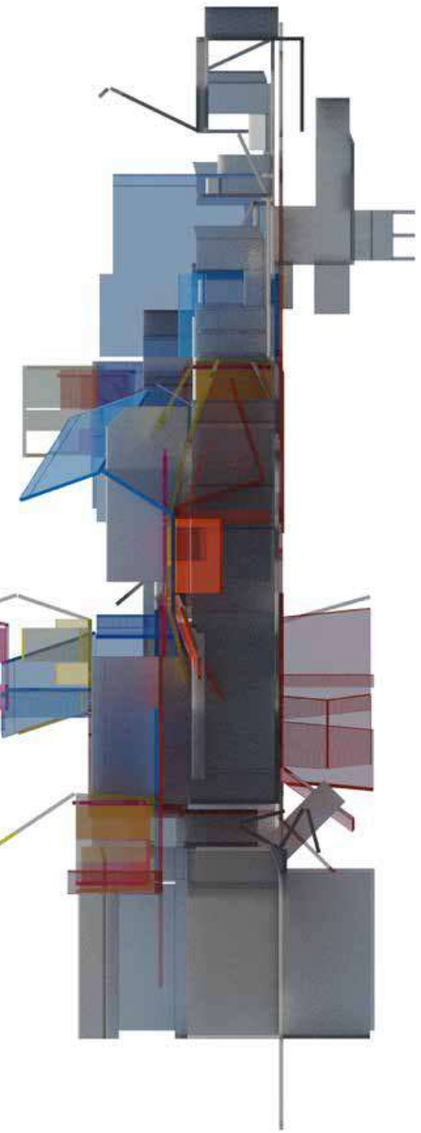
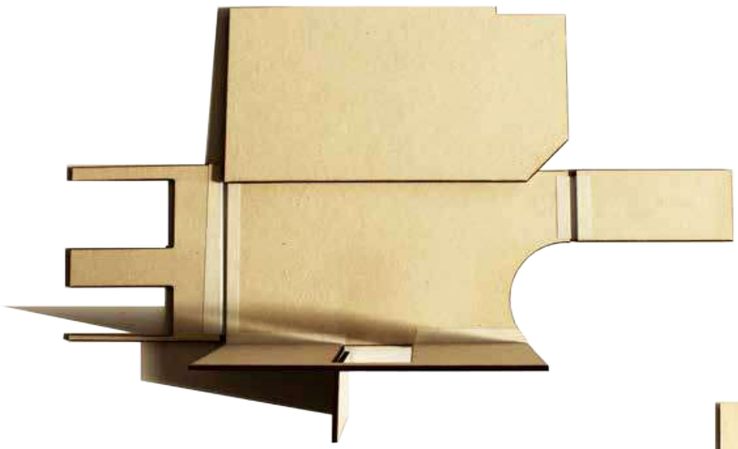
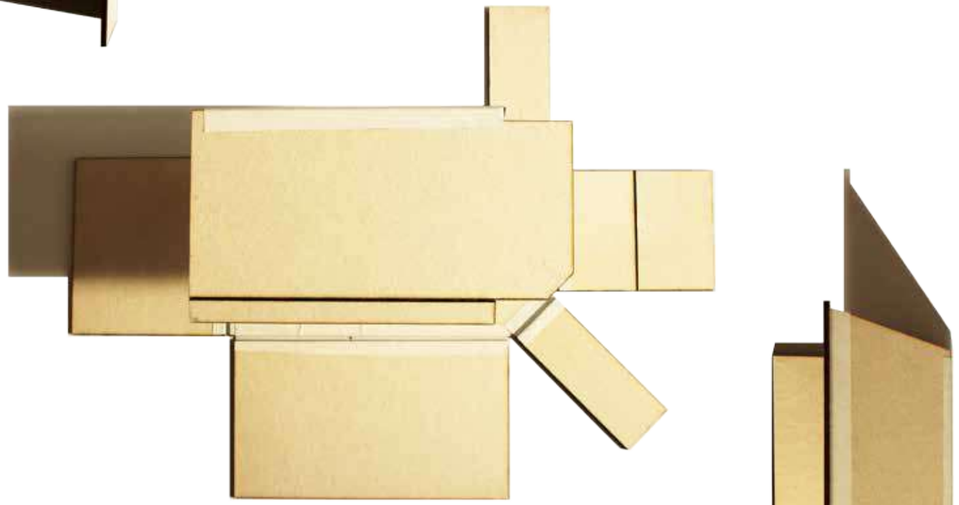
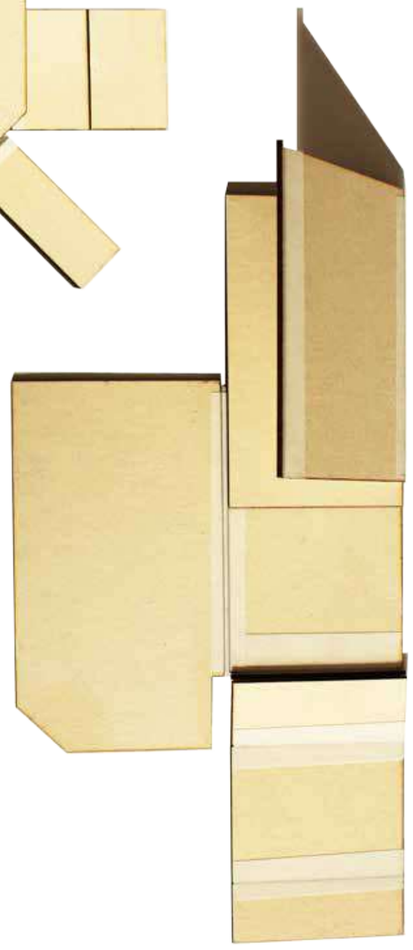
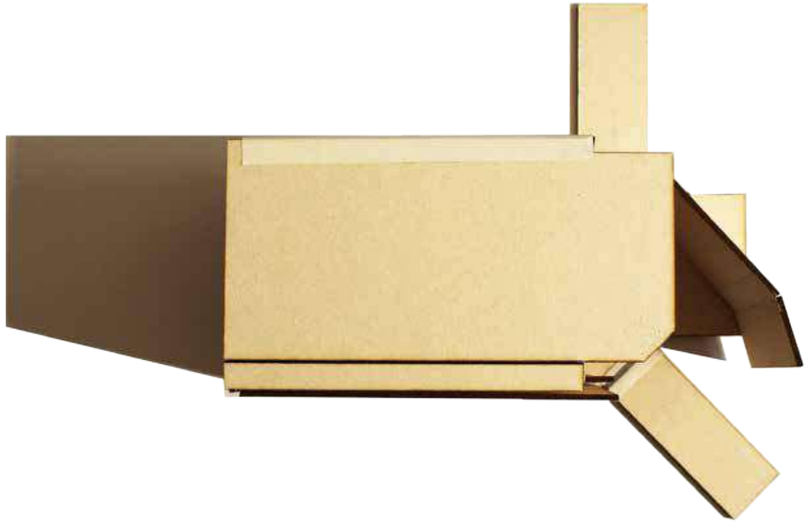


