A conversation between Art Nouveau and Digital design

FELIX LOTZ
A CONVERSATION ON
ART NOUVEAU,
COMPUTATIONAL DESIGN AND
THE CURVILINEAR FORM

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Master thesis spring term 2016
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The thesis consists of four chapters that without any hierarchy in different ways explore similarities and differences in design methods, philosophy and forms, contrasting the Art Nouveau period of 1880-1915 to Computational curvilinear designs created 1980-2015.

Chapter one: **CONTEXT HISTORY AND PHILOSOPHY** is the result of literature studies of Art Nouveau and Computational design theory and practice and is concluded by a discussion that can be seen as strongly influenced by the findings in chapters 2-4.

Chapter two: **TRANSLATION ABSTRACTION AND SCALE** studies buildings, ornament and scale in a series of translations from photograph/concept to 3D model and in text discusses Art Nouveau scale and ornament.

Chapter three: **CURVE GEOMETRIES** defines the geometries used within Art Nouveau and discusses regional differences. The defined geometries are explored in a design for a facade and stairwell. The chapter is concluded with a drawn study in line endings between Art Nouveau and curvilinear Computational design.

Chapter four: **REALITY AND FICTION** is a drawn conversation between contemporary society and Art Nouveau. In this conversation I redraw realised designs by Zaha Hadid and Norman Foster using Art Nouveau design strategies and contemporary construction techniques.
INTRODUCTION

My interest in Art Nouveau/Jugendstil architecture from the early twentieth century was awakened in my early teens when I discovered, and was fascinated by, the florally decorated facade of Norrköping’s Enskilda Bank by Gustaf Wickman. As an adult, Alfred Grenander’s curved bridge supports for the U-bahn in Berlin as well as Hector Guimard’s metro entrances in Paris have reawakened my interest in Art Nouveau architecture. This interest also made me reflect on the differences between architecture of the late nineteenth - early twentieth century and curvilinear architecture of today. The feeling I get is that today’s curvilinear architecture, which is often generated with computer supported design tools, fails to fascinate me in the same way. Through my thesis work I hope to find the geometries, motives and scales which I consider make the curvilinear architecture of the late nineteenth and early twentieth century so attractive. I hope that my findings will enhance and develop my future architectural practice.

Three questions I have asked myself at the beginning of the thesis:

1. Are there one or more significant form or geometric markers in curvilinear architecture between 1890 and 1920?
2. How does the form language and geometrics of this architecture differ from post 1980 curvilinear architecture?
3. Can I re-interpet architecture from the period 1890-1920 in a way that is relevant to curvilinear architecture of today?

DEFINITIONS

Curvilinear architecture in this thesis is defined as architecture in which the curved line and the curved surface are the most important elements of the design. The formwork can take its inspiration from nature (often referred to as organic) but can also be abstract. The curved form can be expressed in plan, facade, details, and ornament.

Significant architectonic styles using the curved line and surface are: Rococo, Gothic and Neo-Gothic architecture, Art Nouveau/Jugendstil, Expressionism, Surrealism, Blobitecture and Parametric architecture. Within some of these styles there is also a crystalline form language; studies of crystalline architecture are outside the scope of this thesis.

CONTEXT

By 1890 the industrialization of parts of the building trade through mass production had distorted the classical form language of the antique into an ornamented eclecticism. Architects sought a new, historically unbound, style that would appeal to the growing upper middle class. They found inspiration in nature, in the medieval gothic architecture as well as in new influences from Japan. Art Nouveau, or Jugendstil as it was called in the German speaking parts of Europe, developed at the turn of the last century and flowered in a short period during which a considerable number of buildings, ranging from villas and apartments to concert halls and bridges, were constructed. Although the new style was on the decline by 1910 it was picked up again and in part re-developed by the Expressionist movement but resulted in few built works, partly because of the lack of building activity during the war but also due to the complexity encountered in the building of double curved forms.

The countries today leading the development of architectural form language have all passed the turning point from having a production-based economy to a knowledge-based economy. New digitally based design and production methods are radically changing the way goods are produced. Globalised economy, with its utilisation of cheap labour in developing countries, has made it possible to produce complex products at relatively low prices. Compared to the period around the turn of the previous century we today have the ability and methods to produce curvilinear surfaces in a relatively rational way.

Is not the transition to a knowledge based economy a situation similar to the one that affected architecture during the turn of the last century when the transition from an agrarian society to an industrialized society and production based economy was more or less completed? With this background in mind I find it relevant to explore and compare how the curvilinear form has been used in architecture during these different periods of time in which we see major transitions taking place.
I

CONTEXT HISTORY AND PHILOSOPHY
THE CURVILINEAR THREAD OF MOVEMENT: A SHORT SUMMARY OF THE HISTORICAL USE OF NATURE-INSPIRED LINES IN ARCHITECTURE BEFORE 1800

Curvilinear forms, as used in the depiction and abstraction of nature and its movements, can be traced back to the roots of mankind. Examples can be seen in the cave paintings (illust. 1) of Lascaux, France, estimated to be 17300 years old, and the clay-animal figures of the Indus civilization, from around 6000 BC. Evidence of the use of natural forms in the building of shelters and later houses can be found in most “primitive” societies. Further examples of the use of rounded building forms in prehistoric time can be seen in Stone Age buildings in Scandinavia (illust. 2).

The inclusion and inspiration of nature in architecture is also apparent in the Greek and Roman civilisations. In Greek architecture, examples are the nature-inspired Corinthian capital first found in the temples of Bassae, and the feminine Caryatid figures used as load-bearing structure in the temple of Erechtheion (illust. 3). In Roman architecture a less abstract organic form-language is found in the rich depiction of nature in ornamentation. Examples of this are the entrance arch to the temple of Hadrian in Ephesus and the triumphal entrance to the main square in Pompeii (illust. 4).

The tradition of using natural form in design continues through the European history of architecture, with varying degrees of separation between its structural usage and its implementation as decorative ornament. During the medieval and gothic periods there was a tendency towards a merging of the organic ornament with the load bearing structure. In the Renaissance a separation between the organic ornament and structure occurred, resulting in rectilinear buildings decorated with nature-inspired figures and ornaments.

A tendency towards merging the curved form with structure is apparent again in Baroque and, even more so, in Rococo architecture. An example of this can be seen in the spiralling Solomonic columns (illust. 5) bearing the baldacchino in St. Peter’s in Rome, by Bernini. The Baroque and Rococo period also introduced asymmetry and the elliptical form into architecture, thereby putting into question the idea of divine symmetry since the eclipse was seen to be imperfect through its lack of radius. That architects of the late 19th century looked for inspiration in nature, in their search for a new style, can therefore be seen as the continuation of a long tradition.

1. Cave painting of bison ox in cave of Altamira, Spain. Image licensed under Creative Commons by Rameessos
2. Stone age Longhouse, Trelleborg, Denmark. Image licensed under Creative Commons by Malene Thyssen,
3. A caryatid from the Erechtheion, displayed at the British Museum. Image licensed under Creative Commons by I. Sailko
4. Organic ornaments from the main portal entrance to the central square in Pompeii. Photograph: E.Latz

References:
2 The Scandinavian longhouse see Ale Vikingagård and the reconstruction stone age house in Körunda
5 August Hahr (1902) Arkitekturens Historia
6 Giovanni Lorenzo Bernini (Gian Lorenzo Bernini), 1598 - 1680
7 Marvin Trachtenberg  Architecture: From Prehistory to Postmodernity
THE HISTORICAL CONTEXT AND PHILOSOPHY
OF ART NOUVEAU ARCHITECTURE IN THE PERIOD
1880 -1920

VIOLLET-LE DUC AND ART NOUVEAU

The revival of gothic architecture in the early 19th century - and its theorizing by Eugène Viollet-le-Duc (1814 -1879 ), were formative for the design language of Art Nouveau. Viollet-le-Duc claimed that gothic architecture had its higher meaning in that all parts in the structure were necessary and worked together to produce both structural stability and beauty.

Viollet-le-Duc’s thoughts on gothic architecture may also reflect a general growing interest in natural history and an extensive cataloguing of nature and animal anatomy. In the newly created museums of natural history displays of skeletons from both living and extinct animals visualized the way nature formed structure. The bones in these prehistoric skeletons combined together to give a bigger picture in which all parts have a function.

It is interesting to note that Viollet-le-Duc also advocated the use of new materials both in his contemporary design suggestions (illust. 6) and in his renewal of gothic structure. He widened John Ruskin’s theory of material honesty to include new materials such as iron and glass.

Viollet-le-Duc’s glorification of the skilled medieval craftsman coincided with William Morris’s thoughts on labour and Morris’s criticism of the industrially produced object. Together with this theoretical critique of industrialised society there was a growing discontent among the upper middle class with the results of industrialisation. Foremost this was a crisis of identity: mass production made objects that previously had been reserved for the few, commonplace and affordable. The increasingly inhuman conditions that industrialisation created for those involved in production also contrasted sharply with the concepts of equality and solidarity.

5. Baldachin with spiralling columns 1623-34 by Gian Lorenzo Bernini in St. Peter’s Basilica, Rome. Image has been released into the public domain by its creator under a public license.

6. Eugène Viollet-le-Duc’s design for a concert hall, dated 1864, expressing Gothic principles in modern materials; brick, stone and cast iron. from “Entretiens sur l’architecture”

7. Triceratops skeleton at London Natural History Museum. This is a papiermodel, not a fossil. Image licensed under Creative Commons by Zachi Evenor
**Art Nouveau, Idealism and Spiritualism**

Within the Art Nouveau movement there was a clear urge to create art and architecture for a better world. Wiliam Morris expressed this in his idealization of labour\(^{13}\) and Hector Guimard (1867-1942) in his experiments with rapid house fabrication at the 1900 Paris exhibition\(^ {14}\). Expressing the ideal of perfection in design and architecture became an integral part of the Art Nouveau movement. This is perhaps most clearly shown by the often repeated idealized feminine figure, (illus. 9) the reinvention of the female goddess. The feminine body was seen as a personification of youth and perfection\(^ {15}\).

The early 20th century society found both a fascination - but also a horror - in the strength of the suffragettes’ fight for equal rights between the sexes. Within the Art Nouveau movement it is easy to see a strong yearning to express the power of women. Within the movement there was both support for, and dislike of, the suffragettes. Van der Velde, for example, was involved in the design of ‘Reform Kleidung’, dresses without corsets\(^ {16}\).

Complimenting ideas of natural evolution and the positive effects of science, as well as the critique of industrialization, there was also a growing spiritualism at the end of the 19th century. Both Ruskin and Viollet-le-Duc connected spirituality with architecture, particularly in their references to ancient structures as having a life and spirit\(^ {17}\).

The weakening power of state religions and the new theory of evolution ‘encouraged alternative interpretations of the spiritual. Philosophy moved towards a scientific approach. This can be seen in Sigmund Freud’s writings on psychotherapy and also in the idea that nature through evolution strives towards perfection, as introduced in philosophy by Friedrich Nietzsche (1844-1900) in his theory of the *Übermensch*\(^ {19}\). Rudolf Steiner (1861-1925) was also one of the first in philosophy to apply scientific theory to the spiritual world\(^ {20}\).

\(^{13}\) William Morris 1890 News from Nowhere


\(^{17}\) Eugène Emmanuel Viollet On restoration chapter of Dictionnaire raisonné de l'architecture française du xie au xvie siècle

\(^{18}\) Charles Darwin’s  *On the Origin of Species* (1859) introducing the idea of evolution

\(^{19}\) Friedrich Nietzsche 1883 Also sprach Zarathustra: Ein Buch für Alle und Keinen

\(^{20}\) Rudolf Steiner (1904) The philosophy of freedom
**Art Nouveau and Expressionism**

It was first within early Expressionism that writings about interactions between the built room and the spiritual world became more usual. Paul Scheerbart, Bruno Tatut and Hermann Finsterlin's writings all imply a connection between the built environment and Stimmung (the mood or feeling) people in it have. The wish to explore, methodize and document this interaction can also be seen in Kandinsky's statistical study of the connection between form and colour at the Bauhaus school. In Concerning the spiritual in art, a further study of the connections between spirituality, form and art, Kandinsky argues that the avant-garde artist is a driving force in the evolution of human thinking.

Although in their writings the Expressionists (just like Art Nouveau architects) rejected all earlier styles, strong links can be discerned between the two styles. Both take inspiration in nature. In Expressionism it was abstracted to a higher degree, and also methodized through a system of metamorphoses. This was a concept of form inspired by the natural process of changes in form taking place in the different developmental stages of an organism, for example a frog's metamorphosis from egg to tadpole to full grown frog.

Art Nouveau and Expressionist styles also both favoured the idea of the Gesamtkunstwerk: i.e. a work of art created by a designer who, through genius, has the ability to see beyond the imperfections of the physical world. Other links connecting Art Nouveau with Expressionism are their endorsement of new materials, their critique of the bad quality of mass produced goods and their ideas of an idealized society. Bruno Taut's drawings of an ideal city in Alpenarchitektur is an example of this. The Jahrhundert Halle and interiors for the Großes Schauspielhaus in Berlin by Hans Poelzig (1869-1936), as well as the fantasy writings of Paul Scheerbart (1886-1915), can both be seen as illustrating Expressionism's inclusive and social line of thinking.