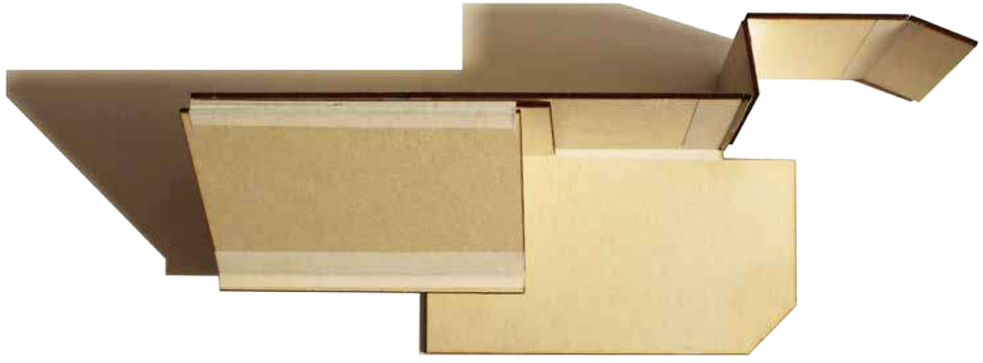
Photo collage of model photos

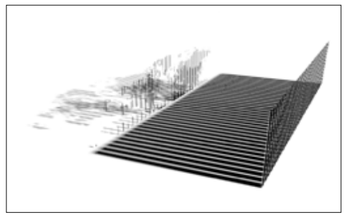


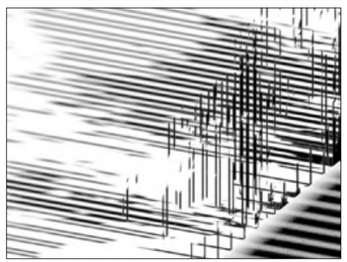


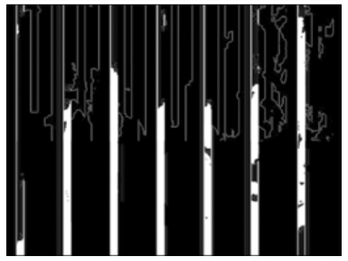


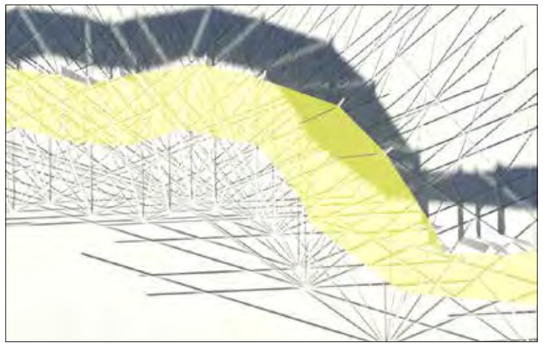


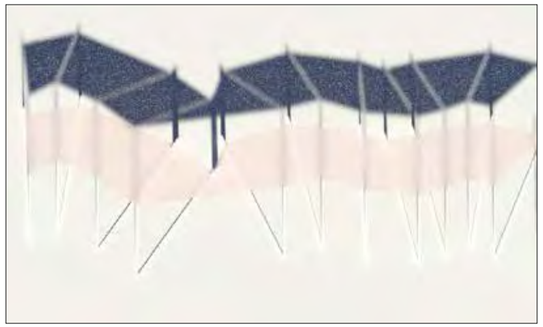


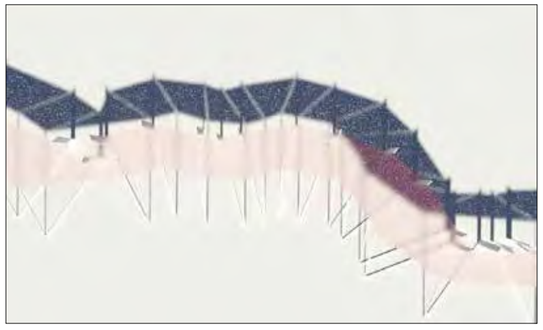


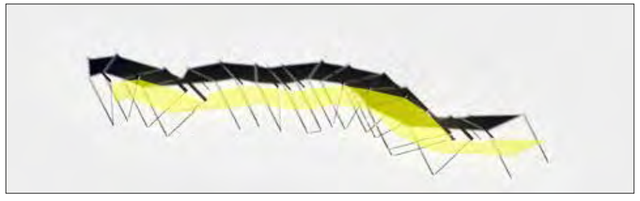


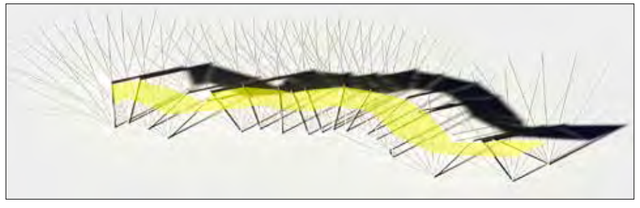


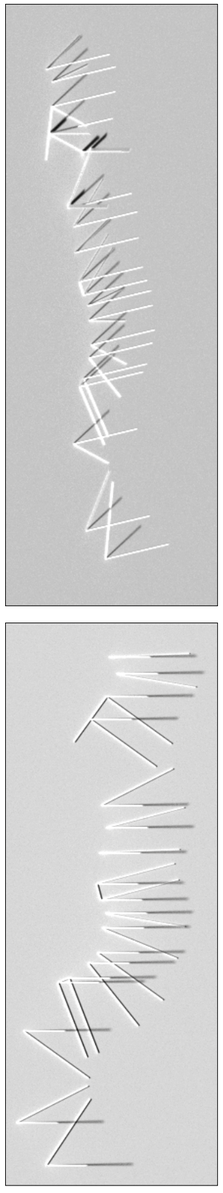


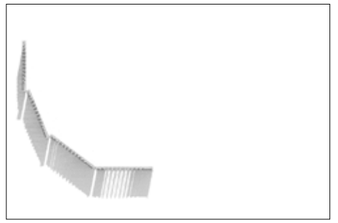


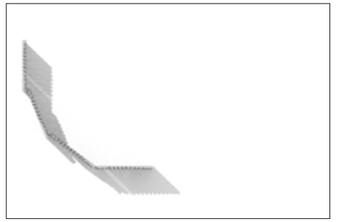


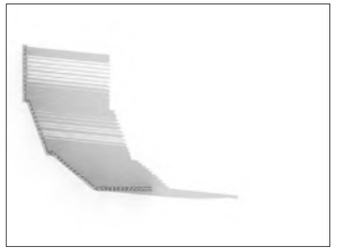


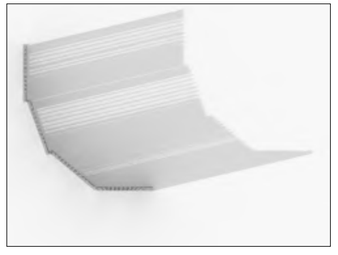


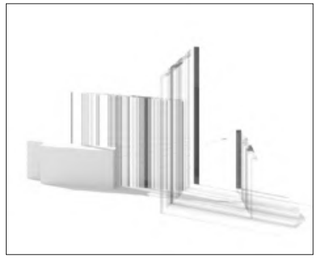


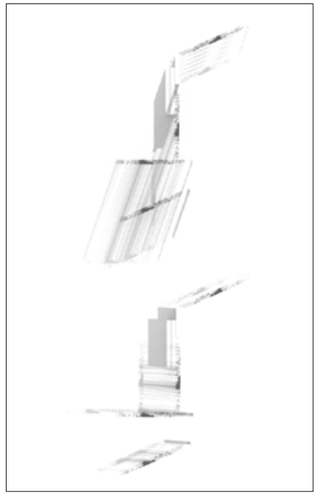


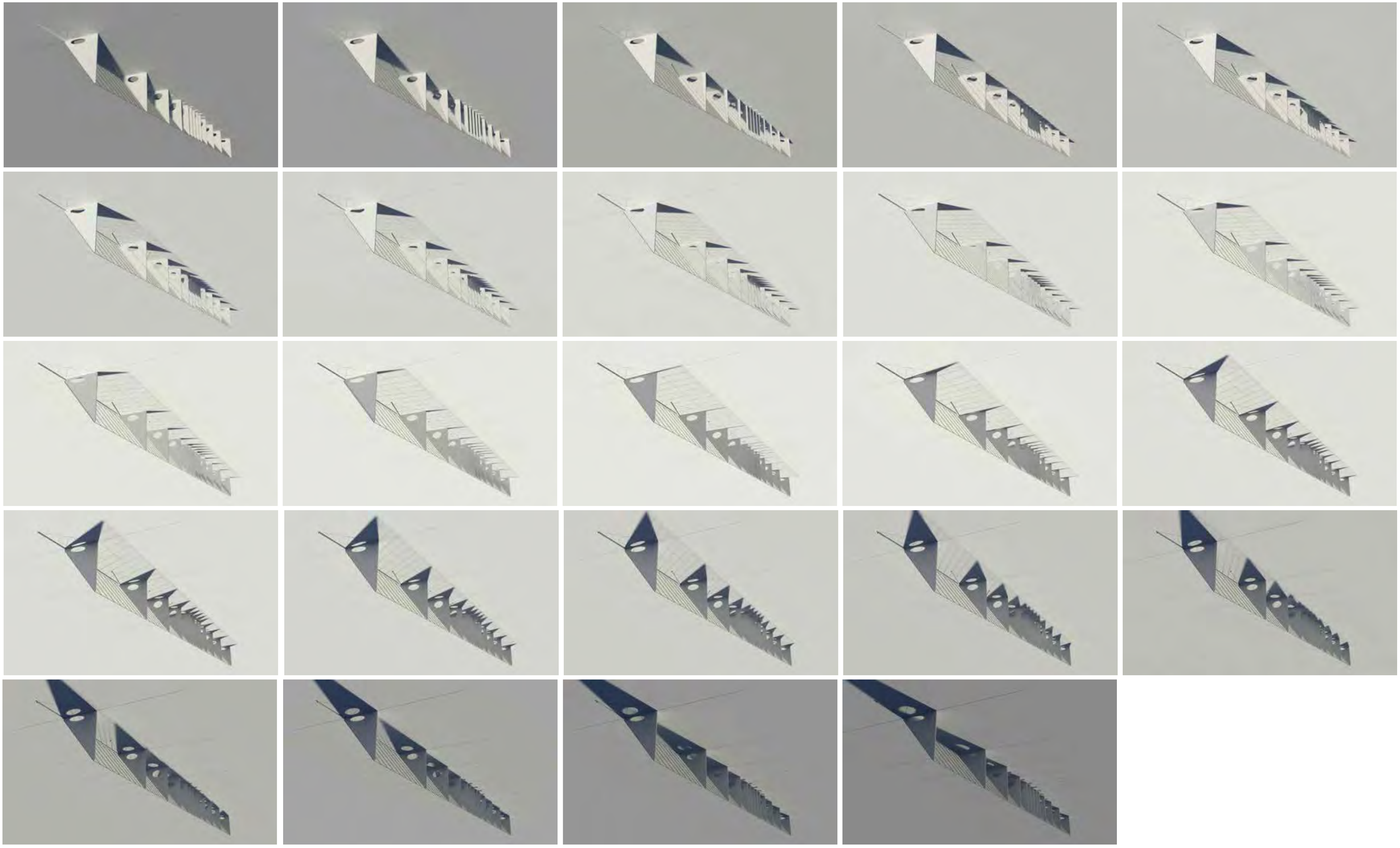


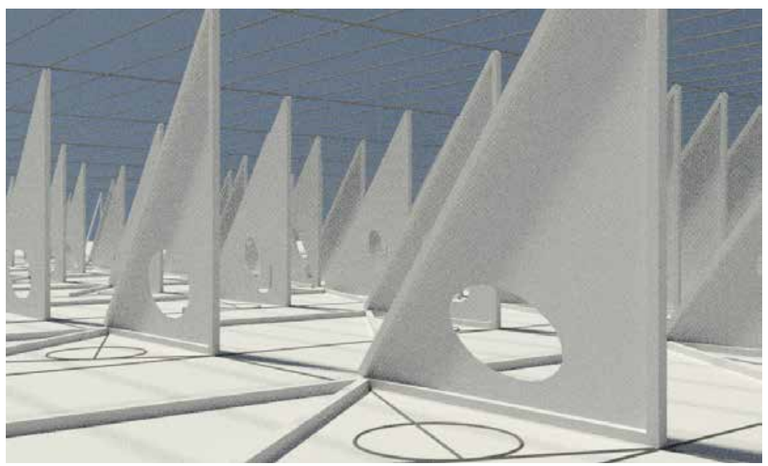


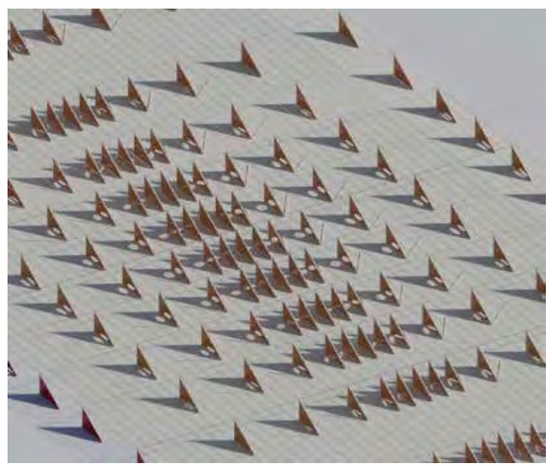


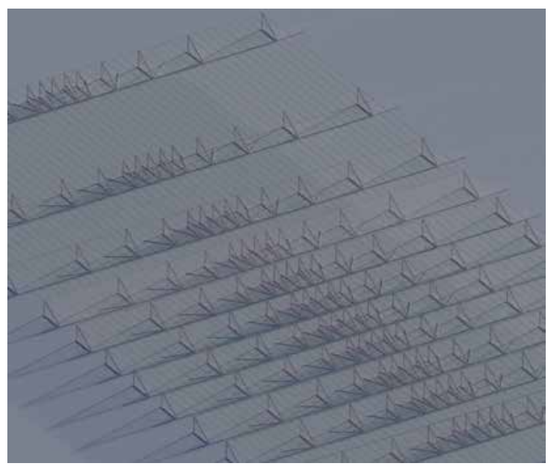


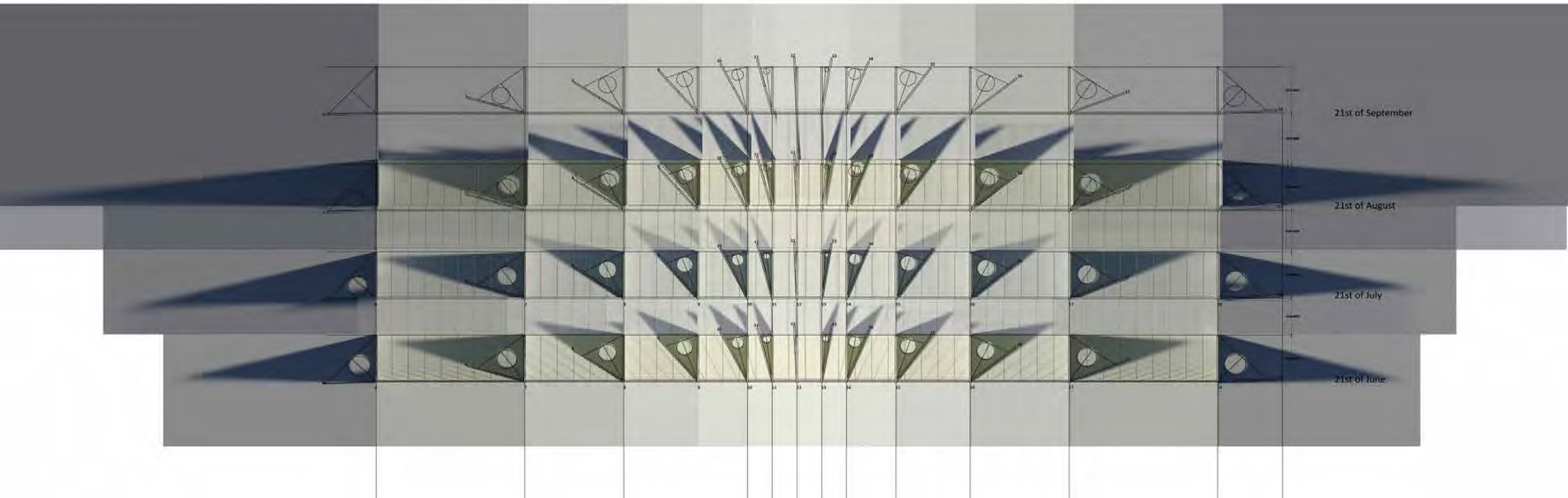


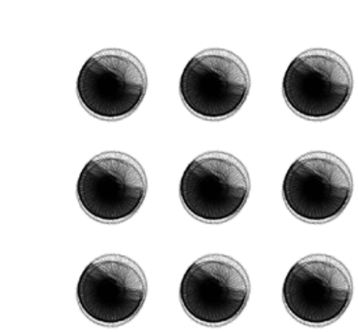


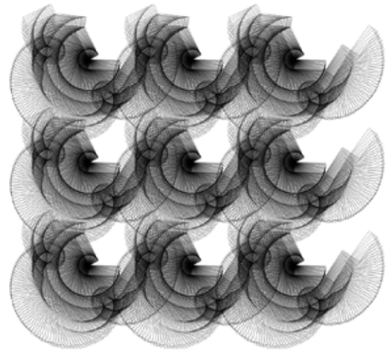


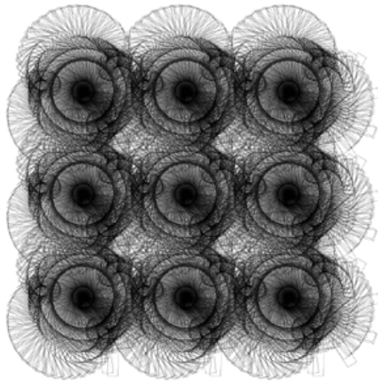


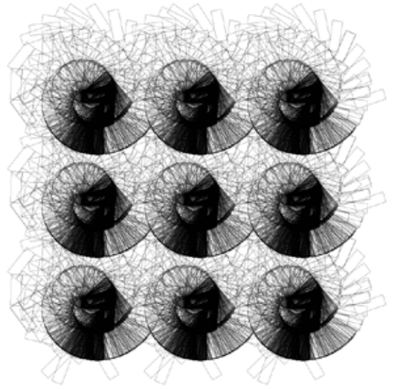


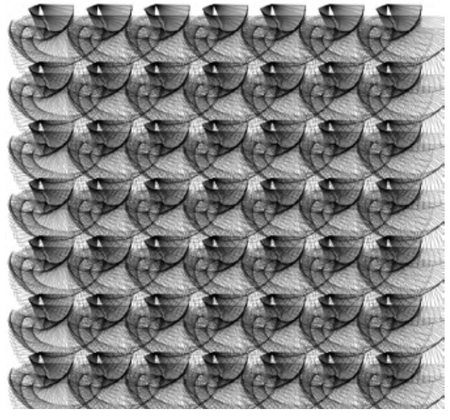

21st of September
21st of August
21st of July
21st of June

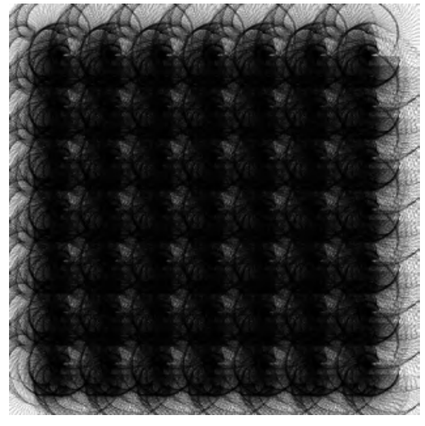


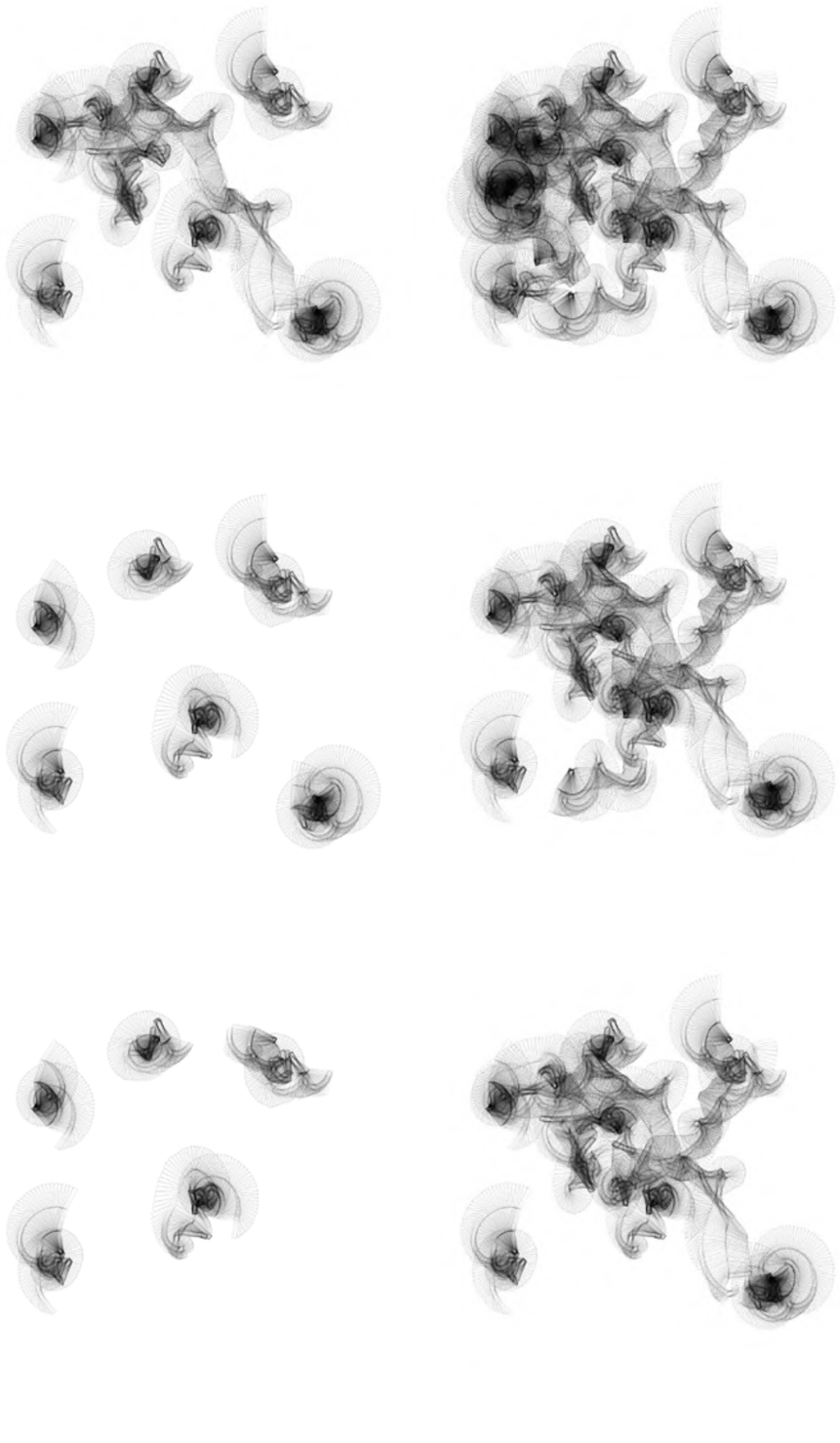


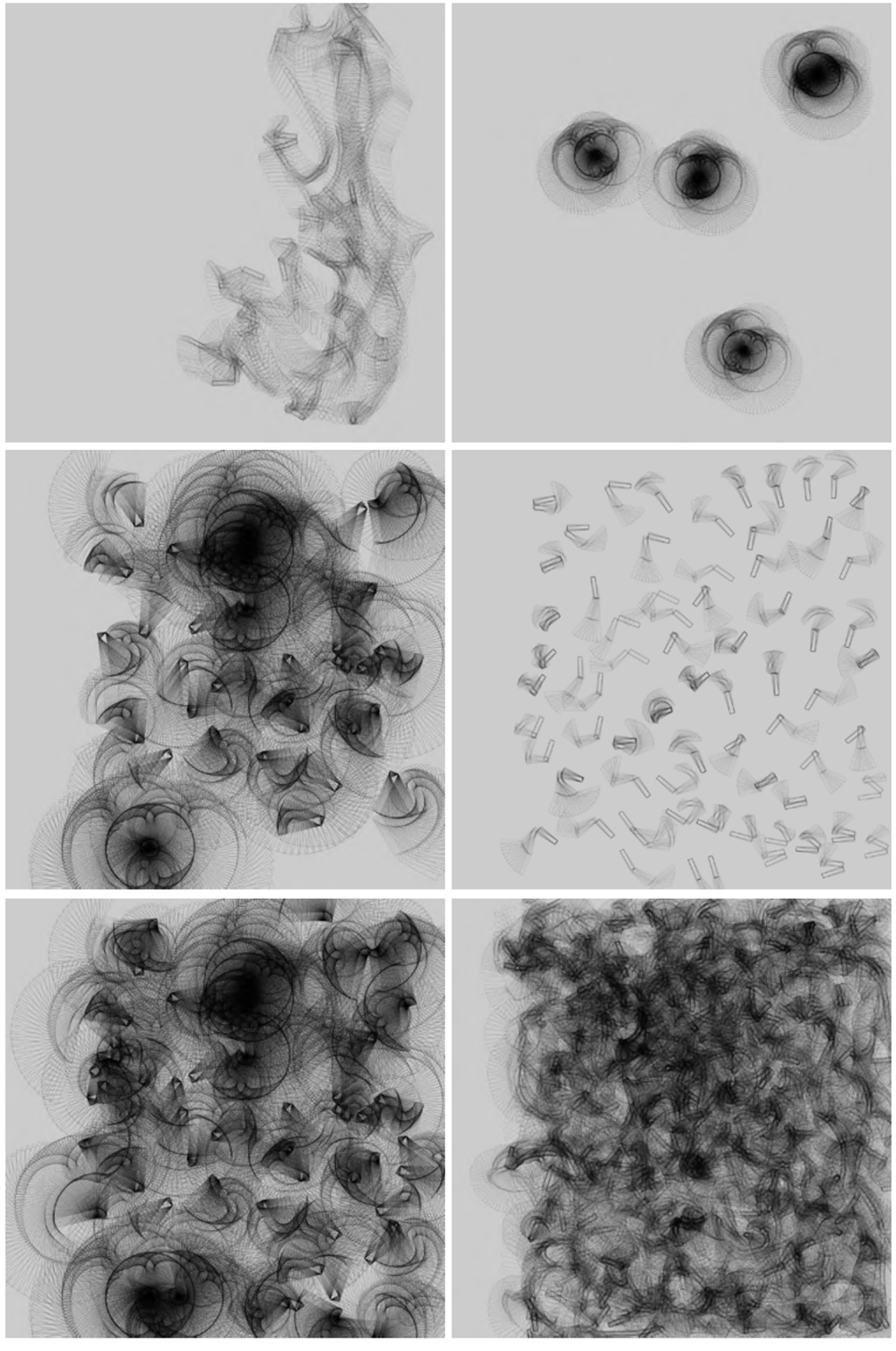


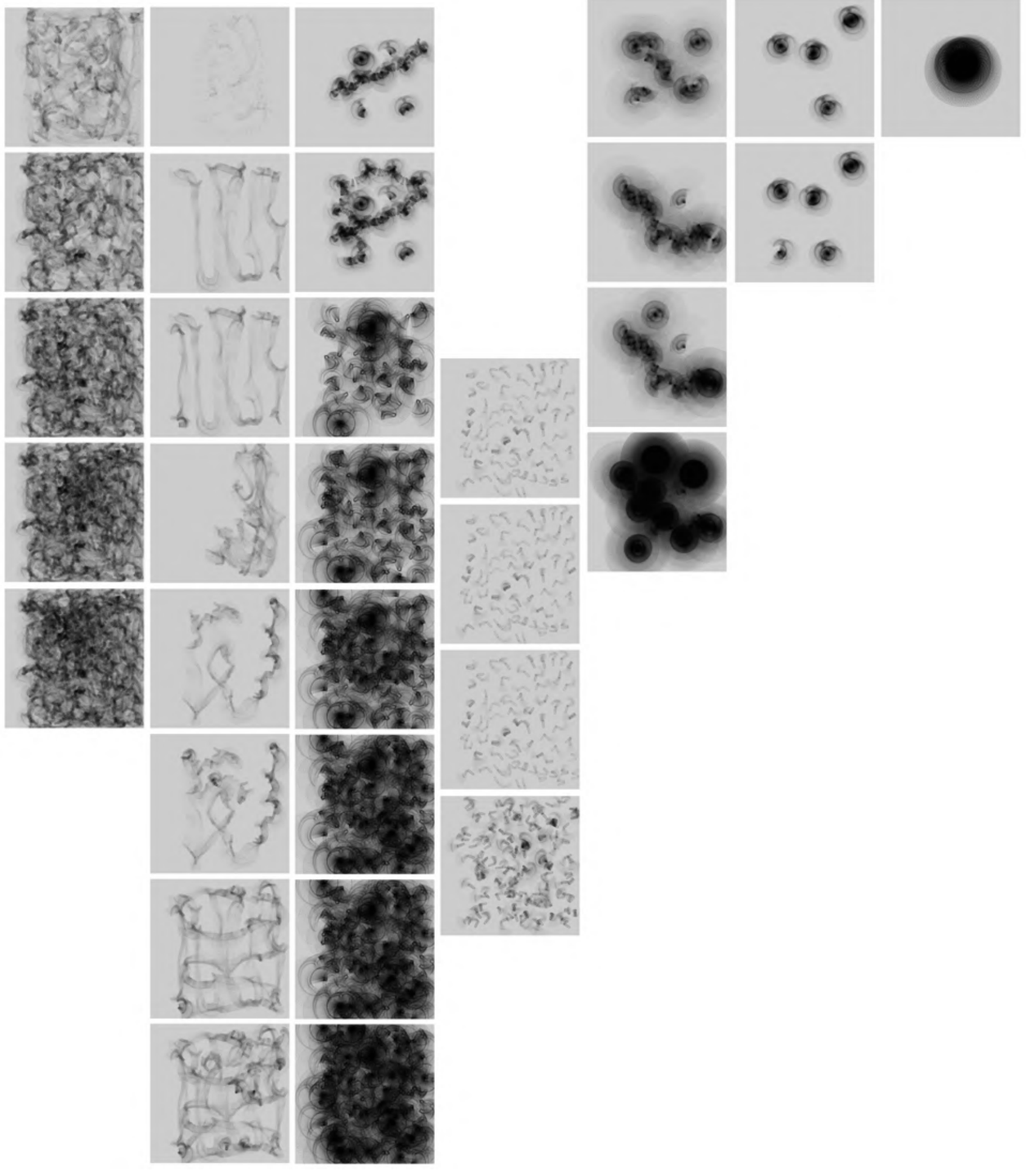


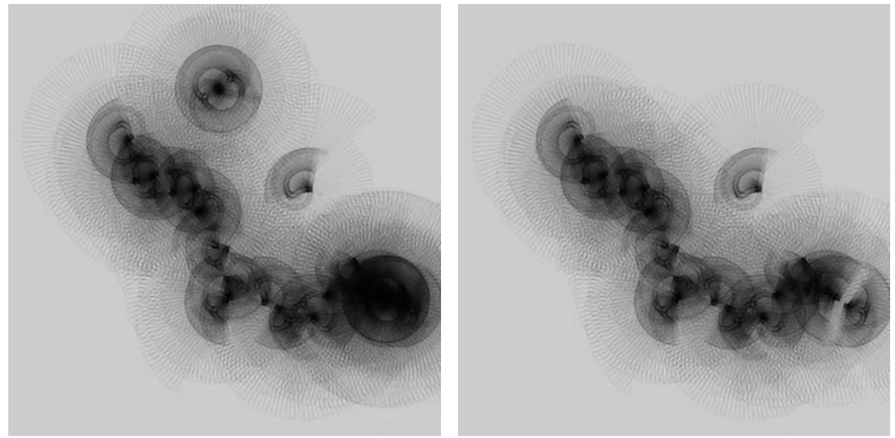


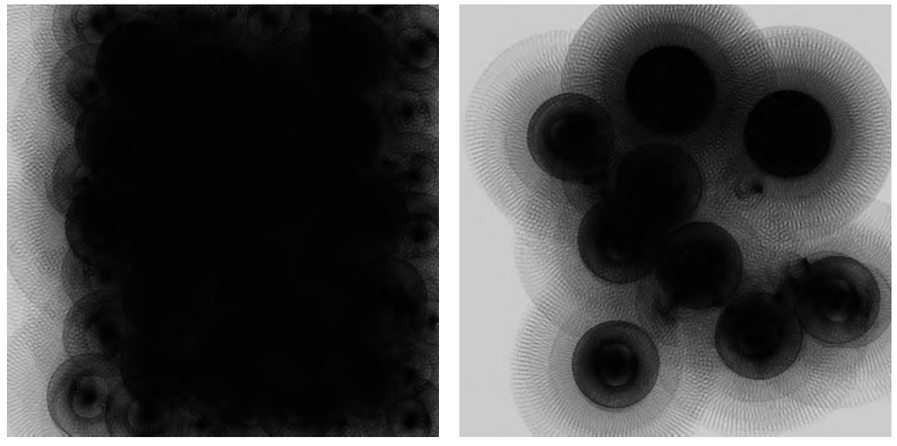


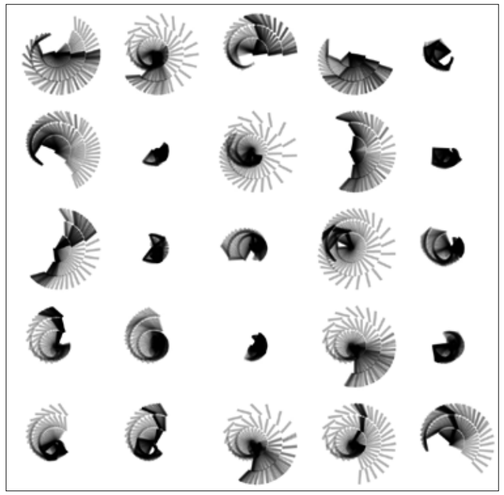


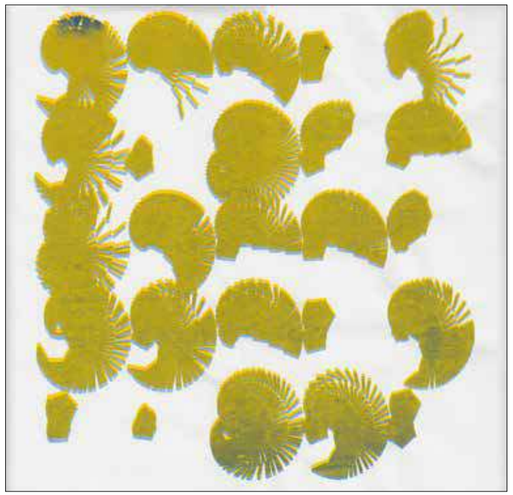


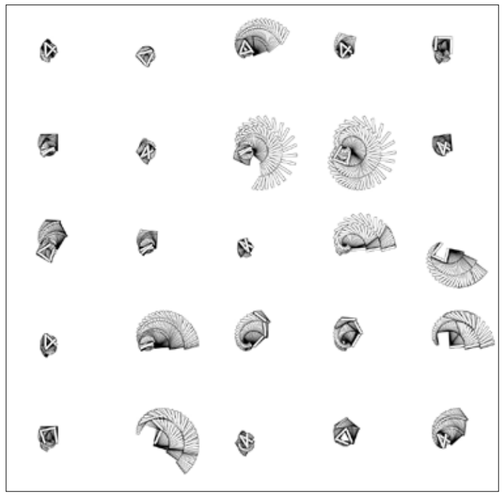




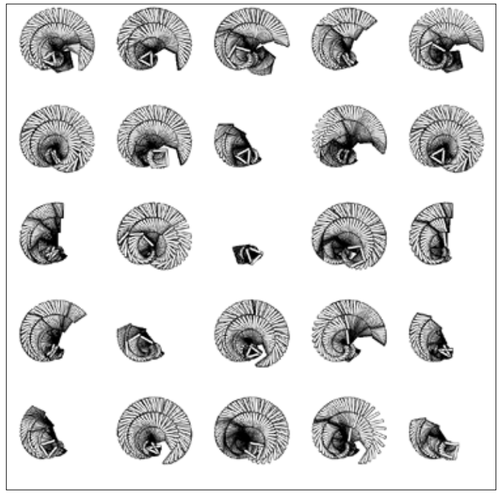


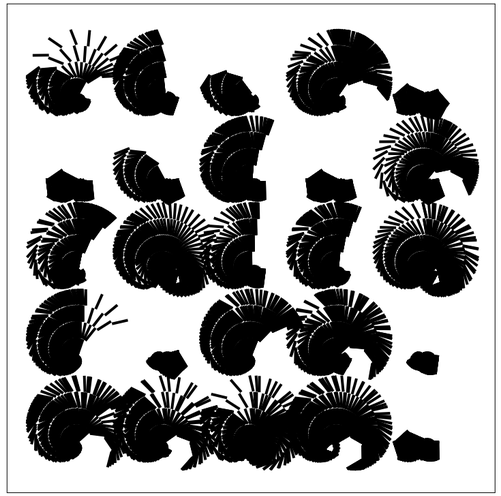


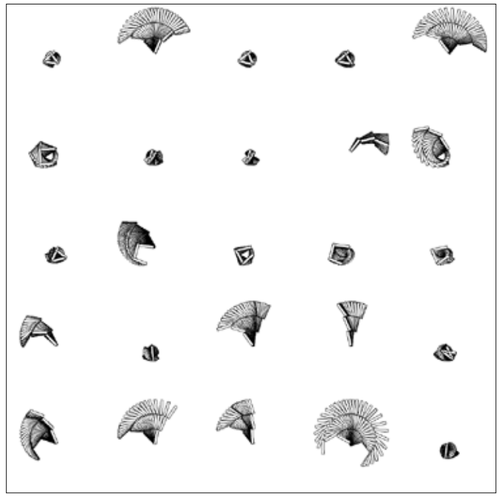


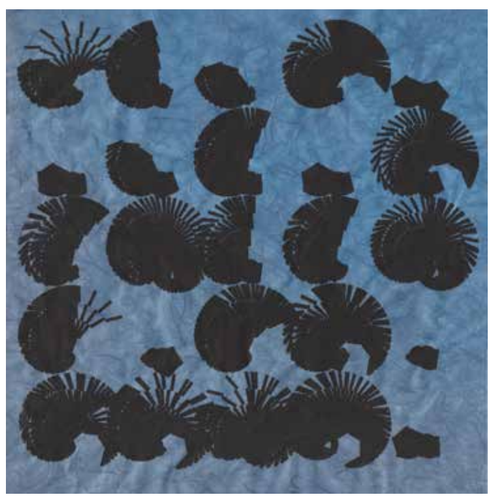


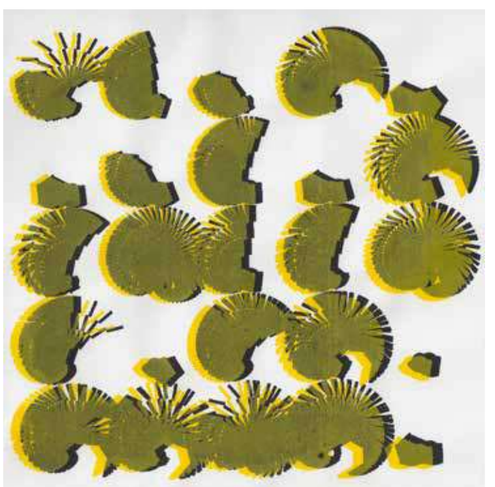
Screen prints. Every screen print is slightly different from another. Screen printing is an analogue way of creating variety in the same motif.