Rudolf Steiner's two Goetheanum buildings and Erich Mendelsohn's (1887 – 1953) Einsteinturm also are evidence of design connections between Art Nouveau and Expressionist architecture. The handling of surfaces in these buildings may have been inspired by the Spanish Modernista movement and the façade of Antoni Gaudí's Casa Mila. Rudolf Steiner's first Goetheanum, consisting of two intersecting spheres, can also be seen as one of the first buildings with a spiritual theoretical background to its surface geometry.
The problems encountered in constructing Mendelssohn’s Einsteinturm, and that the style could not be used to contribute to improved living conditions for post WW1 working populations, pushed these forms of Expressionism towards the periphery of the architectural discipline. Rudolf Steiner’s second Goetheanum and Hermann Finsterlin’s continuous production of utopian design (illus.14) (none of which, regrettably, was executed) are generally treated as abnormalities in literature on Modernist building.

The split between the spirituality of expressionism and the rational modernist approach was already apparent in the 1914 Köln Werkbund Exhibition where Van der Veldes theatre can be seen as an attempt to mediate between Bruno Taut’s utopian glass pavilion (illus.15) and the growing rationalism of the Hilberseimer generation of architects (illus.16). WW1 gave the Expressionist movement the possibility of developing their ideology and form without having to confront the realities of building such complex geometry or experience the same moral problems in producing high quality handcrafted goods that Morris had encountered 20 years earlier.

The evolution of scientific research theory and development of the method of proof by the repeatable experiment also restricted science from studying areas requiring soft data. Function in modernist architectural philosophy is strongly restricted to materialistic function: the room prompted by feelings is seldom discussed.

It is interesting to note that the majority of exceptions from the Modernist design paradigm – form by function – almost all have a strong connection to earlier Expressionist and Art Nouveau design philosophy. Often the architect’s parent was an architect with designs resting in the Expressionist and Art Nouveau traditions. Examples are Eero Saarinen (1910-1961) whose father, Eliel Saarinen, designed the Helsinki railway (illus.17) station and Gottfried Böhm (1920-), whose father, Dominikus Böhm, drew the Baptism chapel of St. Johannes Church in Neu Ulm. Sometimes the architect had a teacher with connections to Art Nouveau/Expressionism: Hans Scharoun (1893-1972), for example, had Hans Poelzig as teacher. An elaboration on this connection can be found in my essay “Expressionism and the Frülich newspaper” attached to this thesis.

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30 Hyman Trachtenberg (1986) Architecture From Prehistory to Post-Modernism

15. The Glass Pavilion, Cologne, 1914, by Bruno Taut. Expired copyright for this image
17. The Railway station of Helsinki, 1919, by Eliel Saarinen. Image licensed under Creative Commons by Revontuli
18. The TWA Flight Center built as a concrete shell structure, 1962, by Eero Saarinen. Image licensed under Creative Commons by pheezy
ARCHITECTURE IN THE DIGITAL AGE

SOFTWARE AND DIGITAL MANUFACTURING

In the introduction to *The Digital Turn in Architecture 1992-2012* Mario Carpo states that building a typical multi-storey car park today generally involves more digital technologies than were available to Frank Ghery’s office for the design of the Guggenheim museum in Bilbao. Carpo also describes the computer as a very clever tool that clearly does not have any aesthetic preferences.

The calculating power of the computer, together with software developments, has affected the way we create, communicate and build architecture. Computer Aided Design (CAD) programs have enabled users with little or no knowledge of programming to manipulate complex forms and datasets relatively easily. Greg Lynn, in his study *Archaeology of the Digital*, investigates different approaches to the use of digital tools in architecture. The examples given range from early code writing (scripting), as a means of producing abstract variations of a chosen system (Eisenman Biocentrum Frankfurt am Main), to the interplay between physical models and digital tools (as used by Ghery in his Lewis Residence).

Although the use of digital tools has a history in architecture ranging back to the late 1970’s architectural design, at the start, it was not a driving force in the development of digital modelling software.

The imperatives for developing software for the digital modelling of curvilinear and organic forms came from other sectors, as diverse as aeronautics and the defence industry. (the development of CATIA an acronym of computer aided three-dimensional interactive application created by Dassault Systèmes)

The first programs for handling surfaces and splines were developed to digitalise the clay models of car designers. They mimicked the analogue tools used by the aeronautical and naval industries. (illus. 20) The mathematical functions for the B-spline - which enabled it to be calculated and thus computed - were developed more or less simultaneously in the early 1960s by both Citroën (by Paul de Faget de Casteljau) and Renault (Pierre Bézier).

In the film industry, Lucas film and Pixar continually were simultaneously developing tools used to create 3d animations. Such tools were, for example, used in *The Adventures of André & Wally* 1984, and the first full length 3D animated feature film: *Toy Story*, released 1996. Film animation techniques for merging one picture into another developed into being capable of morphing nurbs forms. (Gryphon Software’s program Morph released 1991.) The costs and risks that creating physical special effects and filming environments entail have driven the development of realistic renderings and 3D models forwards. Software became available capable of producing realistic depictions of hair, among many other things. The first realistic animated feature film *Final Fantasy*, (2001) used Maya software (released 1998) together with PowerAnimator and RenderMan.

Software designed specifically for architects was a relatively late development. Autodesk released the first version of Autodesk architecture in 1998, a program only capable of digitally replicating hand drawn, two-dimensional line drawings. Subsequent programs intended for architects incorporate 3D features. However most of them have been confined to the platonic solids and only allow modifications to the initial form by cutting, joining and segmenting. Consequently architects have had to rely on software generally not developed for architectural design in order to create forms outside the standard Euclidian geometry.

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1 Digital turn in Architeture 1992-2011 AD reader Edited by Mario Carpo Wiley 2013
2 Greg Lynn (2014Author, Editor)Archaeology of the Digital
3 http://www.eisenmanarchitects.com/biocentrum.html
5 Dassault Systems product description:phttp://www.3ds.com/products-services/catia/
6 https://en.wikipedia.org/wiki/CATIA
7 https://en.wikipedia.org/wiki/Computer_Animation_Production_System
8 http://www.pixar.com/about/Our-Story
9 https://en.wikipedia.org/wiki/Computer_Animation_Production_System
10 https://en.wikipedia.org/wiki/AutoCAD
The development of scripting platforms that started within experimental architectural has during the last decade resulted in a number of plug-ins and programs directly developed for an algorithmic / parametric design method.

Early examples of such platforms are, Generative Components (first beta version 2003 - commercially released 2007) and Grasshopper plug-in for Rhinoceros 3D (first released 2007 and fully integrated into Rhino 5 released 2015). In the past years programs for extracting and analysing BIM models specifically developed for Architects have also been gained such as Vasari and Dynamo.

Mark Foster Garge’s conclusion, in Software monocultures, is that today’s architects are dependent and rely on a relatively limited number of software packages. Garge argues that this has resulted in a culture “producing a predictable sameness in formal, programmatic and sustainable projects alike” as architects develop styles dependent on certain closely guarded software - or even tools, commands and scripts within the software.

Both Foster Garge and Jason Payne see scripting of specific code through applications such as Grasshopper, and interdisciplinary work between professional computer programmers and architects, as ways of avoiding the drawbacks of relying on specific software. This approach can be found on a small and large scale: Bernard Caches has created open source programs to help small architectural practices develop large projects, Frank Gehry and Gehry Technologies have developed advanced software packages intended for use both in realizing house designs and in working as consultants.

The most widely used development of software today, driven on by the architecture and building industry, is the development of BIM (an acronym for building information modeling) technologies. The term, coined in conjunction with the construction of London’s Heathrow airport in 1986, was presented to the larger architectural community in 2002 by the Autodesk white paper entitled Building Information Modeling. Contrary to the expectations of Richard Garber, who anticipated the inclusion of parameters for material properties in the BIM databases and that BIM would make the intermediate step of the drawing redundant, BIM technologies are generally only used today for collision controls and for cost and time estimation of the construction phase in building. The development of BIM software has had a large impact on work flows and necessary understanding of computer interfaces required in the architectural practice. This has as yet not effected the actual built result where it is close to impossible to visually distinguish between an architectural project drawn in a BIM environment from a traditionally hand drawn project. BIM software also has not had a large impact on the way architects communicate their designs towards the building industry, (the majority of architectural projects are still communicated trough 2D drawings, mostly printed on paper). Regardless of these facts the notion that the digital age and its computing tools are in the process of reducing the importance of the drawing as the main way of communicating architectural designing, is still present both within the building industry and in the architectural research community. Mario Carpo argues that today’s architects are moving towards a position that is more akin to their pre-Renaissance and pre-projective drawing role. This transition is taking place due to the increasing usage of CAM (Computer aided manufacturing) fabrication methods as well as rapid prototyping of models using 3D printing techniques.
Kas Oosterhuis's description of the building of the Salt Water Pavilion\textsuperscript{18}, an early example of a building process in which the drawing had a subordinated role. A large number of more recent smaller scale projects that utilised direct communication between architect and the production machine can be found in Lisa Iwamotos book on digital fabrications\textsuperscript{19}.

**THE EVOLUTION OF ARCHITECTURE IN THE LIGHT OF SOCIETY AND THE SO CALLED MODERN CONDITION**

Among contemporary architects there appears to be a clear notion that architecture must respond and adapt to the current condition in society. The impact a globalized world and the possibilities of the internet, computer aided design as well as computer aided manufacturing of consumer goods have clearly affected architecture. Patrik Schumacher claims that we now live in a society\textsuperscript{20} where personal customisation of product is becoming an integral part of corporate imaging and globalized consumption patterns. Greg Lynn also takes up this advocacy of consumerist thoughts, as well as corporate branding in architecture, in *Embryologic Houses*, describing it “as a strategy for the invention of domestic space that engages contemporary issues of brand and variation customisation and continuity”\textsuperscript{21}.

Although the belief in the possibilities of creating curvilinear blobs was somewhat dampened by the dotcom crash at the beginning of the new millennium\textsuperscript{22}, the thoughts that the digital revolution must bear with it a new paradigm and visual style in architecture seems to have persisted. Malcolm McCullough (the first product manager for Autodesk Architecture) states that in the computer age, “it makes no more sense to design by drawing each line and modelling each surface than it does to drive a aeroplane down a highway”\textsuperscript{23}.

This sums up the idea that, using the computer, parts of the transition from idea to built matter can be atomised in an automated manner. In the parametric/algorithmic approach to the construction of complex forms using CAD/CAM (Computer aided Design/Computer Aided Manufacturing) the initial input of form and its creation is open. It can range from physical manipulations of material, such as in Frank Gherys designs process\textsuperscript{24} to a hand drawn sketch as in Toyo Iitos Mediatheque project\textsuperscript{25}, or even a non developable computer generated form as described by Helmut Pottmann in the book *Architectural Geometry*\textsuperscript{26}, the common idea being that the computer, through scripts (customized programs), can facilitate the division of a large whole into buildable parts by steering the tools to create the parts, as well as producing the structural calculations and instructions required to assemble them in an automated process.

**COMPUTER FACILITATED USER PARTICIPATION – A MORE DEMOCRATIC APPROACH IN DESIGN?**

A more philosophical approach to the implications of the computer age are the thoughts of Stephen Perrella and Bernad Cache\textsuperscript{27}. Both clearly express hopes that the user participation made possible by the parametric/algorithmic design process will facilitate a more democratic approach to the design, a process which ultimately could result in making the architect as a designer of form redundant. Michael Meredith expresses similar thoughts when he describes his own office as parametric, meaning a place where everybody’s different personal opinions are registered as parameters that affect the design process.\textsuperscript{28} M Meredith claims that this approach helps eradicating the traditional top-down hierarchical structures...
present in most practices. Meredith goes on to argue that parametricism has its potential not so much as a visual style but as being able to “produce a hyper inclusive network of parameters and relationships” thereby also producing broadly inclusive architectural designs.

THE FOLD THE FIELD AND THE RHIZOME

Throughout history critical reactions to the prevailing philosophy and form language in architecture appear to have been a driving force in finding new expressions and design methods. Today’s deconstructivist approach to architecture can be seen as a reaction to the Post Modern style, itself a criticism of Modernist ideology.

The concept of deconstruction was put forward by Jacques Derrida in his work *Grammatology.* Although Derrida tried to avoid classifying what deconstruction is, most simply it could be described as a critical outlook concerned with the relationship between text and meaning. Extracting (deconstructing) parts of a text, or in the case of architecture a built environment, and then placing them in a new context is seen to facilitate an alternative reading that is less dependent on the cultural values often unconsciously affecting human thinking.

In his text *Twisting the Separatrix* Jeff Kipnis claims that deconstruction within architecture can be produced through the use of an oblique (slanted) plane and by twisting the horizon and thereby altering the way we perceive our environment. (paratropic in Latin is the feminine form of the word separator as for example the horizon separates the earth from the sky) Kipnis exemplifies this by analysing Jacques Derrida’s, Peter Eisenman’s and Bernard Tschumi’s collaboration in the *Parc de la Villette* project in Paris. Towards the mid 1990s both Kipnis and Greg Lynn signaled a move away from the shredded forms of deconstructivism and towards a more seamless architectural style. In his book Lynn introduces this with an analogy between surfaces in architecture and culinary viscous mixtures, and continues by using the concept of the pliable found in Gilles Deleuze book *Le pili: Leibniz and the baroque* (1988). *Trans The Fold: Leibniz and the Baroque* 1993). In *Animate Form, published 1999*, Lynn continues to explore Deleuze’s re-reading of the Baroque and Leibniz theories of non-linear gravity, and their implications in architecture. Mario Carpo writes that Greg Lynn defines the new style of smooth transformations

as the almost inevitable, Hegelian resolution of the dialectical opposition between Post-Modernism and Deconstructivism. Lynn’s growing interest in deformation and the animation of form by folding and bending (also by external nonlinear forces such as wind and earth movements) foreshadowed a later interest in self orienting systems and forms created by the utilisation of material properties conjointly with digital fabrication methods.

In *Towards a New Architecture* Kipnis refers to *The Fold*, but also introduces the theory of the Rhizome presented by Deleuze in six points at the beginning of the essay *A Thousand Plateaus*. After reading this summary of the principles of the Rhizome it is easy to see that Kipnis, as early as 1993, anticipated what Mario Carpo calls the second age of digital smoothness, in which “the theoretical emphasis and radical experimentation of the first generation of digital designers are abandoned in favour of practices and elegant making…” Kipnis also anticipated Patrik Schumacher’s writings on Parametricism that define the five principles of parametricism, another link to Deleuze’s theory of the Rhizome. In *Towards a new Architecture* Kipnis considers both the material and the formal collage to be methods of form finding incapable of producing a new architecture. Instead, in referring to Lynns *The Folded, the Plant and the Supple* he looks to chaos theory, self orienting systems (exemplified by the pile of sand) and biology as inspirational fields for a new architecture.

Thoughts reflecting the growing interest in these fields (translated into topography) and commuter aided parametric/algebraic systems) at the beginning of the new millennium can be found in Carles Jenk’s *Nonlinear Architecture: New Science = New Architecture*. Here the title directly makes plain that architecture should take inspiration from new scientific findings. Jenks discusses nonlinear functions and their calculations, both in relation to architecture and to material performance.
Michael Hensel, Achim Menges and Michael Weinstock explored the biological aspect of self-orienting systems, the convergence of biomimetic engineering, architecture, emergence and material sciences. Their book, Emergence: Morphogenetic Design Strategies, starts with an often recurring reference to Frei Otto Frei and his material experiments, going on to argue for structural systems mimicking biological emergence implying that in architecture: “Emergence provides models for lifecycle and the way in which different lifecycles interact... This is the key to the understanding of densely occupied environments in which topological, structural and programmatic integration facilitates human activity.”

The growing interest in integrated systems in which unique individual parts seamlessly interact and adapt to create a greater entity is manifested in the AD issue on Elegance published in 2007. In Ali Rahim and Hina Jamelle present a project for a skyscraper in Dubai that uses a structural skin together with double twisting core. Every module in both the facade and core is unique. The project uses the same principles as those Patrick Schumacher used in describing, defining, and arguing for elegance in contemporary architecture. The same AD issue also has a text by Mark Foster Gage (Dna ex Machina: Semiology to the Elegance of Aesthetics) arguing that elegance is first achieved through the designer’s active manipulation of a parametric system. Foster Gage compares the process with mutations in gene theory. The idea that outside manipulation of an algorithmic /parametric system can be beneficial to the design is also endorsed by Jason Payne, who describes a creative parametric system can be beneficial to the design. Foster Gage compares the process with mutations in gene theory. The idea that outside manipulation of an algorithmic/parametric system can be beneficial to the design is also endorsed by Jason Payne, who describes a creative process in which the design is manipulated through a series of translations between digital and physical modeling. In this process initial forms are created in a digital environment and, utilizing rapid prototyping, are then transferred to physical models that can be manually manipulated. The design is then 3D scanned and further manipulated before being manufactured using advanced CAM techniques.

Formalism, Capitalism, Elegance and Beauty

Within the traditional architectural discourse formalism is often seen as something negative, this may explain why the Wikipedia article on formalism does not contain any reference to architecture, referring only to formalism within art, literature, poetry and film. Starting within deconstructivism the concept of formalism has become an integrated part of today’s computational architecture.

Michael Meredith states in the introducing essay to From Control to Design “like the other architects in this book, we’re guilty as charged: formalist.”

The processes leading to - as well as the end result of - today’s architects’ designs are strongly connected to the concept of architectural storytelling.

This in combination with the commercial approach mapped by Robert Venturi in Learning from Las Vegas where function is not readable in the façade can be seen as a starting point for endorsing the ideas of corporate branding and free market principles in architecture which has produced an architecture of the envelope. Inspiration for the process of finding the envelope’s form generally comes from other fields than architecture, such as topology, (illus. 25) biology, or even communication technology. At the start large amounts of data may be collected. The initial references or data can then be processed in several ways: through the deconstructivistic approach of scaling, summarised in a process of 2- or 3-dimensional diagramming, or manipulated through twisting, bending or folding. The aim of this process is generally to produce an abstract and non-referential form, with a new identity relating to the client’s or architect’s aims.
23. Example of a construction detail generated in an automated manner through a script.
Louis Vuitton Foundation 2014 by Frank Ghery. Photograph by F. L. for this thesis.

24. Example of a construction detail generated in an automated manner through a script.
Santa Caterina Market Barcelona, 2005 by Enric Miralles and Benedetta Tagliabue. Photograph by F. L. for this thesis.
The form then generally has to be tessellated, (illust. 21-22) that is it has to be divided into buildable parts and this process has over the last 20 years been dramatically simplified with the help of computers\(^6\). The choice of construction material, as well as different approaches to the process of subdivision (such as listed in the visual catalogue of Greg Lynn Studio)\(^6\), will produce different aesthetic results. Patric Schumacher maintains\(^6\) that total fluidity is achieved by dividing a form into parameterised objects, which automatically and seamlessly adapt to alterations and variations in the overall envelope (the initial form input).\(^6\) Schumacher goes on to say that only architecture with total fluidity, an architecture that mimics both the post-fordist information society and nature’s self orienting systems, can be considered to be contemporary and elegant\(^6\).

Greg Lynn, as well as Schumacher, argue that customisation is an integral part of the post industrial consumer society. Lynn also appreciates the aesthetic qualities of the creation of parameterised variations in a form through a given set of control points. In describing his Embryologic Houses he states that the project is: “most importantly an unapologetic investment in the contemporary beauty and voluptuous aesthetics of undulating surfaces...”\(^6\) The word beauty is otherwise often conceived of as problematic and intimately connected with the past. This point of view can be found in Sanford Kwinters conversation with Jason Payne\(^6\) as well as in Schumacher’s “Arguing for Elegance”. Stephens Nielson can be seen as an exception to this when he argues that both digital modelling and production: “enables the architect to bring ornament back to the table without a reliance on excessive labour or material wast...”\(^7\).


26. The textile membranes in the trusses of Grand Central, Birmingham, 2015 by architecture firm AZPM. The structure can be seen as a example of a self organizing system. Photograph by F.L for this thesis

27. Louis Vuitton Foundation, Paris, 1915 by F. Ghery. Similarities in surface handling between this building and the Guggenheim Museum in Bilbao (see Illust. 29) can be seen as branding by the architect. Photograph by F.L for this thesis


64  Visual Catalogue of Greg Lynn studio at The University of Applied Art in Vienna
DISCUSSION

What is the relevance of Art Nouveau today? What are the similarities and differences between the architecture of the Art Nouveau period and today’s curvilinear architecture and can we learn anything from the Art Nouveau period today?

ARCHITECTURE AND SOCIETY

Art Nouveau architecture was born out of an industrialised society. At the end the 19th century the initial upheavals of industrialisation were maturing, and the resulting, industrialised society, and largely unregulated capitalist economy, became apparent. The middle class bourgeoisie as well as the working class were both, in different ways, coming to the realization that the industrial revolution and the laissez-faire economy had produced a society of extreme inequality.

This may be compared with today’s globalisation of the economy, with free market mechanisms and multinational companies enjoying unprecedented power. The contemporary ideology of consumerism, encouraging the personal acquisition of goods and services, is a driving factor in the global economy. Globalised news networks have moved the social conscience of global economic inequality, with labourers in developing countries being subjected to atrocious working conditions, straight into our living rooms. Although perhaps not as obviously visible on the streets of western cities as they were 120 years ago, these inequalities are nonetheless present.

Within the Art Nouveau movement the results of industrial society were strongly criticised. This critique included both the mass production of objects and the transformation of the craftsman into a non-creative machine operator. Art Nouveau architects and theoreticians wished to raise the value of craftsmanship. Inspiration for this revival was taken from the Pre-renaissance gothic and medieval period. In practice this resulted in two approaches to design. Either the design was made specifically for a project with an individual in mind, resulting in a unique design that could not be produced industrially, alternatively the design was produced in an industrial process that required extensive knowledge and skill in order to achieve the desired result. In the concept of the Gesamtkunstwerk the architect, although seldom directly involved in production, was seen as a guarantor of craftsmanship. Thus Victor Horta, for example, was present on the workspace overseeing the execution of his Hotel Tassel.

In this context it is interesting to draw parallels with the discussion in Mario Carpo’s The art of Drawing in which he argues that the computer, together with CAM manufacturing techniques, is enabling architecture to become more than the art of drawing. Referring to the pre-Renaissance state of architecture Carpo writes that “…architecture was a mechanical craft, and buildings were conceived and made by artisan workers”, suggesting that a more direct link between the architect and the built result may be beneficial. A similar point of view is expressed by Richard Gruber in his essay on BIM (Building information modelling).

Art Nouveau architects showed their opposition to the poverty and poor working conditions in society by trying to present possible alternatives in their designs. This took its form in the idealisation of nature and the human body. The holistic interpretation of nature that is found in Art Nouveau and early expressionist designs contrasted with the fragmentation of society. The idea of art as fostering society, as well as the artist being seen as a progressive genius or prophet, engendered the will to create designs communicating idealised beauty.

This approach in many ways differs from today’s design strategies in which the tendency to visualise the current condition of society seems to predominate over strategies contrasting with the current condition in society.

While the Art Nouveau movement generally used references from the organic world in a holistic manner, within the computational design discourse it is possible to detect an atomistic viewing point in references both to earlier historic styles and to nature. An example for this might be Mario Carpo’s referring to a microscopic picture of the Geranium stem as a perfect illustration of self-organizing structures within architecture.

Another example might be found in Frank Gehry’s reference to the Renaissance handling of fabric. Gehry focuses on a small part of Michelangelo’s sculptures and makes it the central design of a building. These atomistic readings of references can be seen as relating to Jacques Derrida’s philosophy of deconstruction and Gilles Deleuze rhizome theory, both of which emphasise the importance of individual parts and their organisation in relation to the whole.

Antoine Picon argues that the movement, shock and fluidity of contemporary society has and will produce an architecture of fluidity and shock. It is interesting to note that a very similar argument has been used by K Sembach and J Schmidtulzer separately in their explanations for the curvature of the Art Nouveau movement. They see the Art Nouveau style as a result of the new technical possibilities of the early

1 The example for comparison of the 2013 Savar building collapse in Bangladesh
3 The woodworks of Alexandre Charpentiers studio as well as Viktor Hortas iron works in Hotell Tassel can be seen as an example of this approach.
4 This approach in many ways differs from today’s design strategies in which the tendency to visualise the current condition of society seems to predominate over strategies contrasting with the current condition in society.
6 In which he
7 Richard Gruber. Building Information Modelling. All March April 2010
8 Richard Kennedy (1952) examining the Appeal of Art
12 Antoine Picon
20th century, such as moving pictures and mass transportation. These two examples clearly illustrate how a relatively similar condition in society can generate two quite different ideologies and approaches on how to handle influences within society. Design strategies visualising the fluidity of the globalised society in design can be found in the blurring of borders between spaces and functions advocated by Patrick Schumacher. A response to contemporary society can also be seen in Lars Spuybroek’s and Kas Oosterhuis’s project for fresh- and saltwater pavilions. The interaction between the visitor and building relates to their interpretation of contemporary society.

Both Michael Meredith’s essay Never enough (transform repeat ad nauseam) and Robert Somol’s description of Ron Witte’s IntraCenter: “the organisational mimeticism of the Intra centre produces the perpetual effect that wherever you go, you are sure to be somewhere else” the interest contemporary computational architecture has in creating spaces that produce effects of disorientation. The endeavor in architecture today, of seeking to mirror the liquid condition of today’s society, may possibly explain its tendency of omitting familiar references (discussed in chapter 2) as well as of using curves without apparent endings (discussed in chapter 3).

The will to break taboos and borders has a long history, especially in conceptual art.

Within the contemporary reading and reinterpretation of modern society one can see a tendency to push beyond conceptual and factual borders. Alistair Robinson gives voice to this in his explanation of the Danish designer Mathias Bengtsson’s design strategy, saying that Bengtsson’s aim is to give life to what we could not previously have been thought possible. The propensity for extreme effects is also taken up by Helene Furjan in her description of contemporary architecture, and the influences of interactive media on it, as: “flood the visual field with information, demanding, as a result, ...an absorption that pushes perception to its limits.”