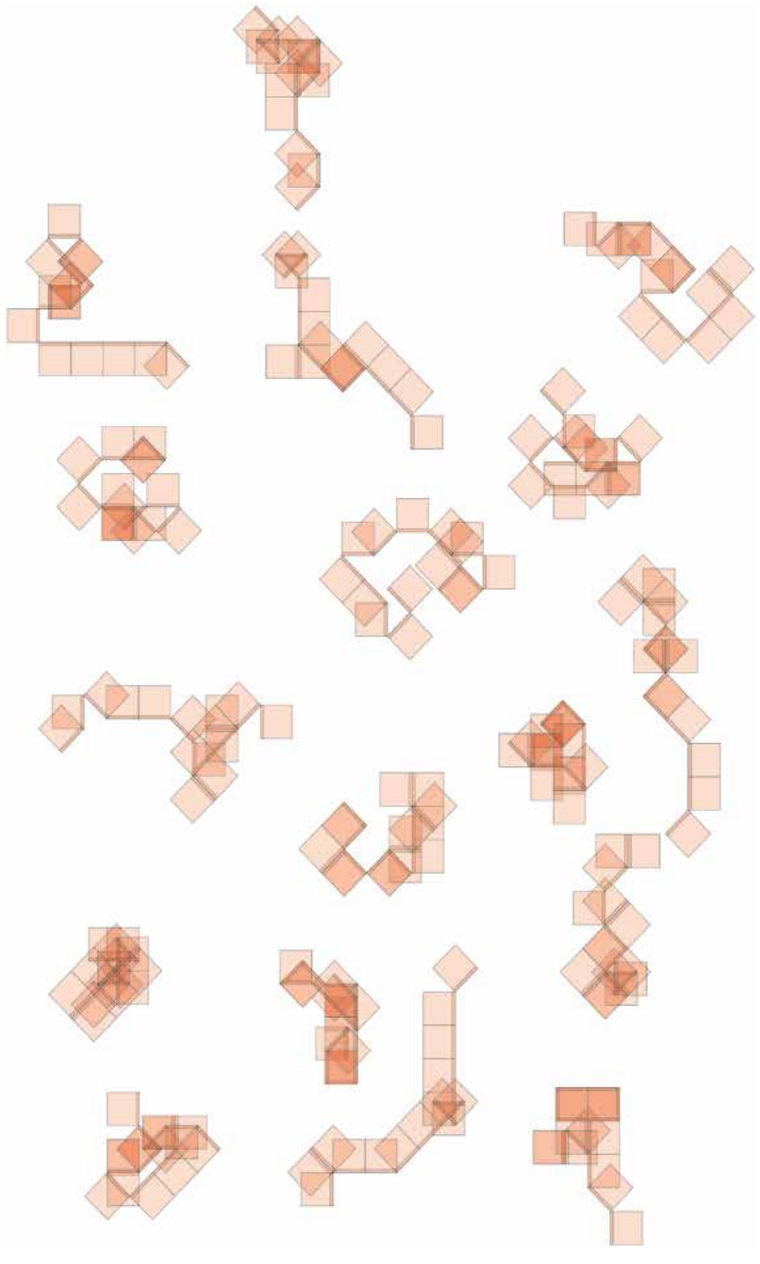


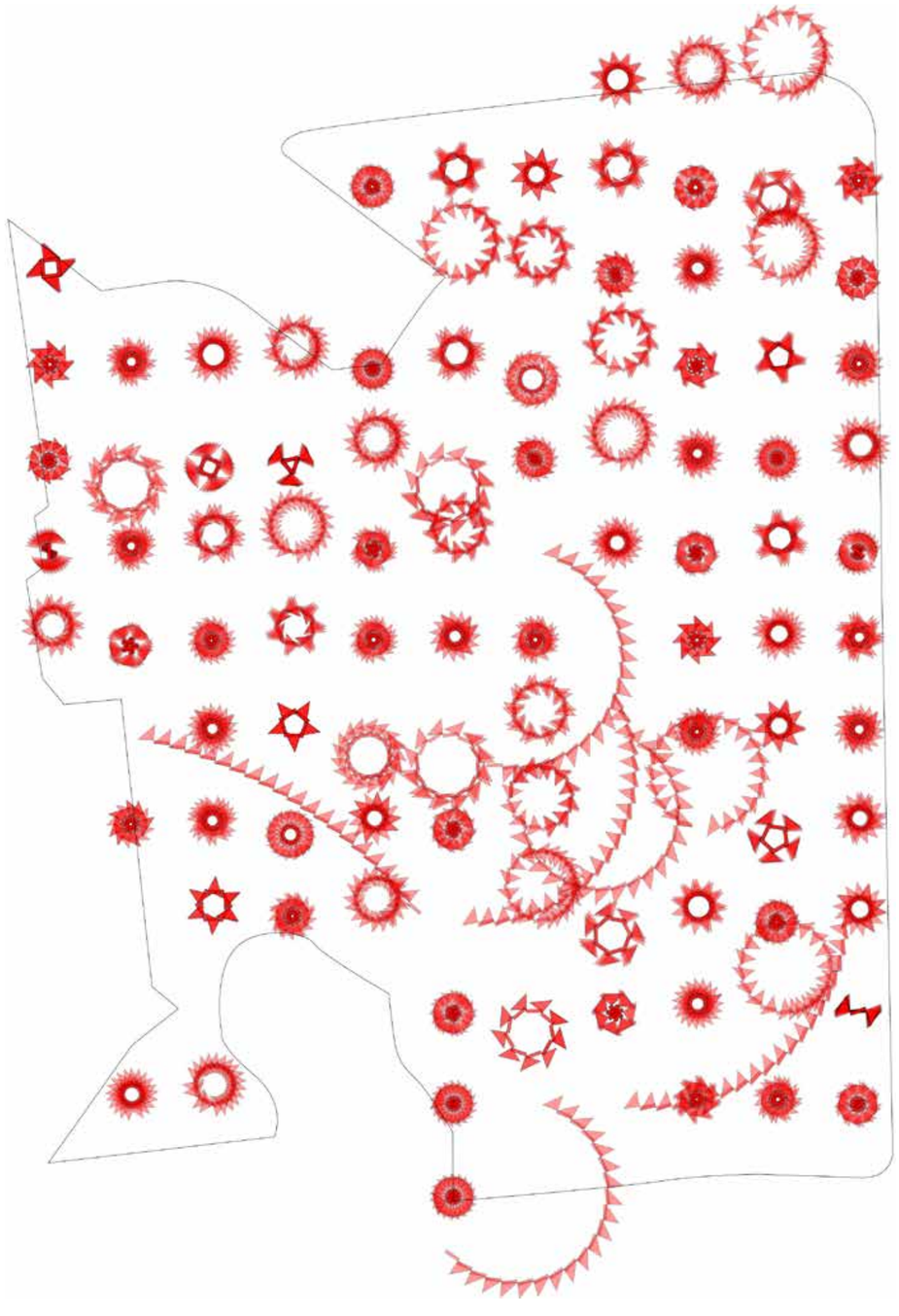


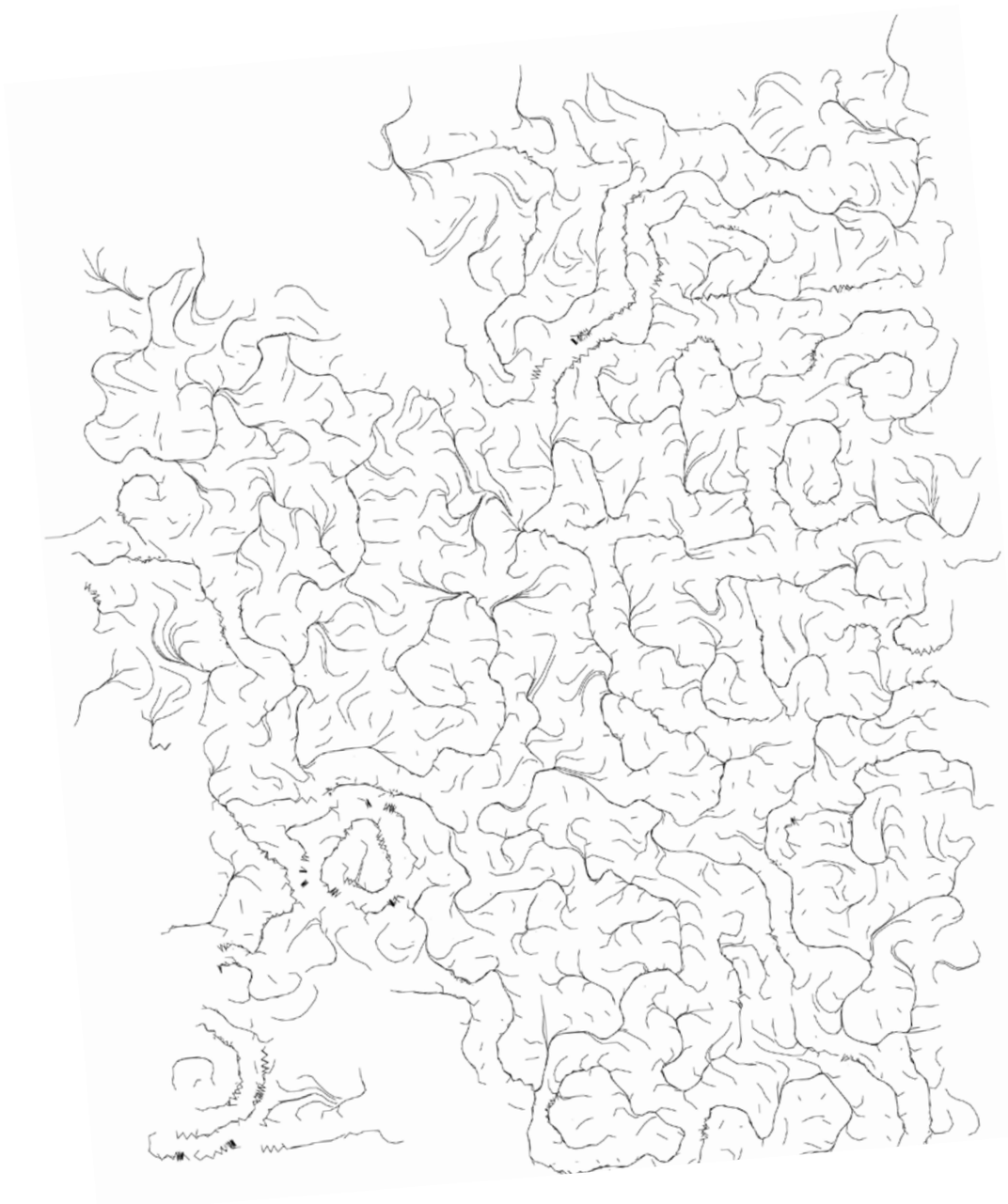


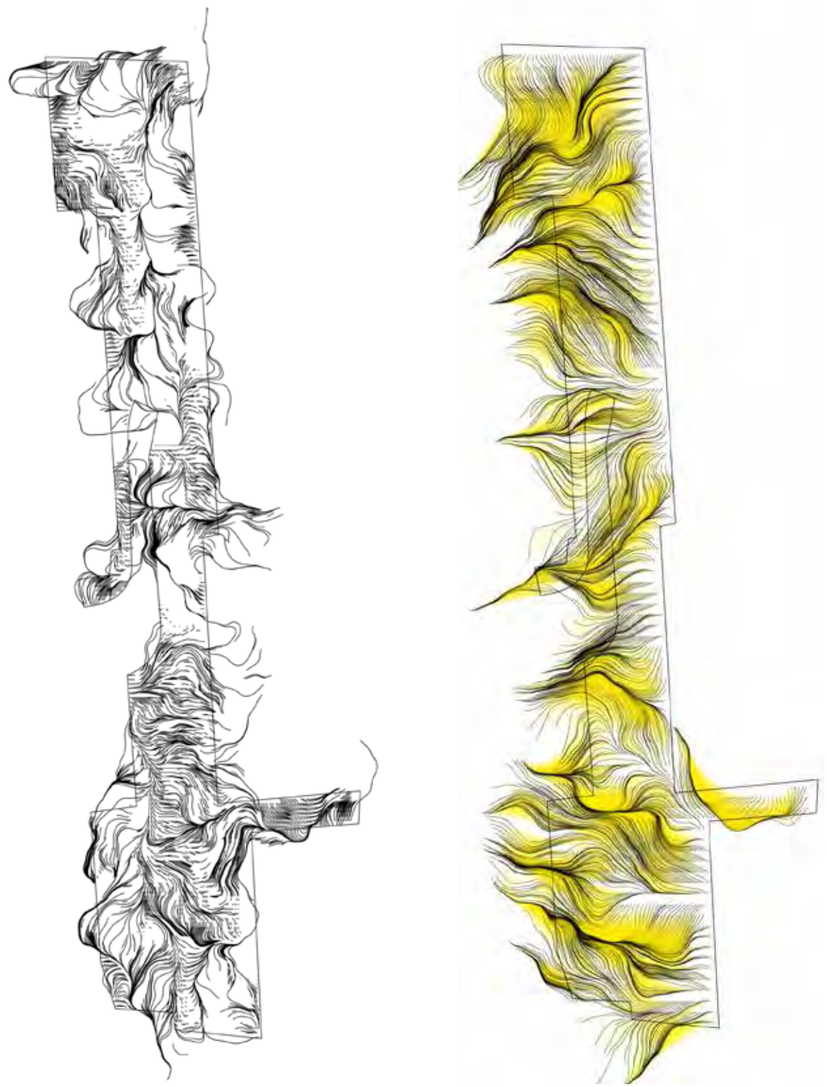


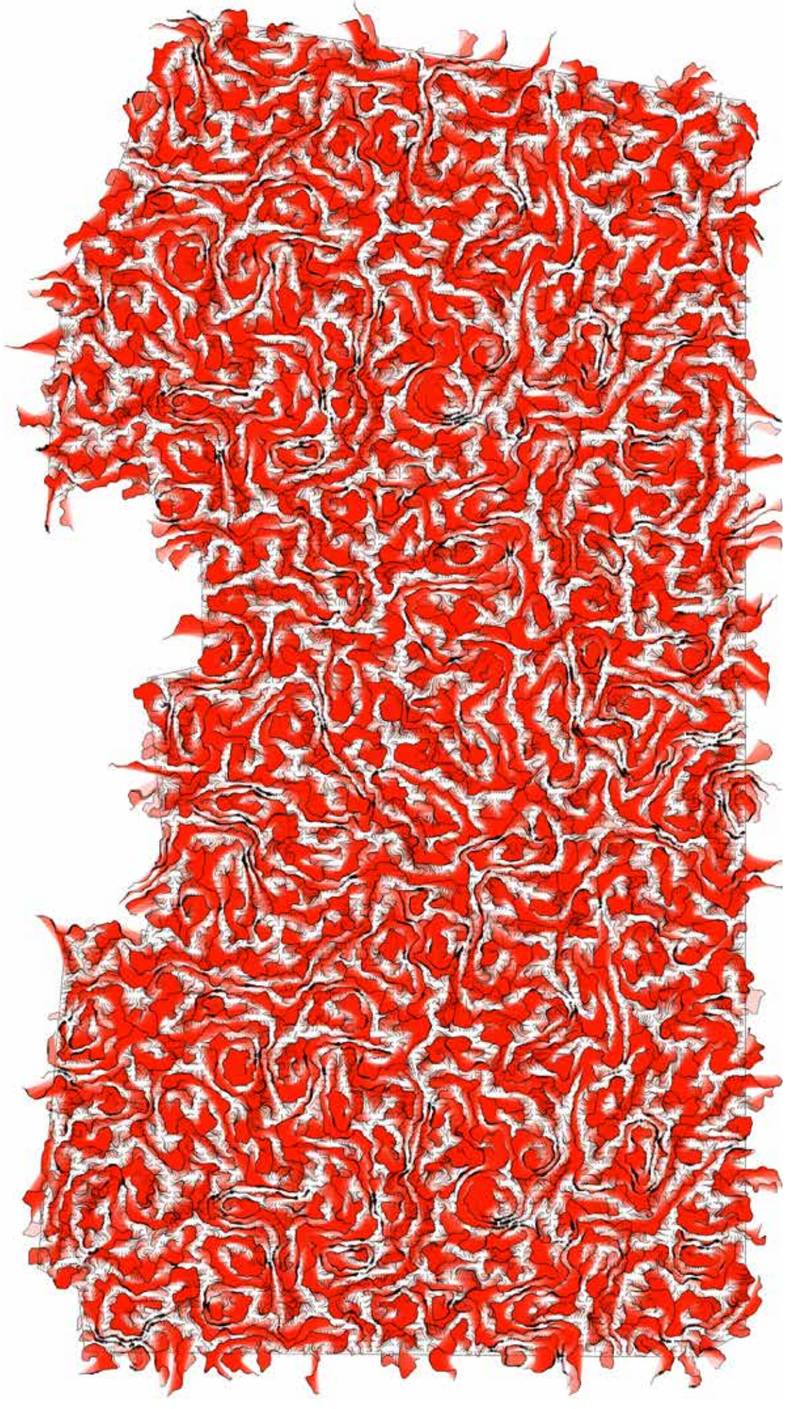




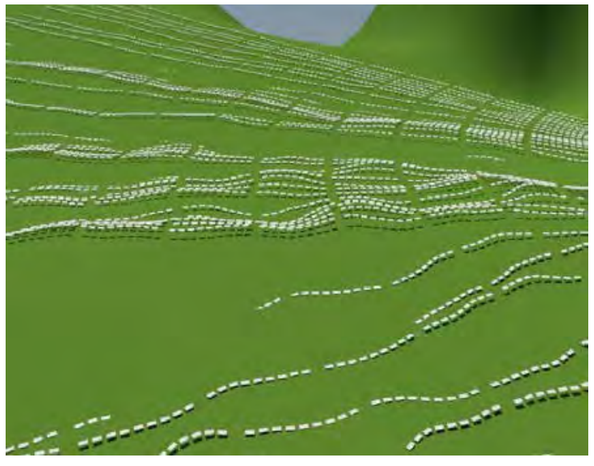




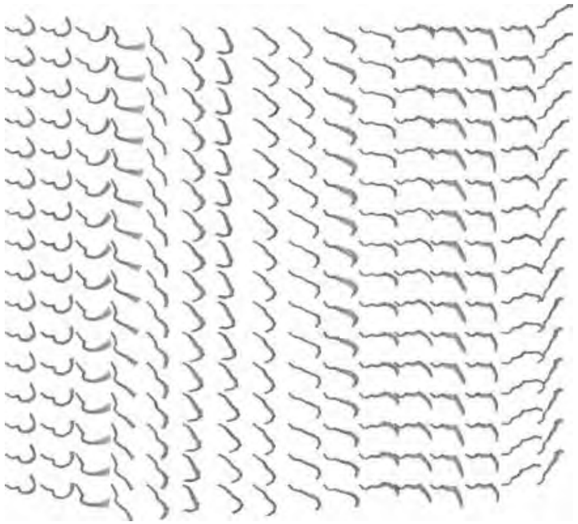