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Similar tendencies can be seen in early in Art Nouveau designs such as the facade of Jules Lavirotte’s 29 Avenue Rapp apartment development, and of Castel Beranger, the first apartment house by Hector Guimard, where the use of ornament and new materials created a shock effect. Within Art Nouveau this tendency relatively quickly lost relevance as the style matured, as exemplified by Guimard’s removal of the tower on his Castel Henriette villa (1899) that he had drawn a few years earlier. Within the expressionist movement and the period during WW1, when there was little building activity, architecture shifted towards a more theoretical discourse. Both Hermann Finsterlin’s and Fredrick Kiesler’s utopian designs -most of which at the time were technically unrealizable- can be seen as paving the way for pushing conceptual boundaries forward. In this aim and in the aim of mirroring the fluid / liquid conditions of contemporary society I see a possible explanation for the tendencies of omission of familiar references I discuss in chapter 2 and the tendency to use curves without apparent endings as discussed in chapter 3.

Uniqueness and customization in architecture and design became a selling factor to the expanding bourgeoisie of Europe’s cities during the Art Nouveau period. The periods elaborate and exclusive designs resulted, however, in a discrepancy between the ideology and the clientele of the Art Nouveau style, i.e. in a disconnection between society and the style. This may have led to the style itself being seen as disconnected and distastefully excessive and possibly also to Bruno Taut’s and Henry van der Velde’s later attempts at finding a new and socially relevant architectural style after the end of WW1 and to Hector Guimards experiments with rapid house fabrication. Possibly there are lessons to be learned here from the Art Nouveau period?

Contemporary computer aided design and manufacturing can be seen to have resulted in designs that often are relatively exclusive and, due to production costs, aimed at a small initiated intellectual audience. Architecture critic Ellis Woodman, in an online article on Zaha Hadid’s Serpentine Sackler pavilion, compares the building with a super yacht shop, a place selling products completely out of reach for the majority of society. Within architectural theory Deconstructivism has received a critic in Kenneth Framton, who calls it “elitist and detached”.

In relation to labour skills Greg Lyn points out that today all larger curvilinear structures made with CAM manufactured parts are assembled with millimetre precision by highly educated engineers.

From another standpoint Bernad Cache sees CAM production methods, together with personal customization through designed parameters, as a means of producing a more democratic design practice that allows the inclusion of a wide array of values and points of view.

Contemporary computational design discourse in both ideology and design draws references from many earlier historic periods with Antoine Picon specially emphasizing the importance of the Baroque period and Gilles Deleuze’s rereading of it. Gothic architecture is also used; references to it can, for example, be found in Santiago Calatrava’s Attium of Brookfield Place, Toronto. Although references to Art Nouveau architecture do occur -as in some projects by for example Gage / Clemente Architects, and IAMZ Design studio- interest in this period within computational design theory appears to focus on Gaudí’s research in parametric control of catenary arches. There is little evidence of an interest in manifestations of the Art Nouveau period’s ideals of beauty, as well as the concept of Gesamtkunstwerk.

33. Detail of fabric in sculpture of the Greek goddess, probably Nyx, 1 or 2 century BC, National Archeological Museum, Naples. Photograph by F. Latz

34. Creased fabric on a very large scale, 8 Spruce Street, New York City, 1912 by Frank Gehry. 2012 Titanium and Glass exterior, 76 stories. Image licensed under Creative Commons by Dbox
II

TRANSLATION ABSTRACTION AND SCALE
Translation Abstraction and Scale

This study has four parts:

Part 1
Translating photographs of buildings to large scale hand drawn elevations using pencil and chalk crayon. This study has been conducted by a trial and error method, using the paper as a palimpsest where multiple versions are drawn and erased before arriving at an acceptably correct translation. By hand drawing the photographed building, without using a tracing table or architectural drawings, the buildings’ designs are translated into a personal experience.

Part 2
Tracing hand drawings with the computer, thereby creating reduced line and surface drawings that define structure, ornament, scale and points of recognition.

Part 3
Translating line drawings into 3D computer models in order to visualise the complete building in relation to its parts as well as the connection between structure and ornament.

Part 4
Design studies to find transition points where abstraction and reduction affect the design, made as described in part 1 but starting with a sketch instead of a photograph. The designs were then processed as in part 3 and 4. Key models were also 3D printed to enable physical and tactile understanding.

Interimiate scale
The intermediate scale is the scale connecting the scale of detailing with the overall scale of the building. I see this scale as representing a human scale in that it allows the human body to relate to architecture. The scale of detail is tactile – it can be explored and felt by the hand. The intermediate scale enables the eye to continue the exploration of the hand to the entire building, thereby joining detailing with the scale of the building. A fine example of this use of the intermediate scale can be seen in the ornamentation around the entrances in illus. 36 and 37 where the form of the ornaments above the door is taken up in a larger ornament spanning the first three floors with a similar, but mirrored, geometry.

Familiar references
By familiar references I mean the use in architecture of elements such as windows and doors, that are familiar in that they are features continuing earlier (often renaissance and gothic) building traditions. Even the most outlandish Art Nouveau designs (such as the facades of Gaudí’s Casa Batlló and Sagrada Familia) use traditional window and door formations as well as a familiar overall building geometry. The use of such familiar references is also applicable to built Expressionist architecture, such as Steiner’s first and second Goetheanum and Mendelsohn’s Einstein tower. They are, however, absent in projects that were not realized such as Finsterlin’s house designs. (illus. 14)

Combining form and function
Luis Sullivan is credited with being one of the first architects to claim that form follows function. This is hardly a coincidence. The idea that ornament and function can be combined into a totality is very apparent in Art Nouveau projects. Brilliant examples are the window sills of Hector Guimard (illus. 42) which have been given a form that allows water to drain off in a controlled manner without staining the facade. The form of the window sill is also an ornament interacting with both the abstract ornamentation above the window and the form of the window mullions. Another example of this merging of ornament and function is Pont de Bir-Hakeim. (Illus 61-63)

Here the form of the columns is not only structurally relevant but also creates a beautiful space under the bridge. In the visible structure of the Salle de concerts Humbert-de-Romans by Guimard (illus 64-69) the structure and ornamentation merge to form a Gesamtkunstwerk. The combining of form and function, ornament and structure can also be seen in Ernst Hecher’s balcony supports in his Rue Agar apartment development in Paris. (Illus. 79)
Can similar tendencies be found in contemporary curvilinear designs as those found in the Art Nouveau period?

Intermediate scale

In contemporary curvilinear computer aided design a possible tendency to omit or, in any case to reduce, the importance of the intermediate scale can be observed. In agreement with Ellis Woodman, I find not only the scale of the detail, but also any familiar objects in the intermediate scale, are completely omitted in many contemporary buildings such as Lars Spuybroek’s and Koen Oosterhuis’s project for fresh- and saltwater pavilions. I found that some contemporary curvilinear buildings, such as Hadid’s Serpentine Sackler Gallery, are actually totally without scale. This became evident in the process of translating photographs of these buildings to drawings. It was exceedingly difficult to find references in the actual building itself, making it impossible to draw to the correct scale. Instead the surrounding buildings, or people present in the photograph, needed to be used as a measurement of scale. Clearly this omission of intermediate scale can only be seen as a tendency as there are many examples of the opposite. Calatrava’s architecture, for instance, draws reference from the gothic period and makes use of the intermediate scale, as seen in the detailing of his Gare de Lyon Saint-Exupéry railway station. (Illust. 72-76)

Familiar references

In contemporary curvilinear designs traditional windows and doors seem to have become less important. Windows and especially doors in their traditional form are often handled as if they were inserted at the last moment and not integrated into the design. An example in which this is obvious are the door and windows of the Poppenbüttel bus terminal in Hamburg by Blunck-Morgen Architekten. The tendency can also be seen in the doors of the Serpentine Sackler Gallery by Hadid. Greg Lynn has pointed out that the evolution of the digital design discourse has seen different paradigms, or design strategies, in how daylight is let into the building. Lyn sees an early handling of the problem in the practice of the replacing the non see-through panels of a tessellated surface with glass panels where daylight is needed. Alternatively light is led to enter at an angle using the louvre, such as in the Basel switching tower by Herzog & De Meuron and Greg Lynns embryonic houses, as well as his Presbyterian church. The use of perforated panels forming a second layer of tessellation is seen as a third approach which has gained importance in more recent years, an example being La Philharmonie de Paris, by Jean Nouvel. (Illust. 21-22)

Combining form and function

The idea of combining structure and ornament is still present in today’s discourse. Schumacher argues for it in writing: the membranes of the Serpentine Sackler Gallery can be seen as a built example. The architecture of Santiago Calatrava also shows structure becoming ornament. There are, however, also many projects in which the structure is hidden i.e. not evident in the actual design. In the Qatar Education City by Arata Isozaki, for example, the structure -consisting of straight bolted beam sections- is completely covered by cladding. This is also true of Hadid’s Heydar Aliyev Centre in Baku in which the curvilinear outer form consists of panels resting on, and completely concealing, a rectilinear steel grid.

1 In this 2012 BD online article on Zaha Hadids Serpentine Sackler pavilion see http://www.bdonline.co.uk/
26

EXPLANATION FOR TERMS USED IN DRAWN STUDY

**Axis**
The blue vertical lines show mirroring axes in the building, thick lines represent major axis’s, thin lines secondary and local axis’s.

**Curvature and Radius**
This study is focused on the relationship between the different radii used in the building. If the geometry is built up of splines I have tried to estimate the point where the radius changes from larger to smaller.

Curves marked in red have a radius with a diameter that is at least a third smaller than the adjacent radius on the same curve, or if there is no connection, has a radius that is half the size of the meridian of the building’s larger radiiuses.

Curves marked in green have a radius that is at least a third larger than the adjacent radius on the same curve or, if there is no connecting curve, has a radius that is double the size of the meridian of the building’s larger radiiuses.

**Ornamentation - Defining the level and scale of ornamentation**
Ornamentation is divided into three levels

**Global ornaments**
Global ornaments imply a formation stretching over a minimum of 60% of the visible building or facades. Minimum length or diameter of the form or ornament is 4m.

**Local ornaments**
Local ornamentation applied on a local scale round a building feature such as a window or door. Minimum length or diameter of the form or ornament is 1m

**Macro ornaments**
Ornamentation within a global or local orientation or as freestanding objects; Maximum diameter or length of the form or ornament is 0,5 m

**Surfaces**
Concave surfaces are marked in blue
Convex surfaces are marked in red
Double-curved surfaces are marked with a darker nuance of the relevant colour

FACADE

Period 1880-1920

**Architect/Office**
Name: Hector Guimard
Date of birth: 1867-1942
Country and town of principal residence: France, Paris

**Studied Object**
Name and type of building: Immeuble Trémois,
Function: Apartment housing
Location: Rue Agar Paris
Completed: 1909
Materials used: Sandstone, Brick
Aspects studied: Facade

37. Detail of entrance to Immeuble Trémois, rue Agar Paris 1912 by Hector Guimard. Photograph by F L. for this thesis.
Surfaces

38. Surface and detail analysis, Immeuble Trémois, rue Agar, Paris, 1912 by H. Guimard.
Overlay of hand drawing in Autodesk AutoCAD processed in an Adobe Illustrator by the author

- Concave
- Convex
- Coarse detailing/ornamentation
- Medium detailing/ornamentation
- Fine detailing/ornamentation


ARCHITECT/Office
Name: Hector Guimard
Date of birth: 1867-1942
Country and town of principal residence: France, Paris

STUDIED OBJECT
Name building: Hôtel Mezzara,
Function: Private residence
Location: Paris France
Completed: 1910-1911
Materials used: Brick, Sandstone, Wood, Iron
Aspects studied: Interiors and Facade

43. Facade of Hôtel Mezzara, 60 rue Jean-de-La-Fontaine, Paris, 1910, by H. Guimard. Scale 1:50 pencil and chalk on paper by the author

44. 2D CAD drawing of facade of Hôtel Mezzara, 60 rue Jean-de-La-Fontaine, Paris, 1910, by H. Guimard. AutoCAD Auto C-A-D drawing by the author
FACADE
Period 1980-2020

ARCHITECT/ OFFICE
Name: UNStudio, Ben van Berkel and Caroline Bos
Date of birth: Ben van Berkel 1952, Caroline Bos 1959
Country and town of principal residence: Holland, Amsterdam

STUDIED OBJECT
Name and type of building: Le Toison D’or
Function: Mixed use high end retail, housing and parking
Location: Avenue Toison d’Or, Brussels, Belgium
Completed: 2009
Materials used: Glass-fiber reinforced concrete.
Aspects studied: Facade

47. Facade of Le Toison D’or, 2013, by UN Studio.
Photograph by F.L. for this thesis.

48. Surface and detail analysis of Le Toison D’or.
Overlay of hand drawing in AutoCAD and Adobe Illustrator by the author.
49. 2D Curvature analysis of Le Toison D’or. Overlay of hand drawing in Autodesk AutoCAD processed in and Adobe Illustrator by the author.