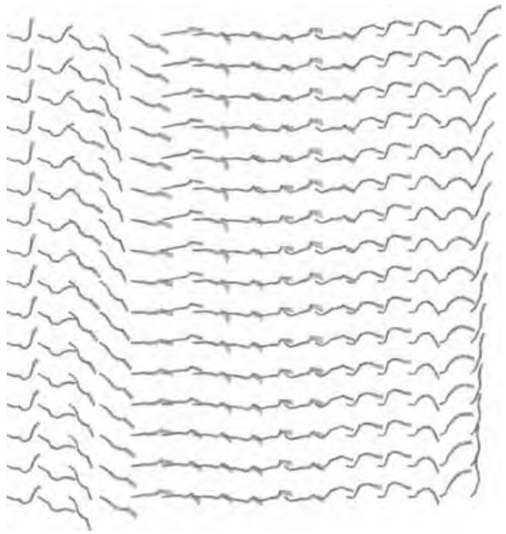


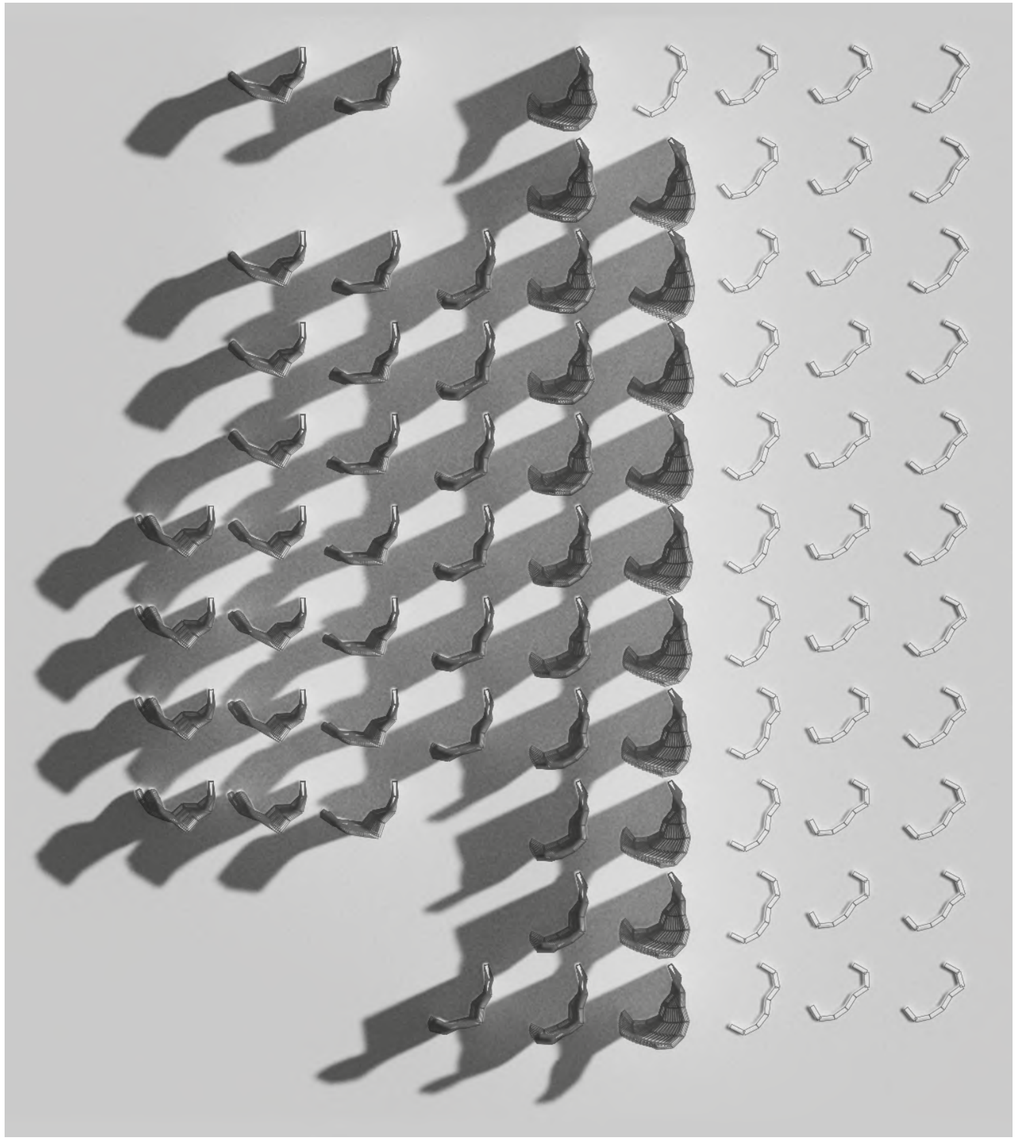
Setting a table vs. setting a table in a landscape. Messiness vs. randomness

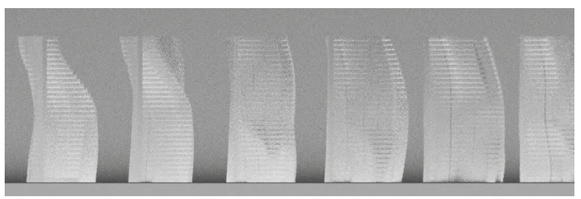


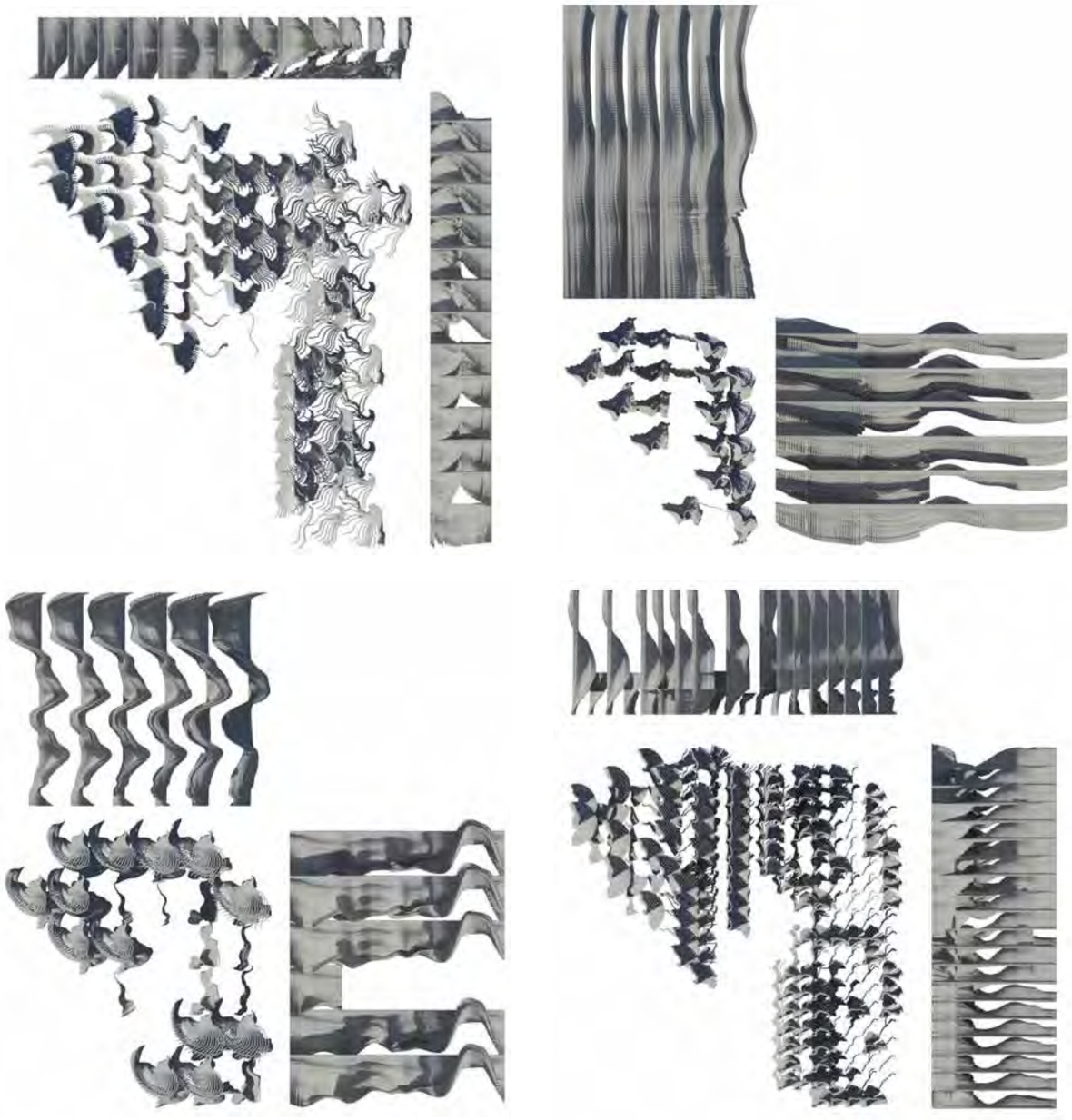
Plan and elevation view of tables in landscape