- Small radius
- Large radius
- Straight

50. Detail of facade of Le Toison D’or, 2013, by UN Studios. Photograph by F.L for this thesis.

51. Detail of facade of Le Toison D’or, 2013, by UN Studios. Photograph by F.L for this thesis.
52. Hand drawing in scale 1:50 of facade of Le Toison D’or.
Pencil and chalk on paper by the author.

53. Three dimensional curvature analysis of Le Toison D’or.
3D line drawing in Vectorworks 3D software processed in and Adobe Illustrator by the author.
**ARCHITECT/OFFICE**
Name: Henry van de Velde  
Date of birth: 1863-1957  
Country and town of principal residence: Germany, Weimar

**STUDIED OBJECT**
Name of building: Werkbund-Theater  
Function: Theatre for the 1914 Cologne Werbund exhibition  
Location: Cologne, Germany  
Completed: 1914  
Materials used: Rendered bricks, Steel  
Aspects studied: Curvature, Volymes, Surfaces

54. Front facade of Werkbund Theater, Cologne, 1913, by H. van der Velde.  
Photographed by Deutsche Werkbund around 1920  
Image courtesy Werkbundarchiv at the Museum der Dinge, Berlin

55. Surface and detail analysis of Werkbund Theater, Cologne, 1913, by H. van der Velde.  
Overlay of hand drawing in Autodesk Auto CAD processed in an Adobe Illustrator by the author
Curves

56. Two dimensional curvature analysis of the Werkbund Theatre Overlay of hand drawing in AutoCAD AutoCAD processed in an Adobe Illustrator by the author.


59. Facade of Werkbund-Theater, hand drawing in scale 1:50
Pencil and chalk on paper by the author

60. Three dimensional volume and curvature analysis of Werkbund Theatre
3d line drawing in Rhino/3D software processed in an Adobe Illustrator by the author
STRUCTURE

ARCHITECT/Office
Name: Jean-Camille Formigé
Date of birth: 1845-1926
Country and town of principal residence: France, Paris

STUDIED OBJECT
Name and type of building: Pont de Bir-Hakeim, formerly the Pont de Passy
Function: Underground bridge
Completed: 1913
Materials used: Steel, Sandstone
Aspects studied: Structure
63. Structure of Pont de Bir-Hakeim, formerly the Pont de Passy, drawn by Camille Formigé. Hand drawing in scale 1:20 Pencil and chalk on paper by the author.

64. Three dimensional structural analysis of Pont de Bir-Hakeim, formerly the Pont de Passy, drawn by Camille Formigé. 3D model in Rhinoceros 3D software processed in Adobe Illustrator by the author.
ARCHITECT/OFFICE
Name: Hector Guimard
Date of birth: 1867-1942
Country and town of principal residence: France, Paris

STUDIED OBJECT
Name and type of building: Salle de concerts Humbert-de-Romans
Function: Concert hall
Location: Paris
Completed: 1898-1905
Materials used, facade: Sandstone, Brick. Structure: Wood
Aspects studied: Structure

Hand drawing in scale 1:50, pencil and chalk on paper by the author
66. Three dimensional structural analysis of Salle de concerts Humbert-de-Romans, Paris. 3D model in Rhinoceros 3D software processed in an Adobe Illustrator by the author.

67. The structure of Salle de concerts Humbert-de-Romans, drawing by Hector Guimard. Archives of Cooper Hewitt, Smithsonian Design Museum.

68. Photograph of the façade, Salle de concerts Humbert-de-Romans, Paris, by H. Guimard. Archives of Cooper Hewitt, Smithsonian Design Museum.
69. Three-dimensional curvature analysis of Salle de concerts Humbert-de-Romans.  
3D line drawing in Rhinoceros 3D software processed in an Adobe Illustrator by the author.

70. Interior photograph of the Salle de concerts Humbert-de-Romans, Paris, 1901, by H. Guimard.  
Postcard from 1902.
Period 1980-2020

ARCHITECT/OFFICE
Name: Santiago Calatrava
Date of birth: 1951-
Country and town of principal residence: Spain, Valencia

STUDIED OBJECT
Name and type of building: Gare de Lyon Saint-Exupéry,
Function: Railway station
Location: Lyon France
Completed: 1994
Materials used: Concrete, Steel
Aspects studied: Structure

72. Two dimensional Curvature analysis of Gare de Lyon Saint-Exupéry, 1994, by Santiago Calatrava.
Overlay of hand drawing in AutoDesk AutoCAD processed in Adobe Illustrator by the author
73. Three-dimensional structural analysis of Gare de Lyon Saint-Exupéry. 3D model in Rhinoceros 3D software processed in Adobe Illustrator by the author.

74. Structure and facade of Gare de Lyon Saint-Exupéry, hand drawing in scale 1:50. Pencil and chalk on paper by the author.
75. Gare de Lyon Saint-Exupéry, Lyon, 1994, by Santiago Calatrava.
Photograph by F. L., for this thesis.

76. Platform canopy, Gare de Lyon Saint-Exupéry, 1994, Santiago Calatrava.
Photograph by F. L., for this thesis.
ART NOUVEAU, EXPRESSIONISM, ORNAMENT AND THE REDUCTION OF SCALE

Defining simplification and abstraction
Abstraction implies the re-working of reality into a new entity that relates to reality, but does not literally depict it. Abstraction and simplification are often thought of as closely related. A combination of both abstraction and simplification, which might be seen as a tree, is a vertical line intersecting a circle. Although abstraction most often means simplification, this is not always the case.

Drawing a tree realistically will result in both an abstraction and a simplification of reality. A painting of the same tree, using the form language of cubism, will almost certainly be more complex than the realistic drawing. The abstraction of an object can be conducted without simplifying it.

Simplification is usually achieved through reduction. Yet reduction, by definition, does not in itself result in abstraction. A tree, in a reduced form, might be shown by drawing its realistic contours as a single line. Although this might seem to be an abstraction, in fact the only operation carried out by removing all lines other than that of the tree’s contours has been simplification.

It is only when (in this example) the contour line is re-drawn using a different geometry than that of the original object (the tree) that abstraction has taken place. An abstraction (which probably would not be recognised as a tree) might be a rectangle rotated 45 degrees. If the rectangle were filled with innumerable curved lines and small circles (branches and leaves) the image created is certainly more complex, and less realistic, than a single line tree contour.

77-80 Piet Mondrian (1872-1944) The tree abstractions can be seen as an example of abstraction without reduction.
HOW DO ABSTRACTION AND SIMPLIFICATION AND REDUCTION RELATE TO ARCHITECTURE?

It must first be stated that drawings of three-dimensional objects on two-dimensional paper will always produce a degree of abstraction. Drawing the majority of objects in scale 1:1 will most probably also include a large portion of simplification and reduction. Drawing at scales smaller than that, for example in 1:20 or 1:100, will require an even larger degree of reduction, simplification and abstraction.

Gothic design was produced by the master-builders’ thoughts of an abstract ideal building. This concept was then communicated by means of geometry, proportions and models to the workforce, a way of building that made it possible for the master to add or subtract material and alter proportions during the building process.

It was not until the early Renaissance that it became normative to draw buildings first, before construction. An explanation for the relative flatness commonly found in later Renaissance architecture might be found in the abstraction, simplification and reduction required by the process of drawing three-dimensional structures on two-dimensional paper. In Gothic architecture there were no drawings and thus no need for this kind of simplification.

Ever since the Renaissance objects that are not visible on an over-view small scale drawing (e.g. 1:100) have generally been drawn separately to a legible larger scale such as 1:10. This process of drawing details separately will result in an urge to re-use the drawing, and thus repeat using the detail in a structure instead of drawing innumerable new details.

In the middle of the 19th century a common library of published detail drawings, in varying scales, existed within the architectural trade. The mixing of these details from different periods -and their application to relatively flat facades- resulted in eclecticism. It is important to note that Renaissance re-interpretations of the classical form-language, which were the basis of the eclectic library, did not involve a great degree of reduction, simplification or abstraction.
FORM, FUNCTION, SIMPLIFICATION, ABSTRACTION AND ORNAMENTS IN ART NOUVEAU

Art Nouveau design and architecture added a new chapter to the library of ornament. Within the Art Nouveau style ornaments of all scales were developed, but ornaments containing multiple scales were favoured. The concept of combining ornament with function cannot be ascribed to Art Nouveau yet it nevertheless formed a central part of the movement. Examples of this can be seen in Ernest Hecher’s balcony supports in Rue Agar (illust. 81), Paris, as well as in Guimard’s balcony grilles (illust. 42). Art Nouveau designers were also the first to utilize the effects of artificial lighting. A combining of ornament and function, where the primary function gives an additional dimension to the ornament, can be seen in lamp designs by François-Raoul Larche and Peter Behrens (illust. 82).

Art Nouveau artists, designers and architects took inspiration from nature and movement, both movement within nature and movements created by man. Early Art Nouveau designers studied animals and plants and re-drew them as realistic ornaments with or without function. Using natural forms in design must have raised the questions of simplification and reduction. Drawing realistic movement poses even greater problems since trying to show movement in static designs always necessitates abstraction. The most common procedure in the abstraction of movement realistically is freezing it in time. The invention and popularization of the camera rapidly made the practice of freezing objects and movements in two-dimensional representations commonplace. These frozen movements were then transformed into three-dimensional sculptures. Examples of this practice are the porcelain sculptures of dancing women by Agathon Leonard (1841-1923) (illust. 83). The long flowing hair of the idealised feminine figure, a recurring feature in Art Nouveau, was most often simplified and abstracted, its movements only being shown by using simplified splinar geometry.

Applying this geometry of movement to architectural design might, more or less consciously, have prompted architects to move towards the abstraction of three-dimensional form. Henri van der Velde was the first architect who in text argued for abstraction. He claimed that nature itself produced abstract forms without direct meaning. Van der Velde took nature’s forming of sand, by waves and wind, and the curvature of rising smoke as examples of this abstraction. He argued that architects must take inspiration from nature and its formative processes, but without depicting them literally. Although he argued for abstraction he did not, initially, argue for reduction or simplification. Van der Velde’s candlestick design (illust. 85) can be seen as an abstraction of growth and movement through abstraction. However the candlestick’s geometry and surfacing are not reduced or simplified when compared to other contemporary realistically inspired designs. (illust. 82)
The front figures of Art Nouveau architecture, such as Guimard’s, Van der Velde and Mackintosh, all moved towards abstraction of nature by deploying varying degrees of simplification. Usually this was done by the reduction of secondary curvature and by idealization of their sources of design inspiration. Simplification through idealised abstraction was principally not carried out by a reduction in the use of scales.

Until around 1912 Art Nouveau architects used all the scales of the classical and gothic libraries, often creating structures and ornaments by combining the scales of the human hand with the global building scale. A typical example of the use of both these scales in a realistic ornament can be seen in the climbing plants on Jules Lavirotte’s facades (illus.84). An idealised abstracted design using the same scales can be found in the rose design of Charles Rennie Mackintosh (1868-1928) in which a long global curve ends in a small scale focal point, formed as a rose (illus. 86).

The reduction of scales accelerated after 1910. In Van der Velde’s Werkbund Theatre for the 1914 Köln exhibition (illus. xx) the small and intermediate ornamental scale is much reduced and concentrated to three focal-points. The emphasis moved towards the use of the surface as a means of expression, a tendency clearly seen in Guimard’s facade designs for the Paris Rue Agar apartment development built in 1912. (illus. 36-42)

The Expressionist movement -simultaneously with the early modernists- used reduction as a means of abstraction. Expressionist design theory made little or no use of small scale ornamentation, concentrating instead on the form of the actual building and merging the intermediate scaled ornament, or surface, into a complete object that combined form and function. (illus. 81, 85) In contrast to the functionalist approach to abstraction, by reduction of all form without materialistic function, the expressionists built along the principle of abstracting nature through idealization. They also tried to create buildings that produced different affects or feelings, along lines similar to the Art Nouveau concept of the Gesamtkunstwerk.

The needs of the post WW1 economy fostered rationalisation and abstraction. Economic realities and functionalist abstraction seem to have cemented a form language of reduction in which small and intermediate scales in ornament and building were lost. This further reduction of form and of all non-functional elements in architecture also led to the loss of the scale of the human body. It is interesting to contrast this development with the process of abstraction and reduction that occurred within painting - where the height of abstraction and reduction to minimalism is generally considered to have been reached by Malevich in his Black square painting (illus.87) from 1923.

1 Wolfgang Pehnt (1973) Expressionist Architecture
DRAWN STUDY IN ABSTRACTION AND INTERMEDIATE SCALE
Tree column

This study explores scale and the repetition of geometrical features at different scales.

The practice of using a geometrical feature – a gable roof truss for example – to frame an important object has a long history beginning with the concept of the Aedicula in Roman architecture. In gothic architecture religious figures were often placed within smaller arches using the same geometry as the larger structure of the building (illustr. 88). The concept has been studied by Dirk Somers at the architecture section of Delft University of Technology.