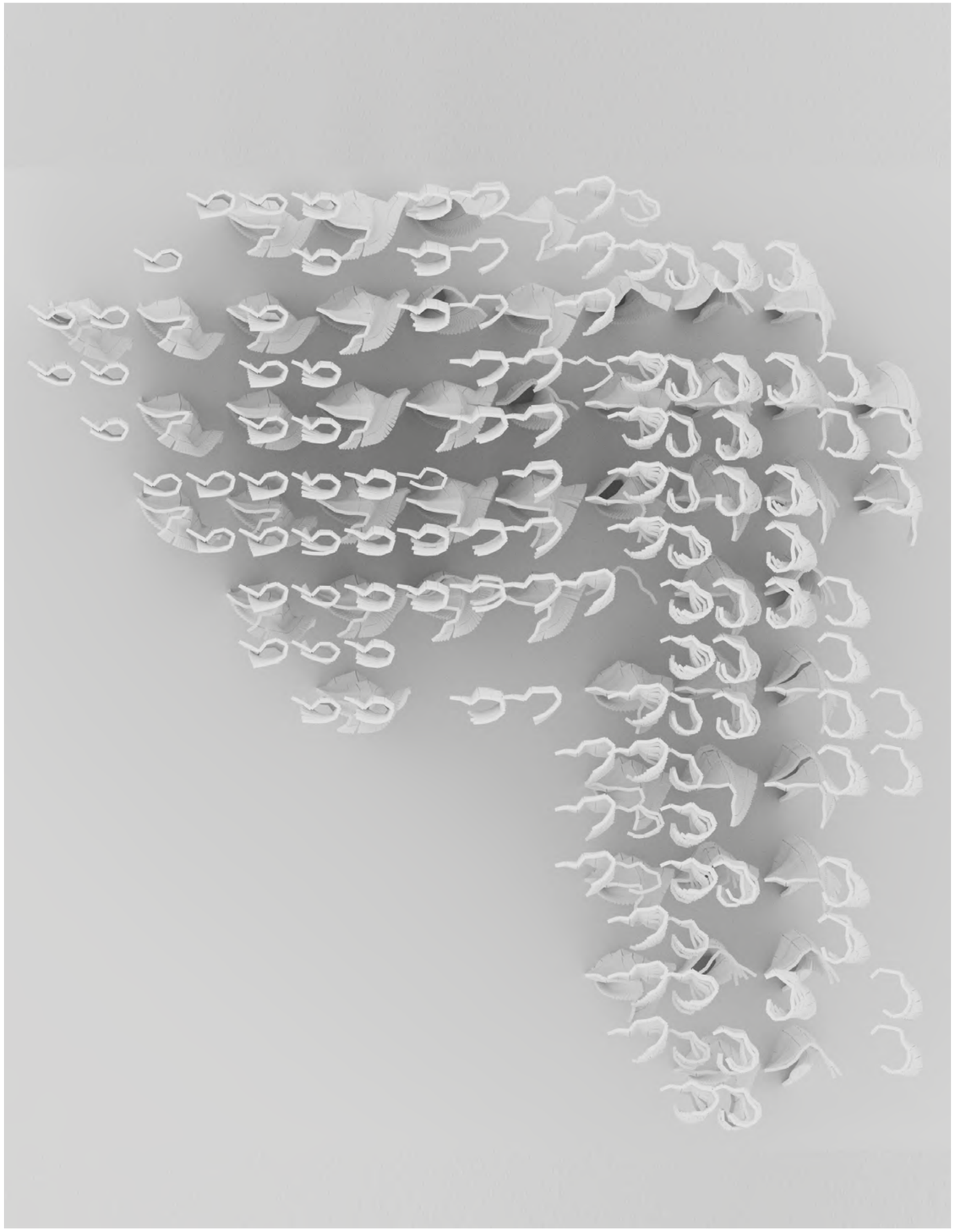


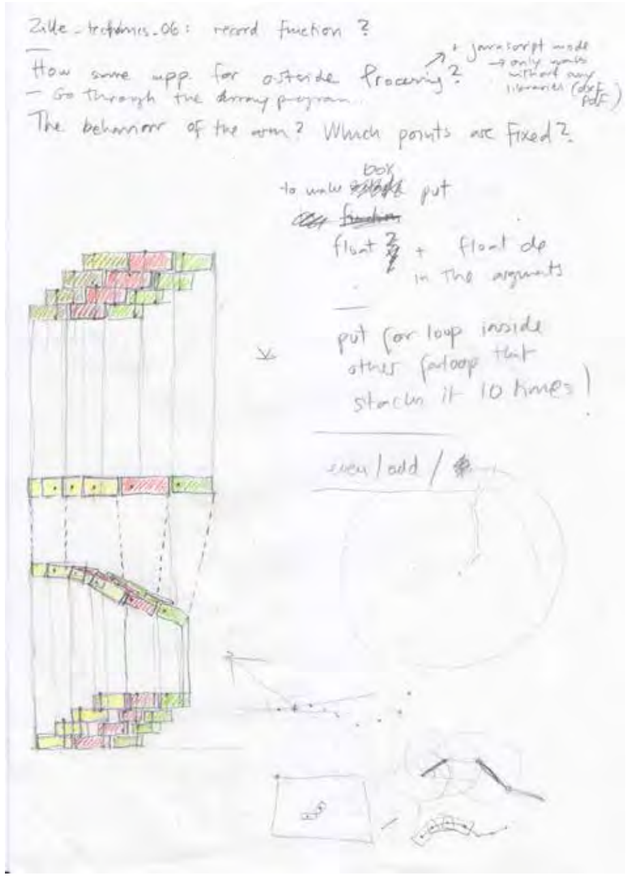




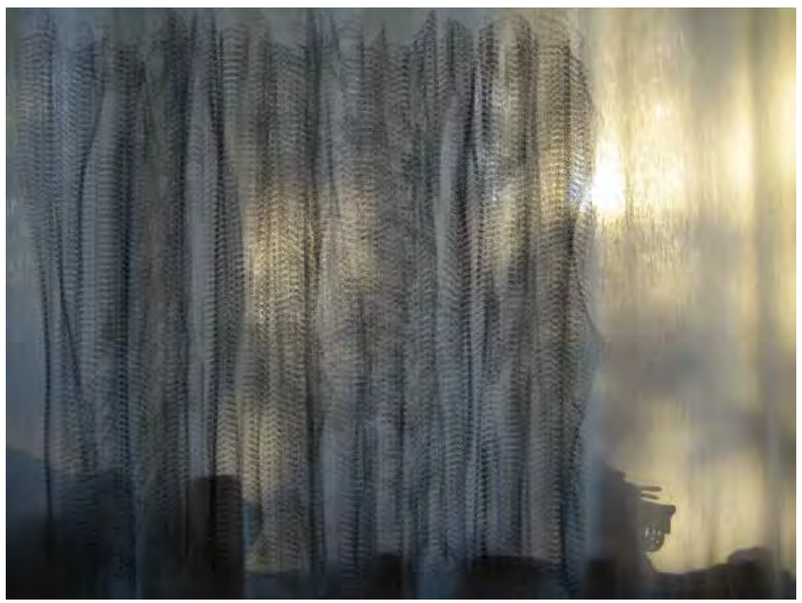


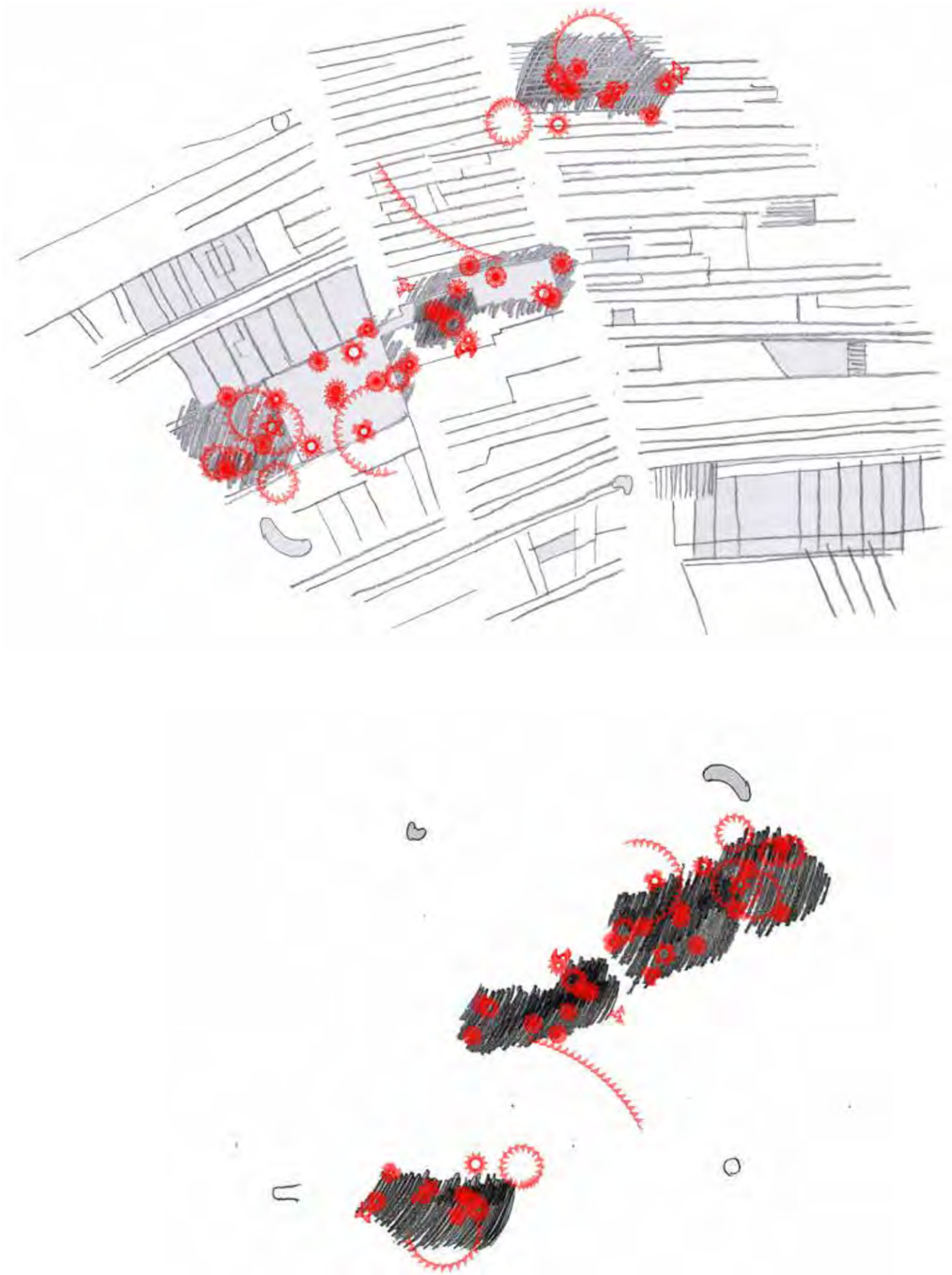


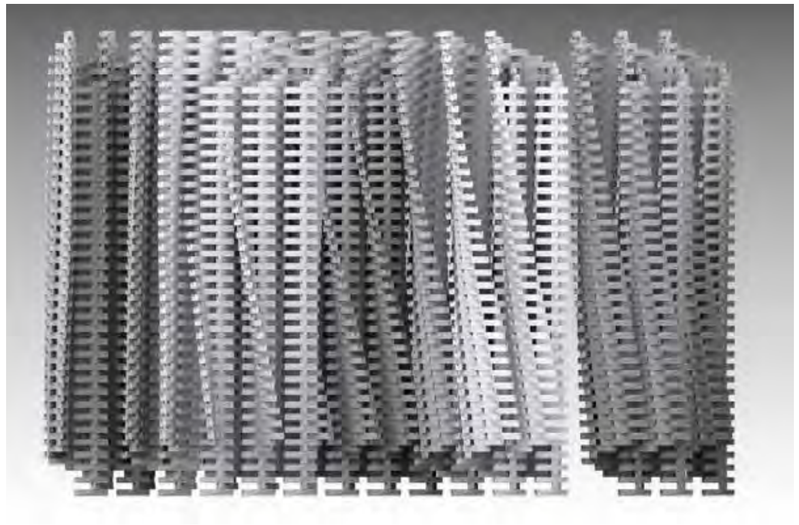


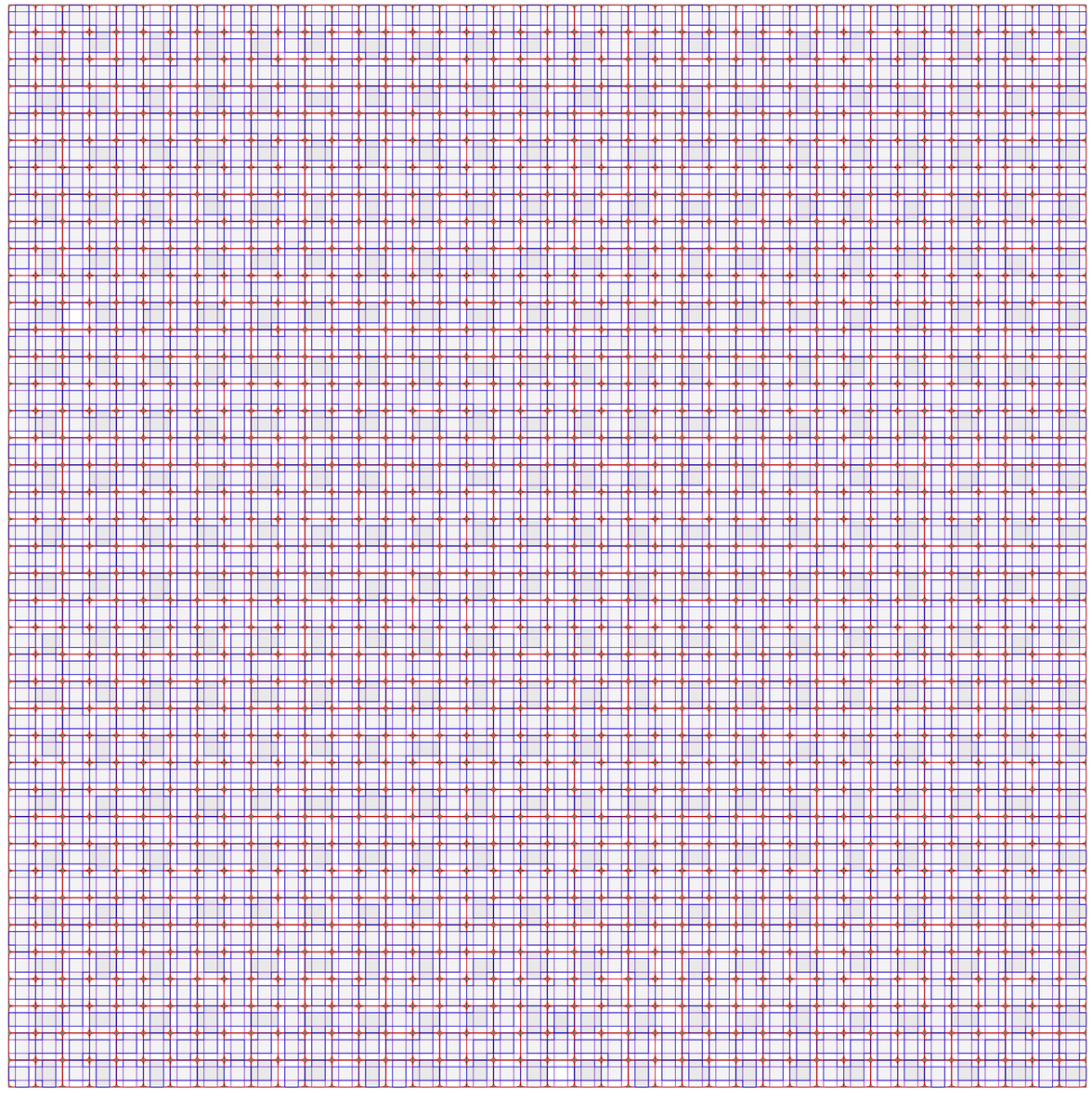


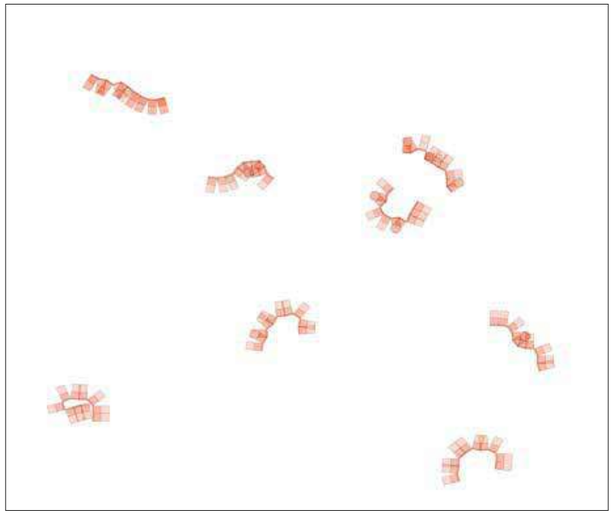
Searching for an interaction between a hand drawing and a digital script.



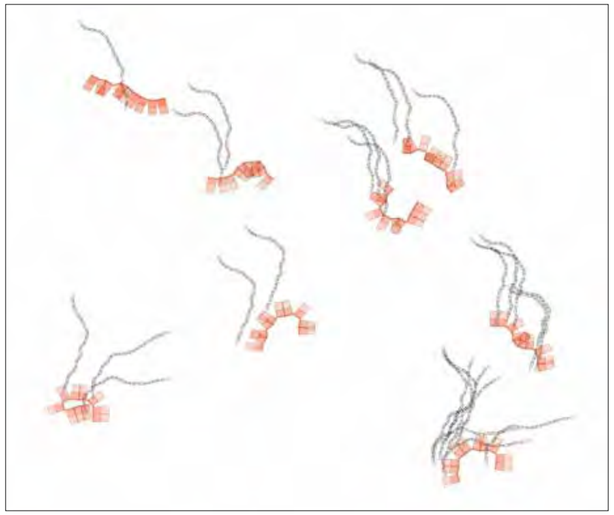




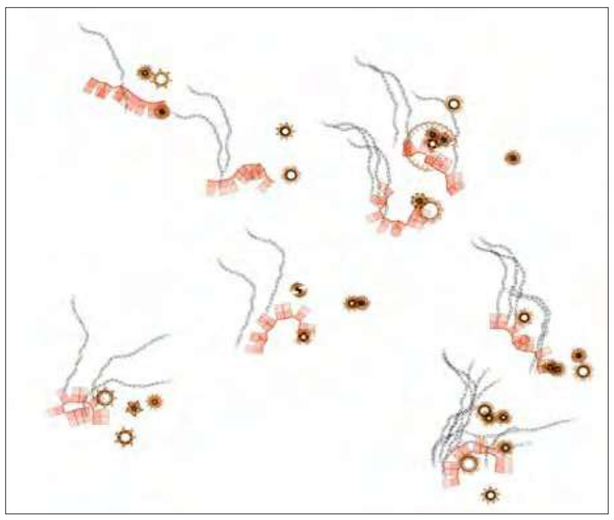




1. turn



2. turn



3. turn

ENGLISH SUMMARY

This PhD project is about conventional architectural drawing, especially orthogonal projection – plan and elevation – and its intensely discussed role as an architectural working medium in the context of the computer. Some architects and theorists prognosticate that, due to current computational affordances, drawing in architecture is a dying phenomenon.[1] However, this is not in accord with the reality in offices and architectural schools where distinguishing between 'either drawing or computational design practice' is of limited applicability.

The PhD suggests that the current change in the use of architectural media, where drawing used to be the well-defined, prevalent working medium, can be conceptualized as a kind of 'media mutation', where a cooperative play between conventional drawing and computer media leads to hybrid practices that work with mixed analogue and digital affordances. It is argued that conventional drawing is a kind of architectural legacy, a shared architectural 'figure of thought', against the background of which new media practices arise. For this reason, it is very important for architects to be aware how the media that they use limit, co-create, or make the design process fertile and generative.

The PhD is carried out as artistic research which means, in short, that the themes being investigated are selected not only given by their current relevance, but also by my drawing practice. My drawings form part of the PhD and are used to think about some of the same themes that are addressed in the written parts of the PhD. While it is argued that drawing is an autonomous, architectural way of thinking, however, the methodological experiment of the thesis consists in arranging the more artistic drawings in close contact with the discursive texts, and thereby relating two usually distinct modes of reasoning. This is done in the hope that the two practices will inflict upon each other in fertile ways. Although arranging two otherwise separate practices in each other's proximity is an experiment, both 'tracks of reasoning' can nonetheless be understood as following abductive and diagrammatic forms of reasoning. These forms of reasoning have been conceptualized by Charles S. Peirce and deal with how new ideas and knowledge emerge. In particular, Peirce's diagrammatic reasoning is relevant not just for the thesis' methodological experiment, but also because the diagram is a concept that is often related to architectural media, both analogue and digital.[2] Therefore the thesis suggests that the diagram is a theoretical concept which can grasp both the changes and the non-changes of architectural media practice, and which perhaps also offers a way to allow drawing to form part of research in architecture. The meta-reflection of the thesis is therefore about precision and openness, about how the diagram is a device for reasoning that makes it is possible to be both rational and intuitive when dealing with working practices that are changing, such as both conventional drawing in the context of the computer, but also in the area of artistic research.

[1] Mario Carpo, *The Alphabet and the Algorithm*, (Cambridge, Massachusetts and London, England: The MIT Press, 2011). See also the conference "Is Drawing Dead?" held at Yale School of Architecture in 2012. http://www.youtube.com/playlist?list=PL79A5264A0ADED746 (accessed 14.12.2015).

[2] Mark Garcia, ed., *The Diagrams of Architecture* (West Sussex: United Kingdom, 2010).

DANISH SUMMARY

Ph.d. projektet handler om den konventionelle arkitekturtegning, særligt ortogonal projektion - plan, snit og opstalt, og dens intenst diskuterede rolle i nutidens computeriserede kontekst. Nogle arkitekter og arkitekturteoretikere, f.eks. Mario Carpo,[1] forudser sågar at tegningen er et uddøende fænomen.[2] Dette stemmer dog ikke overens med nutidens realitet, såvel som at en 'enten tegning eller computer' distinktion virker alt for grov og temmelig u-nyttig.

Ph.d.en foreslår, at den ændring der sker i samspillet mellem konventionel tegning og computermedier snarere lader sig beskrive som en form for *mutation*,[3] hvorfra forskelligartede blandingsformer mellem analoge og digitale mediepraksisser fremkommer. Det argumenteres at den konventionelle tegning er en slags fælles arkitektonisk arvemasse, en delt arkitektonisk tankefigur, på baggrund af hvilken nye mediepraksisser bryder frem. Af samme grund bliver en højnet mediebevidsthed meget vigtig for arkitekter, en opmærksomhed på hvor medier medskaber, hvor de lader valg stå åbne - en forståelse af tegning som både oversættende medie og ting i sig selv, som særligt trækker på Robin Evans' idéer. Tesens metaniveau handler derfor om præcision og åbenhed, om hvordan det er muligt at være præcis i praksisser der forandrer sig, har mange muligheder og er meget åbne. Her stiles både til temaet, altså, konventionel arkitekturtegning som er et felt i forandring, men også til projektets metodologi, artistic research, der også er en forsknings praksis i tilblivelse.

Ph.d.en er udført som 'artistic research', hvilket kort sagt betyder at mine egne tegninger finder en plads i den teoretiske del af ph.d.en. Tegning bruges til at tænke over de samme temaer, som behandles i den teoretiske del af projektet, og det argumenteres, at det at tænke igennem arkitekturtegning er en selvstændig tænkemåde. Mine tegninger trækker på en tegningsdiskurs repræsenteret af f.eks. Bernard Tschumi's *The Manhattan Transcripts*,[4] - bevægelsesnotation og åbne værker. Desuden tematiserer mine tegninger netop en blandingsform af konventionel tegning og computerteknikker, og fremstår som en form for skitser, mappings og notationer. Det metodologiske eksperiment består i at arrangere tegningerne i tæt forhold til de teoretiske dele, og dermed indføre en arkitektonisk tænkemåde i en forskningspraksis. Dog kan begge ph.d.ens 'tænkespor' - tegningen og teorien - forstås som følgende abduktiv og diagrammatisk metode. Denne forståelse understøttes ved at koble videnskabsteori omhandlende nye idéers fremkomst til den konventionelle arkitekturtegning, særligt Charles S. Peirce's diagramtænkning. På denne baggrund bliver det argumenteret både i forhold til temaet og metodologien, at det, at sammenstille et arkitektonisk arbejdsmedium af diverse digitale og analoge teknikker og notationsformer udgør en egen diagrammatisk tænke og handlemåde, der rækker ind i bygningens realitet, og muligvis også ind i en arkitektonisk forskningspraksis.

[1] Mario Carpo, *The Alphabet and the Algorithm*, (Cambridge, Massachusetts and London, England: The MIT Press, 2011).

[2] For eksempel blev der I 2012 afholdt et symposium på Yale School of Architecture kaldt "Is Drawing Dead?" http://www.youtube.com/playlist?list=PL79A5264A0ADED746 (accessed 14.12.2015).

[3] At kalde det en mutation er inspireret af Robin Evans, der i essayet "The Developed Surface - An Enquiry into the Brief Life of an Eighteenth-Century Drawing Technique" beskriver en mutation i de britiske arkitekters brug af den konventionelle tegning. Robin Evans, *Translations from Drawing to Building and Other Essays*, (London: Architectural Association Publishers, 1997), 195-233.

[4] Bernard Tschumi, *The Manhattan Transcripts*, Expanded 2.nd edition, (London: Academy Editions, 1994).

ACKNOWLEDGEMENTS

Most of all, thanks to my husband, Michel, for loving help and support. And thanks for taking such good care of our children, Jakob and Sofie, during the phases where I have been working intensely on this project.

Also thanks to my mother, aunt and uncle, who have made it possible to live in Berlin and work in Copenhagen by helping me with all the family logistics in various, sweet-natured ways.

Thanks to my supervisors, especially Peter Bertram, for helping a lot with seeing this project through and being supportive about (or indeed being the source of) its methodology. Thanks to Per Møldrup for supervision during the initial phases of the project and to Martin Søberg for supervision during last part.

Also thanks to Jørgen Hauberg and Jacob Bang for being good-humoured, supportive colleagues. Moreover, thanks to drawing and architecture teachers for having taught me about diagrammatic drawing, and finally, thanks to friends, family and colleagues, with whom I have discussed the project.

BIBLIOGRAPHY

PRIMARY SOURCES

Allen, Stan. *Practice: Architecture, Technique and Representation*, Expanded Second Edition. Abingdon and New York: Routledge, 2009.

Ammon, Sabine, and Froschauer, Eva Maria. *Wissenschaft Entwerfen*. München: Wilhelm Fink, 2013.

Anderson, Douglas R. "The Evolution of Peirce's Concept of Abduction." *Transactions of the Charles S. Peirce Society* 22, no. 2 (Spring, 1986): 145-164.

Barad, Karen. "Getting Real: Technoscientific Practices and the Materilization of Reality." *Differences: A Journal of Feminist Cultural Studies,* vol. 10, no. 2, (1998). https://conceptsinsts.wikispaces.com/file/detail/Barad+differences98.pdf, accessed 13.01.2016.

Barad, Karen, "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter." *Signs. Journal of Women in Culture and Society*. band 28, No. 3, (Spring 2003): 801-831.

Bedford, Joseph. "In Front of Lives That Leave Nothing Behind." *AA Files* 70 (2015): 4-18.

Belardi, Paolo. *Why Architects Still Draw*. Translated by Zachary Nowak. Cambridge, Massachusetts, London, England: The MIT Press, 2014.

Bertram, Peter. *Frembringelse*. Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2011.

Bertram, Peter. *Intuitiv Metode*. Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009.

Bertram, Peter. *Invention of a Problem.* Copenhagen: Kunstakademiets Arkitektskole, 2013.

Bertram, Peter. "The Useful Icon." Unpublished

Boehm, Gottfried. "Indeterminacy – on the Logic of the Image." In *Dynamics and Performativity of Imagination – The Image between the Visible and the Invisible*. Edited by Huppauf, Bernd and Wulf, Christoph. Routledge. New York and London: Routledge, 2009.

Boehm, Gottfried, "Ikonische Differenz." *Rheinsprung 11 – Zeitschrift für Bildkritik* 1 (2011): 170-76.

Boehm, Gottfried. „Spur und Gespür, Zur Archäologie der Zeichnung." In *Öffnungen - zur Theorie und Geschichte der Zeichnung.* Edited by Fiedrich Teja Bach and Wolfram Pichler. München :Wilhelm Fink, 2009.

Boehm, Gottfried. *Wie Bilder Sinn Erzeugen – Die Macht des Zeigens*. 3rd Edition. Berlin University Press, 2010.

Bovelet, Jan. "Drawing as Epistemic Practice in Architectural Design." *Footprint – Delft School of Design Journal* 4, no. 2 (autumn 2010): 75-84.

Brandt, Per Aage. *Det Menneskeligt Virkelige*. Denmark: Politisk Revy, 2002.

Cage, John. *Notations*. New York: Something Else Press, Inc., 1969.

Cage, John and Helms, Hans G. "Reflections of a Progressive Composer on a Damaged Society." *October* vol. 82 (Autumn, 1997): 77-93. http://www.jstor.org/stable/779001 accessed 16.02.2016.

Calabuig, Deborah Domingo, Raúl Castellanos Gomez, and Ana Abalos Ramos. "The Strategies of Mat-building." *The Architectural Review*. 13th of August, 2013.

Carpo, Mario. *The Alphabet and the Algorithm*. Cambridge, Massachusetts and London, England: The MIT Press, 2011.

Carpo, Mario. "Ten years of Folding." *Folding in Architecture*, revised edition. Edited by Greg Lynn. *AD Architectural Design* (2004): 14-19.

Carpo, Mario. "Craftsman to Draftsman." in *The Working Drawing - The Architect's Tool*. Edited by Anette Spiro and David Ganzoni. Translated by Lisa Rosenblatt. Zürich: Park Books, 2013.

Carpo, Mario. „Die Entstehung des typografischen Architekten." In *Architekturwissen. Grundlagetexte aus den Kulturwissenschaften – Zur Ästhetik des sozialen Raumes*. Edited by Susanne Hauser, Christa Kamleithner, and Roland Meyer. Bielefeld: Transcript, 2011.

Chard, Nat. *Drawing Indeterminate Architecture, Indeterminate Drawings of Architecture*. Consequence book series on Fresh Architecture, vol. 3. Wien, New York: Springer, 2005.

Chard, Nat, and Kulper, Perry. *Fathoming the Unfathomable: Archival Ghosts and Paradoxical Shadows*, *Pamphlet Architecture 34*. New York: Princeton Architectural Press, 2013.

Ching, Francis D. K., *Architectural Graphics*. 5th ed. New Jersey: John Wiley and Sons, 2009.

Christensen, Rikke Lyngsø. "Mellem Fund og Fremtrædelse, Tegning som Undersøgelsesredskab i Renæssancens Arkitektoniske Praksis." 2013. http://www.sbi.dk/arkitektur/generelt/at-give-arkitekturen-ordet/RikkeLyngsoChristensen.MellemFundOgFremtraedelse.pdf accessed 16.02.2016.

Cook, Peter. *Drawing- the motive force of architecture*. Great Britain: Wiley, 2008.

Cook, Peter. ed., *Archigram*. New York: Princeton Architectural Press, 1999.

Cooker, Emma. "Distancing the If and Then." In *Drawing a Hypothesis – Figures of Thought*. Edited by Nikolaus Gangsterer.

Corner, James. *The Agency of Mapping*. In *Mappings*. Edited by Cosgrove, Dennis. London, England: Reaktion Books Ltd., 1999.

Damkjær, Camilla,."Tilfældighed i Bevægelse." In *Bevægelsens Poetik - om den æstetiske dimension i bevægelse*. Edited by Lis Engel, Helle Rønholt, Charlotte Svendler Nielsen, and Helle Winther. Copenhagen: Museum Tusculanums Forlag, 2006.

Deleuze, Gilles. *Bergsonism.* Translated by Hugh Tomlinson and Barbara Habberiam. New York: Zone Books, 1988.

Deleuze, Gilles. *The Logic of Sense*. Translated by Mark Lester with Charles Stivale. London and New York: Continuum, 2004.

Deleuze, Gilles. *Francis Bacon - The Logic of Sensation*. Translated by Daniel W. Smith. Minneapolis: University of Minnesota Press, 2002.

Deleuze, Gilles, and Guattari, Félix. *A Thousand Plateaus - Capitalism and*

Schizophrenia. Translated by Brian Massumi. London: Continuum, 2004.

Dinesen, Cort Ross ,ed. *Cartography, Morphology, Topology*. Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009.

Eco, Umberto. *Horns, Hooves, Insteps*. In *Dupin, Holmes, Peirce, The Sign of Three*. Edited by Eco, Umberto and Soeboek, Thomas. USA: Indiana University Press, 1983.

Eco, Umberto. *The Open Work*. Translated by Anna Cancogni with an introduction by David Robey. Cambridge, Massachusetts: Harvard University Press, 1989.

Elkins, James. *Artists with PhDs*. http://www.jameselkins.com/yy/2-list-of-phd-programs-around-the-world/ accessed 16.02.2016.

Engel, Heino. *"Measure and Construction of the Japanese House."* Boston, Rutland, Vermont, Japan: Tuttle Publishing, 1985.

Erny, Nicola. „Kreativität und Methode. Ein Vergleich zwischen Charles S. Peirces Begriff der Abduktion und der Methodenkonzeption von Giambattista Vico." *Zeitschrift für philosophische Forschung* 53, H. 1 (Jan. - Mar., 1999).

Evans, Robin. "Architectural Projection." In *Architecture and Its Image*. Edited by Blau, Eve and Kaufman, Edward. Montreal: Canadian Centre for Architecture, 1989.

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

Evans, Robin. *The Projective Cast - Architecture and Its Three Geometries*. Cambridge, Massachusetts and London, England: The MIT Press, 1995.

Forty, Adrian. *Words and Buildings*. London: Thames & Hudson Ltd, 2013.

Frayling, Christopher. "Research in Art and Design." *Royal College of Art Research Papers* vol 1, number 1, 1993/4, 1-5.

Fuller, R. Buckminster, *Operating Manual for Spaceship Earth.* Edited by Jamie Snyder. Switzerland: Lars Müller Publishers, new edition 2008/2011, first published 1969.

Garcia, Mark, ed. *The Diagrams of Architecture.* West Sussex: United Kingdom, 2010,

Garcia, Mark. "Emerging Technologies and Drawings: The Future of Images in Architectural Design." In *Architectural Design*, Drawing + Architecture. Edited by Spiller, Neil, sept/oct 2013.

Gjerde, Eric. *Origami Tessellations, Awe-Inspiring Geometric Designs*. Boca Raton, London, New York: CRC Press Taylor & Francis Group, 2009.

Goodman, Nelson. *Languages of Art*, Second Edition. Indianapolis, Cambridge: Hackett Publishing Company, inc., 1976.

Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies,* Vol. 14, No. 3. (Autumn, 1988): 575-599. http://www.jstor.org/stable/3178066 accessed 16.02.2016.

Hauser, Susanne, Kamleithner, Christa, and Meyer, Roland, eds. *Architekturwissen Band 1 - Grundlagetexte aus den Kulturwissenschaften – Zur Ästhetik des sozialen Raumes*. Bielefeld: Transcript, 2011.

Heidegger, Martin. *Spørgsmålet om teknikken og andre skrifter*. Copenhagen: Gyldendal, 1990.

Hill, Jonathan. *Immaterial Architecture*. London and New York: Routledge, 2006.

Hougaard, Anna Katrine. "Architectural drawing - an animate field." *Open House International* 40, no. 2, (2015): 44-54.

Hougaard, Anna Katrine. "Drawing, Mapping and Haecceity." *Footprint* 6, (2012): 37-59.

Hougaard, Anna Katrine. "Architectural Practice in Research framed by Abduction." In *Research by Design*. Edited by The European Association for Architectural Education, 2915.

Hovestadt, Ludger. *Beyond the Grid - Architecture and Information Technology, Applications of a Digital Architectonic*, (Basel, Boston, Berlin: Birkhäuser, 2010).

Ingold, Tim. *Lines: A brief History*. Abingdon, England and New York, USA: Routledge, 2007.

Jensen, Anders Fogh. *Mellem Ting - Foucaults filosofi*. Copenhagen: Det lille Forlag, 2005.

Kinnebrock, Werner. *Was macht die Zeit, wenn sie vergeht?* München: Verlag C. H. Beck, 2012.

Kirkeby, Ole Fogh. "Abduktion." In *Videnskabsteori og metodelære*. Edited by Andersen, Heine. Copenhagen: Samfundslitteratur, 1990.

Lynn, Greg. *Animate Form*. New York: Princeton Architectural Press, 1999.

McCloud, Scott. *Understanding Comics - the invisible art*. New York: Harper Perennial, 1994.

Miessen, Markus. *Albtraum Patrizipation*, Germany: Merve Verlag Berlin, 2012.

Morris, Mark. "All Night Long: The Architectural Jazz of the Texas Rangers." *Drawing + Architecture*, 83, 5 (Sept/Oct 2013): 20-27.

Murray, Janet H. *Hamlet on the Holodeck – The Future of Narrative in Cyberspace*. New York: The Free Press, 1997.

Murray, Janet H. *Inventing the Medium – principles of interaction design as a cultural practice*. Cambridge, Massachusetts and London, England: The MIT Press, 2012.

Nepper Larsen, Steen and Inge Kryger Pedersen, eds. *Sociologisk leksikon*. Copenhagen: Hans Reizels Forlag, 2011.

Paavola, Sami. "Percian Abduction: Instinct or Inference." *Semiotica* 153 - 1/4 (2005): 131-54.

Rutishauser, Stephan. "Future Plans." In *The Working Drawing*. Edited by Anette Spiro and David Ganzoni. Zürich: Park Books, 2013.

Pedersen, Claus Peder. "Digital Imperfection – Polemical outline of a digital form of drawing," in *Cartography, Morphology, Topology*. Edited by Cort Ross Dinesen, Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009.

Pedersen, Claus Peder. "The Provisional Work (inspired by Umberto Eco)," in *Cartography, Morphology, Topology.* Edited by Cort Ross Dinesen, Copenhagen: Kunstakademiets Arkitektskoles Forlag, 2009.

Pedersen, Claus Peder. "Greg Lynn's topologiske ontology," unpublished but accessible at http://www.blankspace.dk/lynn.htm (accessed 20.11.2015).