The overall geometry of the complete column, with outward extending branches and roots, is seen in a smaller scale in the individual line endings of the veins following the branches of the column. The sequence of columns starts with a mood drawing of a forest (illustr. 89). Through a process of abstraction by reduction and simplification the sequence moves from complexity to simplicity. Looking at the first drawing, that has strong associations to a tree with its many weaving branches, and comparing it to the last drawing, of a smooth column where the reference to a forest is hard to find, it is apparent that somewhere in the process certain qualities are lost. The big question for me is where to halt the process of abstraction and reduction, a question to which there are, of course, different answers depending on the project brief. I find that the biggest transition in form happens between the column’s in illustrations 93 and 94.

2 Sommers works within the studio Interiors Buildings Cities for more information see http://www.tudelft-architecture.nl/chairs/interiors-buildings-cities/research

88. Strasbourg Cathedral façade: In gothic architecture religious figures were often placed within smaller arches using the same geometry as the larger structure of the building. Photograph by F. L. for this thesis

89. Forest. Pencil and chalk on paper by the author
Column series
Pencil and chalk on paper by the author
96-97 Column series. Line drawings from 3D models
98. 3D printed model.
Construction Technique

The column is constructed in hollow cast iron segments. Cast iron can withstand strong compression but is prone to cracking in tension. Therefore, the segments are made hollow to allow for a steel cable to be threaded through them. The cable, which can take tension well, is then tightened. This compresses the iron segments and enables the parts of the column in tension to become stable and also allow for a degree of shear forces to be absorbed. The cast iron segments manufactured in 3D printed sand forms allow the segments to be cast in one piece with a bent hollow core. The ends of the segments are precision machined into two conical connection pieces for a tight fit, see illust. 99.

References and Geometry

References can be found in the cast iron column heads of Viktor Horta’s Waucquez textile warehouse, Brussels 1903-1906 (illust.101) and in the lamp post placed in the middle of its entrance hall (illust. 103). The construction and joinery method of the column have references to H. Giomard’s cast iron Paris metro entrances (illust. 104) that were cast from handmade wood models by the St Denize foundry.

The contrasting contemporary references are to columns of the Fira expedition hall in Barcelona by Toyo Ito (image 105) and Qatar Education City by Arata Isozaki. (image 106) The latter project uses a similar overall geometry and starting point (a tree). However it seems to me that the intermediate and small scales are not present in the design. The geometry of the column design is based on a form inspired by the contours of a leaf.

Photograph by F.L., for this thesis.

102. Ironwork holding up the balcony of Viktor Horta's studio, now the Horta Museum.
Photograph by F.L., for this thesis.

103. Lamppost in the center of Waucquez textile warehouse, Brussels, 1903-1906, by V. Horta.
Photograph by F.L., for this thesis.

104. Paris metro entrance lamp post, designed by H. Guimard, made in cast iron and cast from handmade wood models.
Photograph by F.L., for this thesis.
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105. Five Exhibition Centre, in Barcelona, 2010, by Toyo Ito
Photograph by F.L. for this thesis

Image licensed under Creative Commons by Trinidade

107. Reference to Column design, Santa Caterina Market, Barcelona, 2005
by Enric Miralles and Benedetta Tagliabue
Photograph by F.L. for this thesis

108. Wooden columns used in restoration of Koldinghus, Denmark, 1972-1992 by Inger and Johannes Ecker: a reference for column design in this study.
Photograph by F.L. for this thesis
Studies of dome structure, starting with an unornamented sphere and ending in an ornamented dome, in which ornaments and structure are blended together.
Pencil and chalk on paper by the author.
Final dome translated into 3D model.
Line drawings from 3D models
III

Curve Geometries
III

CURVE GEOMETRIES

This chapter is a study of curve geometries used in architecture in the Art Nouveau and Contemporary periods. It includes historical background, illustrations of the different geometries used, and my own drawings.

By first tracing line geometry, both by hand and using digital tools, and then colour coding different radii I have studied their relationship to adjacent lines and radii. I have then analysed the different geometries by drawing them as abstract lines not relating to any specific building.

![Image of line geometries]

134. Comparison of tendency of different line endings. The right lines have a geometry that allows the eye travel beyond the ending of the line. The left geometry lets the eye come to rest at the end of the line.

Drawn by FL.
Retracing the lines of Art Nouveau buildings has allowed me to identify a characteristic formal language the geometries of which can be used to create new designs with formal similarities to designs of the Art Nouveau period. My review of today’s computer-aided curvilinear designs has not revealed any such formal language.

The contemporary computational design discourse, and the forms and geometries generated by it, seem to have a considerably wider geometric language than that of the Art Nouveau period. A connection between the variations in form language and their regional or national origins is not apparent. Instead it seems possible to ascribe the diversity of forms to different architects’ offices and philosophical approaches. As discussed in chapter 1 the software used clearly also has a tendency of producing formal similarities relating to the software’s different capacities and limitations.

Patrick Schumacher describes parametricism as an architectural style with the following characteristics: The Negative Principles include the avoidance of rigid forms that lack malleability; the avoidance of simple repetition that lacks variety; and the avoidance of collage of isolated and unrelated elements that result in a lack of order. The Positive Principles include the intelligent information-rich deformation of soft forms; differentiation of all systems through gradients, thresholds and singularities; and interdependent correlation of all systems.1

In contrast Michael Meredith sees parametricism more as a philosophy or method than a formal style.2 After having searched for common features within curvilinear computational designs of the past twenty years I tend to agree more with Meredith than Schumacher. Taking, for example, two extremes that both use the parametric approach and the computer as a generative tool, it is hard to find formal similarities between Hansmeyer’s and Dillenburger’s Digital grotesque project3 and the smooth surfaces of Hadid’s and Schumacher’s Serpentine Sackler gallery.

According to Saul Fisher4 formal styles within architecture are defined by the compositions and geometries that are used, and they can be categorized by these geometries and compositions without needing to study the Zeitgeist of the society in which they are created. In the geometries studied I have not found an overall formal style linked to the general use of computational design tools.

Possibly a number of formal styles are distinguishable due to the use of different software in combination with different philosophical approaches. I have, however, been able to see tendencies accruing in many curvilinear projects using computational design tools. A great help in identifying these tendencies was my earlier study of the geometries of the Art Nouveau period in which it was relatively easy to identify the geometries defining the formal style. This study provided a reference with which the contemporary projects and their geometries could be compared.

In the comparison with Art Nouveau buildings it is clear that today the overall geometry of the building has acquired much greater importance. The overall form of buildings has moved away from the concepts of carrying and carried elements, and of gravity as being the only force affecting the built environment. For the new and amorphous building forms to be buildable, the surfaces (or in the case of concrete buildings the formwork for the surfaces) have to be divided. This I see as a possible reason for some of the tendencies I have found in today’s curvilinear architecture.

Most interestingly the comparison has allowed me to identify a common tendency in how lines are ended in a surprisingly large portion of contemporary computational curvilinear architecture. I found that lines in the overall composition or form of buildings (not in smaller buildings elements or tessellation) are allowed to continue with the same radius -or a gradually changing radius- through the entire building. This lets the eye travel along the lines and leave the building without coming to rest in a focal point. (Illustr. 121-126) Lines ending within the building only rarely change radius or blend into the building component they meet. (Illustr. 24)

This is radically different from the geometries of the Art Nouveau period. There lines are almost always given an ending, with a smaller radius in the form of a spiralling geometry or, alternatively, a counter curve i.e. a curve with a smaller radius in the opposite direction to the initial curve. (Illustr. 134-135) For a simple comparison between these two ways of ending line geometries see Illustr. 114.

How can this difference between the ways lines are ended in Art Nouveau and today’s computational curvilinear architecture be explained? The philosophical approach discussed in chapter 1 might provide a possible answer: as a mirror of today’s society, in which little room is left for human perception or senses to come to rest, contemporary architecture will also not require the eye to come to rest in a focal point.
Tracings of Art Nouveau buildings showing a clear tendency of line endings with a counter curve or spiraling geometry letting the eye come to rest at focal points integrated into the design.

Tracing using AutoCAD. Photographs for this Thesis by FL.
Tracings of contemporary curvilinear buildings showing a clear tendency of line endings with an open geometry allowing the eye to travel beyond the building.

Tracing using AutoCAD. Photographs 121-125 for this Thesis by FL.

Illustration 126. Image licensed under Creative Commons
Finding the Curvature of Art Nouveau

The curved line and the organically formed ornament are central components of Art Nouveau architecture. The style may at a first glance appear to have a consistent form language, but when studied more deeply a number of styles within the style become apparent. In my study of the curved line in Art Nouveau buildings I have found the main styles and uses of curvature to be those described below.

Although many buildings and designs use a combination of different curvature styles, there usually is an overall predominant formwork and detailing concept to the building. In the smaller scale, ornamentation can be a mixture of styles.

Common Geometric Art Nouveau Features

The flattened or three-centred arch

The most commonly used form, found in most Art Nouveau designs, is the flattened or compressed arch. It consists of a straight vertical support-line that is connected to a sharp radius transitioning into a large radius. (illustr. 119) The arch can also be created using a series of at least two different radii, (illustr.131) but the more elaborate arches use a spline with a continually changing radius. (illustr.133)

The starting points, diameters and proportions of the radial segments appear to vary depending on architect and building. A generic Art Nouveau arch can be created using the model and parameters in illust. 131.

The origins of the flattened arch could possibly be traced to the usage of arches with ever greater radii and the problems arising from the height required for spanning long distances. An early example of its use is seen in the entrance to Brussels Town Hall, completed in 1420 under the direction of Jacob van Thienen. (illustr. 127) An example from the Renaissance is the use of the flattened arch in the 1612 development of Place des Vosges in Paris, in order to accommodate apartments above the passage surrounding the square.

127. Entrance, Brussels Town Hall completed in 1420 under the direction of Jacob van Thienen. Photograph by F.L. for this thesis
128. Seeburg Building, Spitalerstraße 16, in Hamburg, 1908/1909, by Franz Bach. Photograph by F.L. for this thesis
129. The Palau de la Música Catalana, a concert hall in Barcelona, 1905, by Lluís Domènech i Montaner. Photograph by F.L. for this thesis
130. Wood carved dining room, Paris 1905, by Alexandre Charpentier 1905 (collection of the Musée d’Orsay). Photograph by F.L. for this thesis
Parametric model of compressed arch.
Parametric model in Revit
Already at the beginning of the 19th century the deployment of the brick-beam in England made it possible to create increasingly low arches with larger radiuses. An example of this is Brunel’s Maidenhead Railway Bridge over the Thames, constructed 1839. It was considered so extreme that the scaffolding under the arch was not removed for fear that the bridge might collapse. Only a winter storm sweeping away the scaffolding proved the structural stability of the bridge - which is still in use today.

Although the flattened arch has been used throughout history it was not before the end of the 19th century that the use of it dramatically increased. In Art Nouveau the flattened arch and its possibility to create wide and low openings takes a central position. The flattened arch was used in almost all regions and countries where Art Nouveau architecture was built, from Hamburg (illust. 128) to Barcelona (illust. 129) and Paris (illust. 130) to Chicago. (illust.132)

However a possible explanation for the increased usage of the flattened arch might be that the radius at the end of a flat arch can visually make the structure appear statically stable.

132. Auditorium Building by Louis Sullivan and Dankmar Adler. Completed in 1889. Photograph by JW Taylor in Roosevelt University Archives, Chicago

133. Different geometries used to create the arch will result in different looks of the flattened arch, radial, drawn with a continuous line; splinal drawn with a dashed line. X indicates control points.
Counter curves
The counter curve is a curve that continues in a direction opposite to the initial curve. (illust. 135) Counter curves in Art Nouveau design relate to the flattened arch, where the curve continues in the same direction, in that they both use transitions of curves, or splines, with diminishing or increasing radiiuses. In Art Nouveau the counter curve has a clear difference in radius compared to the initial curve. (see red box on series below) The proportional differences between the curves span between 1:2 and 1:8.

Curvature with counter curves is most commonly used in ornamentation, as in the ending or start of larger curves to form an ornamental focal point. (illust. 134) Counter curves can also be found in doors and window mullions, as well as in support structures for cantilevering building parts. (illust. 102)

Inspiration for counter curves with increasing or decreasing radiiuses can be found in nature as fractals, in the shape and geometry of roots as well as in the bodies of many animals, for example the lizard. They are also easily found in the human body and face.

134. Vase, 1901, by Hector Guimard, a study of the endings and beginnings of ornamental curves. Photograph by F.L., for this thesis
**Cantilevers**

Second to the bent line the cantilevering form is a recurrant feature in Art Nouveau design. Art Nouveau cantilever designs often use the counter curve in series, bent in two or three dimensions (illust. 136).

Although the Art Nouveau use of cantilevers may possibly be traced to Baroque rooflines or Asian pagoda roofs, a more probable influence was the medieval use of cantilevers in both fortifications and residential buildings. In the industrial structures of the late 19th century the use of building techniques without underpinning scaffolding was becoming more common. This can also have been a source of inspiration.


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136. Maison Blankenburg, Place Broglie, Strasbourg, 1900 by Gustave Krafft. Photograph by F.L. for this thesis.