Peirce, Charles Sanders. Various sources:

- "Sixth Paper: Deduction, Induction and Hypothesis" (1878). In *Chance, Love and Logic*: *Philosophical Essays*. Edited by Morris R. Cohen. USA: University of Nebraska Press, 1998.

- *Peirce, C. S. Semiotik og Pragmatisme*. Edited by Anne Marie Dinesen and Frederik Stjernfelt. Translated by Lars Andersen. Denmark: Gyldendal, 1994.

- "New Elements (Kaina stoiceia)", *The Essential Peirce vol. 2 (1893-1913)*. Edited by the Peirce Edition Project. Bloomingdale and Indianapolis: Indiana University Press, 1998.

- Eisele, Carolyn, ed. *Historical Perspectives of Peirce's Logic of Science: A History of Science*, vol. II, Berlin, New York, Amsterdam: Mouton, 1985.

- Burks, Arthur W. ed. *Collected Papers of Charles Sanders Peirce Vol. VII*. Ann Arbor, Michigan: UMI Books on Demand, 1996. Reproduced from the manuscript previously published by The Belknap Press of Harvard University, Cambridge, Massachusetts, London, England, Third printing, 1979.

- Turrisi. Patricia Ann, ed. *Pragmatism as a Principle and Method of Right Thinking: The 1903 Harvard Lectures on Pragmatism.* New York, Albany: State University of New York Press, 1997.

- Fisch, Max H., Kloesel, Christian J. W., et al., ed. *Writings of Charles S. Peirce, 1884 - 1886, vol. V*. Bloomington and Indianapolis: Indiana University Press, 1993.

Robbins, Edward. *Why Architects Draw*. Cambridge, Massachusetts, London, England: MIT Press, 1997.

Ross Scheer, David. *The Death of Drawing.* New York and Abingdon: Routledge, 2014.

Scheurer ,Fabian. "Signal to Noise - What is Quality in Digital Architecture." IN *Structuralism Reloaded - Rule-Based Design in Architecture and Urbanism*. Edited by. Tomás Valena, Tom Avermaete, and Georg Vrachliotis. Stuttgart, London: Edition Axel Menges, 2011. 269-74.

Sheil, Bob, ed. *55/02 A Sixteen* (Makers) Project Monograph*. Canada: Riverside Architectural Press, 2012.

Schumacher, Patrick. "Parametric Diagrams." In *The Diagrams of Architecture*. Edited by Mark Garcia. West Sussex, United Kingdom: John Wiley & Sons Ltd, 2010.

Sheil, Bob. "Distinguishing between the Drawn and the Made." *AD Material Computation* (2012):136-141.

Sheil, Bob. "Transgression from drawing to making." *Research Quarterly,* 9, no. 1 (March 2005): 20-32. http://journals.cambridge.org/action/displayJournal?jid=ARQ (accessed 7.1.2016).

Spiller, Neil. "Architectural Drawing: Grasping for the Fifth Dimension." In ed. *Architectural Design, Drawing + Architecture.* Edited by Neil Spiller. Wiley, sept/oct 2013.

Spiro, Anette and David Ganzoni, eds. *The Working Drawing - The Architect's Tool*. Translated by Lisa Rosenblatt. Zürich: Park Books, 2013.

Stjernfelt, Frederik. *Diagrammatology – An Investigation on the Borderlines of Phenomenology, Ontology, and Semiotics*. Dordrecht, Heidelberg, London, New York: Springer, first softcover printing, 2011,

Reas, Casey and Chandler McWilliams. *Code + Form In Design, Art and Architecture*. New York: Princeton Architectural Press, 2010.

Rheinberger, Hans-Jörg. *Räume des Wissens*. Edited by Hans-Jörg Rheinberger, Michael Hagner and Bettina Wahrig-Schmidt. Berlin: Akademie Verlag, 1997.

Rheinberger, Hans-Jörg. "Making Visible. Visualisations in the Sciences – and in Exhibitions?" In *Preprint 399, The Exhibition as Product and Generator of Scolarship*. Edited by Susanne Lehmann-Brauns and Christian Sichau, and Helmuth Trischler. Published online by Max Planck Institute for the History of Science, 2010, 9-23. https://www.mpiwg-berlin.mpg.de/Preprints/P399.PDF (accessed 6.1.2015).

Rheinberger, Hans-Jörg. "Epistemic Objects/Technical objects". The article is originally published by the Max Planck Institute for the History of Science in Berlin as part of the Research Colloquium "Epistemic Objects" at the Technical University Berlin on May 16-17, 2008, 26. http://www.theanxiousprop.org/pdf/AXP_Case2_07-2010.pdf (accessed 5.12.2014).

Rheinberger, Hans-Jörg. "Man weiss nicht genau, was man nicht weiss – Über die Kunst, das Unbekannten zu erforschen." In Neue Züricher Zeitung 5.5.2007. http://www.nzz.ch/aktuell/startseite/articleELG88-1.354487 (accessed 5.12.2014).

Tibbits, Skylar. "Design to Self-Assembly", *Material Computation*. Edited by Achim Menges, AD 82, 2, London: John Wiley Sons, march/april 2012, 68-73.

Tschumi, Bernard. *The Manhattan Transcripts*. Expanded 2.nd edition. London: Academy Editions, 1994.

Tschumi, Bernard. *Architecture Concepts – Red is not a Color*, New York: Rizzoli, 2012,

Turnbull, David. *Masons, Tricksters and Cartographers*. Abingdon: Routledge, 2000, reprinted 2003.

Valena, Tomás, Avermaete, Tom and Vrachliotis, Georg. *Structuralism Reloaded – Rule-Based Design in Architecture and Urbanism*. Stuttgart/London: Edition Axel Menges, 2011.

Venturi, Robert, Denise Scott Brown, and Steven Izenour. *Learning from Las Vegas revised edition*. Cambridge, Massachusetts, and London, England: The MIT Press, 1977.

Vidler, Anthony. „What is a Diagram Anyway?" Translation into Danish by Nils Lyngsø: "Hvad er egentlig et diagram?" Copenhagen: Kunstakademiets Arkitektskole, 2007. Originally published 2006, ed. Luca Molinari and Silvia Cassará, *Peter Eisenman. Faints*, Milano.

Voigt, Jorinde. *NOW.* Edited by Julia Klüser and Hans-Peter Wipplinger. Kunst Halle Krems, Verlag der Buchhandlung Walther König, 2015.

Wood, Denis, Kaiser, Ward L., Abramms, Bob. *Seeing Through Maps*. USA: ODT Incorporated, 2001.

REPORTS

Notat fra arbejdsgruppen vedr. kunstnerisk udviklingsvirksomhed by Cort Ross Dinesen,

Carsten Juel-Christiansen and Steen Høyer, 1996.

Arbejdsudvalg vedr. kunstnerisk udviklingsvirksomhed by Anders Abraham, Carsten Juel-Christiansen, Steen Høyer, Henrik Oxvig, 2011.

Kunstnerisk Udvikling. Forslag til Kriterier for Kunstnerisk Udvikling ved KADK by Sofie Beier, Mary-Ann Hansen, Mette Ramsgaard Thomsen, Anders Abraham, Peter Bertram, Martin Bodilsen Kaldahl, 2015.

Forskningsstrategi for Kulturministeriets område, 2009 (http://kum.dk/servicemenu/publikationer/2009/forskningsstrategi-for-kulturministeriets-omraade/ (accessed 10.12.15).

Kunstnerisk Udviklingsvirksomhed, udredning om vidensgrundlaget på de videregående kunstneriske uddannelser, Research report from the Danish Ministry of Culture, 2012. (http://kum.dk/servicemenu/publikationer/2012/kunstnerisk-udviklingsvirksomhed/ accessed 10.12.15).

Nordic Journal of Architectural Research, Theme: The Autonomy of Architecture? Artistic Development Work, vol 18, no. 3, 2005.

PH.D. AND MASTER THESES

Abraham, Anders. *En Ny Natur*. Copenhagen: Kunstakademiets Arkitektskole, 2002.

Bertram, Peter. *Den Animerede Bygning.* Copenhagen: Kunstakademiets Arkitektskole, 2008.

Gunn, Wendy. *The Social and Environmental Impact of Incorporating Computer Aided Design Technologies into an Architectural Design Practice*. PhD Thesis, Department of Social Anthropology, University of Manchester, 2002.

Hermund, Anders. *Anvendt 3D-modellering og parametrisk design.* PhD Thesis, Copenhagen: KADK, 2011.

Pedersen, Claus Peder. *Arkitekturens Dynamiske Formdannelser.* Århus: AAA, 1998.

Piccolotto, Moreno A. *Architecture in the making – An analysis of the emergence of representational conventions in architectural design during the 15th and 16th Century in Rome in the context of the construction of the new St. Peter's Basilica*. unpublished thesis, The Faculty of the Graduate School of Cornell University, 2002.

Søberg, Martin. *The Oscillating Sketch*, PhD thesis. Copenhagen: Royal Danish Academy of Fine Arts, School of Architecture, 2013.

Riiber, Jacob. *Generative Processes in Architectural Design.* Copenhagen: KADK, School of Architecture, 2013.

JOURNALS

AD, Drawing + Architecture, ed. Neil Spiller. Wiley, sept/oct 2013.

AD, Material Computation, ed. Marc Garcia. Vol. 82, Issue 2, mar/apr 2012. Wiley.

AD, Folding in Architecture, ed. Greg Lynn. Revised edition, Wiley Academy, 2004.

AD, Games of Architecture, Wiley, may 1996.

ARCH +, Tokio - Die Stadt Bewohnen, 208, August 2012.

The Architectural Review, vol. CCXXXVI, 1409, (July 2014), 95.

Nordic Journal of Architectural Research, The Autonomy of Architecture? Artistic Development Work, vol 18, no. 3, 2005.

URL's

Tomohiro Tachi's software *Origamizer:* http://www.tsg.ne.jp/TT/ accessed 16.02.2016

Online dictionary of Peirce's terms edited by Sami Paavola and Mats Bergman: http://www.helsinki.fi/science/commens/dictionary.html

Robin Evans lecture: http://sma.sciarc.edu/lecturer/robin-evans/

Is drawing dead? symposium: http://www.youtube.com/playlist?list=PL79A5264A0ADED746

Skylar Tibbits' Ted Talk on 4D printing: http://www.youtube.com/watch?v=0gMCZFHv9v8

My Youtube channel: https://www.youtube.com/watch?v=Mkc3-HSvMdo&feature=youtu.be accessed 17.02.2016.

Sam Jacob's blog: http://strangeharvest.com/drawing-as-project-post-digital-representation-in-architecture (accessed 20.8.2015).

SECONDARY SOURCES

Atelier Bow-Wow. Tsukamoto, Yoshiharu, Kaijima, Momoyo. *Graphic Anatomy*. Japan: TOTO Publishing, 2007.

Atelier Bow-Wow. Tsukamoto, Yoshiharu, Kaijima, Momoyo. *behaviorology*. New York: Rizzoli, 2010.

DeLanda, Manuel. "Deleuze and the Use of the Genetic Algorithm in Architecture." In *Architectural Design: Contemporary Techniques in Architecture.* Edited by Rahim, Ali. Academy Press, 2002.

Flores, Ricardo and Prats, Eva. *Through the Canvas – Architecture inside Dutch paintings*. Sydney: University of New South Wales, 2008.

Forty, Adrian, *Words and Buildings*. London: Thames & Hudson Ltd., 2000, reprinted 2013.

Gardner, Jean and McGrath, Brian. *Cinemetrics: Architectural drawing today*. Wiley, 2007.

Jensen, Graham H. "Making Sense of Play in Video Games: Ludus, Paidia, and Possibility Spaces." In *Eludamos. Journal for Computer Game Culture.* 2013; 7 (1), 69-80. Downloaded at http://www.eludamos.org/index.php/eludamos/article/viewArticle/vol7no1-4/7-1-4-html

Karkoschka, Erhardt. *Das Schriftbild der Neuen Musik – Bestandaufnahme neuer Notationssymbole Anleitung zu deren Deutung, Realisation und Kritik*. Celle: Hermann Moeck Verlag, 1966.

Hubert, Christian. "PLAYTIME." *Architectural Design, Games of Architecture*, 1996.

Ingraham, Catherine. *Architecture, Animal, Human: The Asymmetrical Condition*. Abingdon, Oxon, England, USA and Canada: Routledge, 2006.

Kwinter, Sanford. "PLAY TIME." *Architectural Design, Games of Architecture,* 1996.

Lüchinger, Arnulf. *Structuralism in Architecture and Urban Planning.*

Translated into English by Peter Green, transduction en français, Jacques Debains. Stuttgart: Karl Krämer Verlag, 1981.

Matossian, Nouritza. *Xenakis*. Cypres, Moufflon Publications Ltd., 2005.

Merrill, Michael. *Louis Kahn- Drawing to Find out – The Dominican Motherhouse and the Patient Search for Architecture*. Switzerland: Lars Müller Publishers, 2010.

Sheraton, Thomas. *The Cabinet-Maker and Upholsterer's Drawing-Book, the Dover edition.* Originally published in London 1793-1802, republished by Dover Publications, Inc., New York, 1972.

Weston, Richard. *Utzon*. Denmark: Edition Bløndal, 2008.

IMAGE CREDITS

Fig. 1: Carlo Scarpa's hand sketch for the façade at Castelvecchio. After *The Working Drawing*, 175.

Fig. 2: Sigurd Lewerenz's drawing for the church in Klippan. After *The Working Drawing*, 51.

Fig. 3: Albrecht Dürer, *Man drawing a Lute*, 1525. Retrieved from Wikipedia Commons: https://commons.wikimedia.org/wiki/Albrecht_D%C3%BCrer (accessed 23.02.2016)

Fig. 4. Richard Buckminster Fuller's first *Dymaxion* map as published in *Live Magazine* in 1946. The maps are published online by the geographer Gene Keyes. http://www.genekeyes.com/FULLER/BF-2-1943.html (accessed 11.01.2016).

Fig. 5. World map of time zones. Reproduced here with courtesy of Her Majesty's Nautical Almanac Office (HMNAO): http://wwp.greenwichmeantime.com/info/timezonemap.htm (accessed 24.02.2016).

Fig. 6. Drawing of a human head by Piero della Francesca, *De Prospectiva Pingendi*, 1474-1482. https://f12arch531project.wordpress.com/2012/12/14/a-study-of-the-human-head/ (accessed 24.02.2016).

Fig. 7: A fresco by Piero della Francesca at the Church of San Francesco in Arezzo made around 1466. Retrieved from Wikimedia commons: https://upload.wikimedia.org/wikipedia/commons/thumb/9/90/Piero_della_Francesca_003.jpg/1280px-Piero_della_Francesca_003.jpg (24.02.2016).

Fig. 8: A developed surface interior drawing by the architect Thomas Sheraton, 1793. Here reproduced from: Thomas Sheraton, *The Cabinet-Maker and Upholsterer's Drawing-Book, the Dover edition.* Originally published in London 1793-1802, republished by Dover Publications, Inc., New York, 1972.

Fig. 9: Drawing by Gillow and Co., early 19th century. The drawing is retrieved from the homepage of the *Victoria and Albert Museum Department of Prints and Drawings and Department of Paintings*. http://collections.vam.ac.uk/item/O580113/architectural-drawing-gillow-co/ (accessed 24.02.2016).

Fig. 10: Karl F. Schinkel, *The Origin of Painting*, 1830. With courtesy of the Von der Heydt Museum, Wuppertal. Low resolution image retrieved from: https://projectionsystems.wordpress.com/2009/09/06/the-origin-of-painting/ (accessed 24.02.2016).

Fig. 11: Competition drawing for Freie Universität in Berlin, made by Candilis, Josic and Woods, 1963. Retrieved from: http://loveyousomat.tumblr.com/post/12689458931 (accessed 24.02.2016).

Fig. 12: Plan drawing of Junya Ishigami's project *Group House*. Reproduced from *ARCH +*, Tokio - Die Stadt Bewohnen, August 2012.

Fig. 13-16: Excerpts from Bernard Tschumi's *The Manhattan Transcripts*. Reproduced here with courtesy of Bernard Tschumi Architects.

Fig. 17: Drawing by Jorinde Voigt from the series: STAAT/Random (IV), 2008. Retrieved from the artist's online portfolio: http://jorindevoigt.com/blog/?attachment_id=6982 (accessed 25.02.2016).

Berlin maps: http://www.stadtentwicklung.berlin.de/geoinformation/fis-broker/ (accessed 3.3.2015)