137. Series of cantilevers top drawings how difference in geometry between spiral and radial cantilevers.
Non parallel offset curves are employed in all scales in Art Nouveau. Non parallel offset curves are commonly used on the outer sides of arches to give the arch a more elaborate form without making the actual construction of the arch overly complicated. (Illus. 37)

The non parallel offsetting of curves within Art Nouveau design is a way to create a feeling of movement and direction. The parallel offset makes the eye travel towards the point where the curves converge, creating a focal point that often consists of a spiralling or counter curve movement. (Illus. 138)

Non parallel curves in arches were also developed within steel construction to take up the additional strain in the corners of framework trusses. If this was a source of inspiration for Art Nouveau ornamentation or vice versa is hard to conclude.

138. Detail of Metro entrance pavilion at Cité station Paris, 1901, by H. Guimard. Photograph by E.L., for this thesis
Asymmetry is often seen as a typical feature of Art Nouveau, but when studying the overall building production of the period 1890-1920 I can conclude that it is still relatively uncommon. Asymmetry is most often found in the scale of the ornament but also in the volumetric building composition. Asymmetry in building volumes is often derived from the Art Nouveau concept of the medieval building conglomerate, created over a long period of time. Asymmetrical buildings using the medieval vocabulary are often relatively static.

Asymmetry as a means of illustrating movement has been used consciously in art and sculpture at least since the early Renaissance. The horses’ movement, in the Fontana di Trevi in Rome, by Giovanni Lorenzo Bernini (1598-1680), is created through asymmetry. Applying movement through asymmetry to ornamentation was commonly done in Baroque and Rococo architecture. In the Rococo asymmetry was also extended to building design, by for example Jean Mondon le Fils, but remained relatively uncommon in the larger scales.

In Art Nouveau architecture asymmetries illustrating movement were used on a somewhat larger scale, such as Victor Horta’s stairs in Hotel Tassel as well as in numerous door and window designs.

339. Doorway at Place Etienne Petrel 24, 1905, by Alfred Wagon. Photograph by F.L. for this thesis
340. Art Nouveau Entrance to 26 Rue des Bégonias, Nancy, architect unknown to the author. Photograph by F.L. for this thesis
Spiralling curves

Spirals relate to asymmetry as they, by definition, create an asymmetric pattern. The obviously visible spiral is often used in Art Nouveau design, for example in the entrance floor design for Hotel Tassel by Victor Horta, and in the roof of the entrance to Casa Batlló. (Illustr. 142) However, the visible spiral is much less common than a spiral used as an ending to a line or curve. (Illustr. 141) The ending of curves through a spiralling geometry is often performed with what today might be considered an approximate logarithmic or hyperbolic spiral.
SPLINES AND RADIISES

Studying Art Nouveau designs by tracing the line work of drawings and details I have found both radial and splinal curves. (illus. 133) The flattened arch is commonly constructed using radial curves. Splinal curves with two or three control points are also used, for example in designs by Hector Guimard. Guimard’s arch in the Paris metro entrances has a splinal geometry. Proof of this can be seen in his drawings, illust.no. which show his use of coordinate systems in order to enable plotting the splinal geometry to larger scale. (illus. 144)

The use of spline rulers was commonplace within the shipbuilding industry at the beginning of the 19th century. Many early 19th century engineers, such as Isambard Brunel (1806-1859) and Thomas Telford (1757-1834), were involved in both shipbuilding as well as the structural design of bridges and tunnels. It is therefore probable that architects, inspired by new materials and building techniques, would have come in contact with these tools for creating splinal structures.

Whether the majority of Art Nouveau architects knew how to create an optimal strain line or not, the usage of splinar curves as an abstraction of movement in both Art Nouveau sculpture and art (for example in the hair curls of Alphonse Mucha’s poster designs illust. 9 ) must have inspired designs for both ornaments and building parts.

143. Drawing showing that relatively complex Art Nouveau geometries can be created using only radiuses. X indicates centerpoints

144. Drawing by Hector Guimard showing his use of coordinate systems in order to enable plotting the splinal geometry to larger scale. Archives of Cooper Hewitt, Smithsonian Design Museum
**Regional Differences in Uses of Curvature**

The usage of these different curvatures appears to be geographically oriented, with groups of architects deploying similar curvature and building styles in different parts of Europe. The differing tastes can also be traced back to how designs were received when exhibited in different countries at the turn of the century. Henri Van der Velde’s interior designs, for example, got a mediocre reception when first exhibited at the Paris fair 1895-96 but were warmly received at the 1897 Handicraft Exhibition in Dresden, Germany.

**Art Nouveau / Jugendstil in Germany**

**Building Composition**

From the start German Jugendstil had a strain of national romanticism with the clear objective of contributing to the imagery of a nation state. Classical and Renaissance building components, such as hierarchical ordered stories and pilasters, were relatively often used, frequently in combination with components with medieval, gothic and baroque references. A classical Renaissance composition can, for example, be juxtaposed with a medieval or baroque pitched roof. Buildings’ roof scapes, with geometries referring to a castle tower or the sagging form of a thatched roof, are predominant.

**Curvature**

German Jugendstil uses radiuses as the primary form for larger design features, such as roof pitches. In the overall building scale the connecting of curves with different radiuses is relatively uncommon.

Openings in buildings, for doors and windows, are either rectangular or circles intersected by a rectangle. The use of counter radial curves is relatively common in window design. Half-moon formed windows, as well as pointed gothic arches, are also common. Window mullions can be radial.

Central points in the facades can be accentuated using eclipses or radial gothic arches - as solitary objects, but also inscribed in radial arches. It is possible that the use of elliptical forms can be traced back to the Baroque style of Naples. The late German Art Nouveau (and early expressionists) also used the parabola in their designs.

**Surfaces**

The facade is often relatively flat. From this layer balconies and bay windows are extruded, forming a secondary layer. A third ornamental layer, consisting of pilasters and bands, binds it all together. Sweeping roof-lines in the form of single curved concave mansard roofs are common, setback balconies in the facade are less common.

In interior design there is a clear usage of single curved surfaces mediating the 90 degree corners common in rectangular rooms. The most famous example of this can be found in Henri van der Velde’s interiors for the Nietzsche archive in Weimar. An example of the, less common, use of double curved surfaces are the interiors of the Münchner Kammerspiele by Richard Riemerschmid (1868-1957).

**Ornamentation**

Early German Jugendstil ornamentation is often more literally inspired by nature in that natural forms are depicted more directly and with less simplification. Ornamentation is often lush and eclectic—as if the building first had received the classical ornamentation and after that had another layer of organic and figurative ornamentation added. This often produces a relatively overloaded feeling to the building.

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135. Typical German Art Nouveau geometries.

145. Entrance to Zeche Zollern by Paul Knobbe, completed in 1904, illustrating different geometries inscribed in an ellipse.

Image licensed under Creative Commons by Uwe Aranas,
**Art Nouveau in Vienna / The Wiener Secession**

**Building Composition**

The building style of the Wiener Secession is closer to Renaissance buildings; the influence of German national romanticism is less obvious. Buildings are characterized by rhythmic facades, symmetry and the use of cupolas.

The usage of glass and nettings in openings is developed to a higher and more elegantly refined level than is common in German Art Nouveau. The tendency shown in the Viennese style, of moving towards lighter composition and minimalism—especially as manifested in Otto Wagner's designs—is often claimed to be a reaction to the eclecticism of the Ringstrasse development in Vienna.

**Curvature**

The use of curvature in the Viennese Art Nouveau style has a higher level of abstraction than in the earlier central German style. The openings in the buildings are usually rectangular or arched using a single radius. Mullions are most commonly straight and rectilinear. Ironwork is often concentrated in window mullions and doors, but is also found in fences and entrance canopies. The ironwork frequently has a formwork of splines or consecutively widening radiusses similar to that seen in the French and Belgian styles.

**Surfaces**

The facades of the buildings often consist of a planer surface punctuated by relatively shallow window bays. Setbacks in the facade are less common. Roof forms are often of less significance for the overall design, the relatively common domes being an exception.

**Ornamentation**

Ornamentation is generally not very three-dimensional and more applied as painting to the facade surface. Perhaps this flattening of the ornament can be traced to the two dimensional poster art being produced by the Darmstadt and Wiener Werkstätte which in itself was inspired by Japanese woodcuts introduced to the Art Nouveau movement by S. Bing.

The Vienna Secession, founded in 1897, may have been a source of inspiration for the use of gold leaf that is common in the Viennese style. The Secession's first president was Gustav Klimt (1862-1918), many of whose paintings from this period included gold leaf. More important, however, may partly have been the aim of producing a style fit for the Habsburg Empire.

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The Spanish Modernista Style

Building Composition

In Spain Art Nouveau was called the Modernista style. This style has buildings that are more closely linked to the medieval form language but which also take up local Moorish forms and patterns. The spreading of Moorish arch in Europe can partially be ascribed to the Spanish Art Nouveau movement.

Spanish Art Nouveau is most commonly associated with the architectural style of Antoni Gaudí 1852-1926, but there were several other architects, such as José Sala’s César Martinell i Brunet (illust. 150) (1888-1973) practicing the Spanish variant of Art Nouveau. Gaudí’s buildings have the most elaborated sculptural qualities in the interior design, but also in the forms of roof and facade. Form influences come from the animal world more than from plants and trees. An example of direct use of animal references is the roof of Gaudí’s Casa Batlló in which the roof-line is shaped as the back of a dragon. There are also clear Moorish references in Gaudí’s works, yet they are even more obvious in Jeroni Granell’s designs (Barcelona, 1867-1933) designs.

Curvature

Gaudi uses the parabolic and hyperbolic curve extensively. Today he is considered to have developed the first parametric building model. For this he hung strings between fixed points and then suspended weights from the strings. By altering the weights, and their positions on the curve, he could adjust the symmetry of the parabolic arches created by the strings.

Surfaces

Gaudi’s style uses three-dimensional parabolic surfaces in pillars. The facades are often three-dimensional, as in Casa Mila, using a patchwork of both double curved, convex and concave surfaces.

Ornamentation

Fantasy animals are used extensively. Possibly this can be seen as a development of the medieval usage of gargoyles and figures on sacral buildings. Ornaments often create associations with faces and bodies showing different emotions. In the Spanish Modernista style the feminine aspects of the ornamentation language are weaker and the direct depiction of feminine busts and figures is less usual.

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**French and Belgian Art Nouveau Style**

**General Building Composition**

Global asymmetries in facades are more usual than in Germany. In the French style references to the Middle Ages are somewhat weaker than in the German, tending to move towards the lighter constructions and assemblies of the late Gothic period. As mentioned earlier the reinvention of the Gothic period by Eugène Viollet-le-Duc and his embracement of new materials played a major role in the French Art Nouveau movement. The strength of the reaction against the classical Beaux-Arts school resulted in facades and buildings in which it is harder to trace the classical order.

**Curvature**

The usage of splines and counter-curves in architectural design is more frequent in France and Belgium than in the rest of Europe. This is also true of asymmetries in metalwork and door design. The splinal curvature is most commonly applied to metalwork -both in the form of cast iron but also in bent standard L, I and flat rod profiles. It is also found in plaster and stonework facades. As far as I have seen the school of Nancy and Brussels were the first to apply the spline to window mullion designs.

In French and Belgian designs the curvature is more often applied on a global building scale, bringing together the small scale ornament with the greater building scale. The splinal curvature is also applied as structural element in buildings. Examples of this can be seen in the Salle Humbert-de-Romans by Hector Guimard and Victor Horta’s columns in the Tassel House. In the smaller scale Gottfried-Julius Berringer and Ernest Hecher’s balcony supports illus are examples of combining splinal curves with weight-bearing structural elements.

**Surfaces**

French Art Nouveau buildings generally have a greater depth to them than the German equivalents. The use of set back balconies and protruding windows is relatively common, especially in Paris and Nancy.

Starting in the modelling of the surface around doors and windows, and continuing with the single curved façade, of for example the Maison de Peuple by Viktor Horta, it is possible to trace the development towards the plastic modelling of the entire facade. This comes to what I consider to be its most elaborate form in Hector Guimard’s Rue Agar apartment development and in the architect’s own house on Rue Mozart. Gaudi’s façades for Casa Batlló and Riemerschmid’s designs for the Münchner Kammeroper may have been sources of inspiration. In Guimard’s designs, from around 1910, the facades consist of a continuous surface integrating doors, balconies and windows and use both single and double curved areas that seamlessly blend into each other.

**Ornamentation**

Early French Art Nouveau architects often tried to create a shook effect in their building ornamentation. Ornamentation was often designed by sculptors working in parallel with the architects. In contrast to the earlier eclecticism that often made use of monochrome ornaments cast in plaster, French Art Nouveau architects and sculptors introduced glazed clay and ceramic ornaments. These were often hand-crafted and unique for the building.

Two features in French and Dutch ornamentation distinguish it from its Central- and Eastern-European counterparts. Firstly, and most important, are the ironwork balcony railings (in French grilles) and their integration as ornaments into the facade, creating an additional layer of scale of ornamentation. A second significant feature is the integration of the ornament into the global building design. Examples of this can be found in Alfred Wagon’s design for Place Étienne-Pernet apartment building in Paris (illust. 139,166-167)


152. Shopfront in Nancy, 1903, by Georges Biet and Eugène Vallin. Photograph by F.L. for this thesis
DRAWN STUDIES USING THE FORMAL LIBRARY OF ART NOUVEAU
STAIRWELL DESIGN EXPLORING ART NOUVEAU
GEOMETRY IN BOTH PLAN AND SECTION

My design for a stairwell, exploring Art nouveau geometry in both plan and section. It also explores the integration of artificial lighting into the design.

The stairway addresses the design problem of a staircase enclosed in a building without any natural lighting, a problem found in many contemporary residential buildings such as Skanska’s standard houses Frida and Johanna. Viktor Horta in Hotel Tassel and Antoni Gaudi in Casa Batil addressed this problem by using colour gradients to create a feeling of movement upward towards the light.

In my design hopefully a similar effect of creating variable gradients is achieved by the LED lighting strips integrated behind the bricks. The lighting can be computer controlled. This makes it possible to create an individualised lighting scheme depending on which level a person enters the stairwell.

CONSTRUCTION TECHNIQUE

The stairwell is enclosed by a backlit brick wall that also serves as formwork for the load bearing concrete wall behind the bricks. A transparent plastic pipe is placed behind each vertical joint in the brickwork, a LED lighting strip is inserted into the pipe and a fibre cloth membrane is then applied outside the tubes and the bricks. Concrete can then be poured in, making the wall structurally stable and supporting the stair risers. The bricks can be laid by hand or a brick laying robot placed in the central shaft of the stairway.

The risers of the staircase are cast in 2-part silicone forms made from a CNC routed original. Each step is tapered, with its thin end towards the centre and the thick end fastened into the cast concrete behind the decorative brick wall.

The railing is made from sheet metal that is laser or plasma cut with a 4-axis machine in order to accommodate the changing tapered edge against the connecting steel handrail as well as the supportive bottom rail that is bolted to the concrete risers.

REFERENCES AND GEOMETRY

References are the two staircases, designed by Horta and Gaudi, mentioned above. The entrance partition before the elevator, and the decorative patterns on the laser-cut ironwork of the frosted windows of the stairwell, relate to the curvature and layout of the entrance of Guimard’s Castel Béranger. The integration of railing and bench in one entity is an attempt at seamlessly blending form and function. Geometries used are spiralling endings of line and converging lines on the railing elements, and counter curves on the stair risers.

SKANSKA Promotion brochure Moderna Hus 2015
ILLUS. 153 Principle sketch of backlit brick wall
ILLUS. 154 Reference to stairwell study: Atmos Studios Sensualscaping Stairs 2015
I have no copyright for this images but they are important for my design.
135. Stairwell with backlit brick wall using the geometries of Art Nouveau defined in this chapter.

Rhino 3d model, rendered in Vrayengo. Image processed in Adobe Photoshop. By FL.
156–157. Section through stairwell with backlit brick wall using the geometries of Art Nouveau defined in this chapter. Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:20. By FL.

158. View down stairwell showing flowing step design and railing coining form with function. Rhino 3D model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.

159. Plan of stairwell with backlit brick wall using the geometries of Art Nouveau defined in this chapter. Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:20. By FL.
160. Further reference to stairwell study staircase leading to the basement of Petit Palais designed by Charles Girault 1900 Photographed by the author as part of this thesis.

FACADE DESIGN EXPLORING THE USE OF DIFFERENT SCALES IN ART NOUVEAU GEOMETRY

My design for a façade, exploring the use of different scales in Art nouveau geometry, in which the global and intermediate lines are hand drawn whilst the fine grain lines are generated by the tool path of the CNC router that cut the drawn geometry. The façade has relatively little depth, the deepest indentons being 60mm from the surface.

Construction Technique
The façade consists of 11 different precast concrete elements created by CNC milling a positive wooden template which then is transferred to a negative silicone form. This enables the grain of the wood to be visible in the final concrete element, forming fine detail scale. The tool paths of the CNC router will form the intermediate scale contrasting with the drawn patterns in the intermediate and global scale. Windows and balcony railings are of rectangular form to minimise construction costs. The process of silicon forming concrete has been used by Francois Eduard in his Hotel Foaquer’s Barriere in Paris.

References and geometry
References for the façade are Alfred Wagon’s façade design for the Place Etienne Pernet façade (illust. 166-167) and the flatter facades of Otto Wagner. Contemporary references the design can be contrasted with are the facades of Renaissance Paris Hotel, by Atelier Christian de Portzamparc (illust. 162) as well as the generic facades of the residential buildings of KV Sädesärlan 2008-2014 in Stockholm, by Reflex Arkitekter.

Geometrically the design uses converging lines with spiralling endings at the top part of the façade and compressed arches in the front shop window. The vertical façade elements are designed so that they can be inserted in any number needed, depending on the flat layout between the window elements.
Facade system of concrete panels fabricated with a CNC routed mould. Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:100. By FL.
View from street level up facade design, exploring the possibilities of working three-dimensionally on a limited depth. Rhino 3d model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.
166-167. Alfred Wagon’s façade design for C. Place Eustienne Vernet façade
Photograph by F.L. for this thesis
IV

REALITY AND FICTION
Using nature as a source for inspiration, and replicating the geometries it uses, might be a way of conveying some of the feelings given by nature, and the effects it has on the human being. Restricting the forms used in creating rooms to rectilinear lines will reduce the possibilities of controlling the feelings and interactions the room can produce.

In Art Nouveau and expressionist architecture, I find the first conscious attempts to discuss and reproduce the interaction of feelings that nature and the human body, itself a part of nature, is involved in. To me it seems apparent that studying nature will result in the urge to combine form and function, reflecting what nature -through evolution (or divine intervention)- has done in its form-work in which the smallest part interacts with the global geometry in forming a coherent entity.

In studying the Art Nouveau interpretation of nature's line-work and surfacing, it is possible to discern this very urge to use all scales and also to produce geometries where the parts and material interact. The inclusion of all possible scales into the design of room enhances the possibilities of communication and interaction between human and design. In the same way the exclusion of certain scales produces a narrower spectrum of conversation. I find that a goal to strive towards is the creation of diversity in space, just as there is diversity in the human mind and the way humans feel and interact. This diversity should ensure that all humans within the built reality can find, and choose, spaces engendering the maximum number of possible feelings.

I also believe the architect must strive towards creating room were the conversation between room and human enhances the materialistic function of the room. As in all design proceeding from materialistic function, this obviously necessitates a generalisation that will result in the production of rooms fit for a normative spectrum of people and, of course, also create rooms less optimal for a smaller minority. However the evolution of the human mind has taken place over a relatively short period of time. This might make it possible to postulate common spatial feeling, and thereby also the possibility of creating rooms in which both the room's form, and its interaction with the body and mind, enhances its materialistic function.

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AN ALTERNATIVE DESIGN SUGGESTION TO ZAHA HADID'S DESIGN FOR THE SERPENTINE SACKLER GALLERY

It is important to note that my suggestions are not a critique of the existing project, nor do I wish to claim that my version in any way is better than the existing design.

CONTRAST TO CONTEMPORARY PROJECT

In the gallery by Hadid there is no clear division between the entrance space and the dining area. The columns that protrude from the canopy are placed in such a way that the visitor does not see any distinct geometry in their positioning. (Ist 171)

The plan layout of my project has two defined rooms in which my aim is to create two different effects on the visitor, through the design of the space. The entrance room (Ist 181) has been given a convex form in order to facilitate the flow of visitors past the cashier and wardrobes, and on to the actual galleries within the restored gunpowder warehouse. The kitchen is directly visible when entering giving the visitor a notion of presence of a dining possibility. The dining area (Ist 180) is defined by its concave shape. To reach it, visitors can follow the span direction of the structural trusses, filtering through to the seating area. In turning towards the dining area, visitors also get visual contact with the park and garden. The cantilevering roof creates a space shielded from sun and rain.

ARCHITECT/OFFICE

Name: Zaha Hadid
Date of birth: 1950

STUDIED OBJECT

Name and of building: Serpentine Sackler Gallery/
Function: public space, restaurant, entrance
Location: London
Completed: 2009-2013
Materials used: Glass-fibre woven textile membrane.
Aspects studied: Interior

169. Elevation drawing of Serpentine Sackler Gallery by Zaha Hadid
I have no copyright for this drawing but they are important for my thesis.

170. Exterior facade of the Serpentine Sackler Gallery by Zaha Hadid
I have no copyright for this image but they are important for my thesis.

171. Interior of Serpentine Sackler Gallery by Zaha Hadid showing the unreadable pattern of columns. I have no copyright for this image but they are important for my thesis.

172. Plan drawing of Serpentine Sackler Gallery by Zaha Hadid
I have no copyright for this drawing but they are important for my thesis.

168. Plan drawing of Serpentine Sackler Gallery by Zaha Hadid
I have no copyright for this drawing but they are important for my thesis.

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CONSTRUCTION TECHNIQUE

The structure is built up of plywood trusses consisting of three layers of water cut plywood. As each truss requires approximately 11 standard (1200x2400) plywood sheets, the cutting paths are drawn so that the parts are left fixed in the sheet for easy transport to the assembly space. At the assembly site, which must be planar and dry, the layout of the trusses are laser projected onto the assembly floor and the parts laid out. Subsequently the plywood parts are fixed together with a combination of screws and glue, which facilitate their division into segments. The truss segments can then be transported to the site for final assembly. On site three trusses are fixed together with bolts and a set of 6 pipe formed spacer tubes (illus.171) fitted with cast iron endings. The spacers bend the trusses, thereby forming a structurally stable unit.

On top of the truss assemblage a tessellated surface is formed of flat windows in a 300x300 mm welded steel grid. Low points are located between the truss units where the roof is given a 300mm thickness to facilitate insulation with cellulose fibres. These parts of the roof are built up with water cut plywood members holding a welded stainless steel sheet metal roof.

173-175 Construction principles of alternative suggestion showing:
Top: The joinery between the roof trusses with windows and insulated parts between the trusses.
Centre: Spacers separating and bending the trusses to a stable form.
Bottom: Truss fastening in slab through a metal sword bolted in between the plywood layers.
176. Spacers separating and bonding the trusses to a stable form.
REFERENCES AND GEOMETRY

The Art nouveau references I have used in this design are the light filtering through fine grained steel trusses as in Hamburg central station (image 178) and Viktor Horta’s Hotel van Eetvelde.

The idea of screens dividing and defining a room is a reoccurring feature in Art Nouveau designs as, for example, in Alexandre Charpentier’s dining room (illustration 130) as well as in the dining room of Atilie Horta by Viktor Horta. The use of rounded corners to create an enclosed feeling can be found in both Van der Velde’s reading room and the dining room of Hector Guimard Rue Motzart residence.

The feeling of the entrance room is inspired by the Pont de Bir-Hakeim metro bridge (illustration 61-63). The passage and cloakroom of my design are an investigation into the fluidity and perspectives that a room with convex walls and roof can produce. A space with a similar geometry and feeling is the entrance to Stockholm’s new school of architecture by Tham Videgård.

The truss in both spaces of my design uses the compressed arch as its main geometry. The geometry does not relate to any specific project reference. Each arch has however been drawn manually, enabling variation in line geometry.

In the exterior the cantilevering roof is drawn with truss endings defined by a counter curve. References here are the entrance canopies of the Old England department store by Paul Hankar (illustration 177) and the Paris metro entrances by

AN ALTERNATIVE SUGGESTION TO NORMAN

179. Cantilevering roof towards the park.
Rhino 3d model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.

180. Dining area with a sculpted concrete geometry. The truss design combining form and sentiment.
Rhino 3d model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.
Dining area with a curved concrete geometry. The truss design combining form and ornament.

Rhino 3D model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.
181. Perspective showing the differently formed spaces. To the left the enclosed restaurant and to the right the fluid reception and cloakroom.

Line drawing from 3D model in Rhino.

183. Section through extension and original building. Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:50. By FL.
Plan of extension showing position of roof trusses.

Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:100. By FL.
Elevation showing extension and original building.

Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:50. By FL.
Foster’s design for the Bilbao Metro station entrances

It is important to note that my suggestions are not a critique of the existing project, nor do I wish to claim that my version in any way is better than the existing design.

This study aims at developing a metro station with a memorable form that can be used as a city’s brand and also function as a point of recognition in the urban landscape. Unlike Foster’s ideas related to creating a global architecture my design focuses on the creation of form contrasting with both historic and contemporary surrounding buildings.

My design actively tries to work with combining form and function. Form is given a structural function, for example in holding the platform doors and polycarbonate glass for the entrance in place. I also try to address the lighting of the underground in a different way from Foster who uses only free hanging armatures for all lighting. In my suggestion the lighting is integrated into the design and its form. Hidden LED strip tubes, placed between the roof panels, light the station indirectly. The form of the roof panels, together with the colour of the LED lighting, give the possibility of lighting the station with two different colours depending on the direction in which the traveler looks. (illus197) Using light gray panels, in combination with LED lighting, makes it easy to customize the station depending on metro line as well as making it possible to colour code the direction of travel.

Construction technique

The inner structure of the entrance canopy and the interior arches holding the roof panels, are manufactured using a CNC controlled 3D tube bender. Joins between tube segments are precision cut using a 5 axis CNC cutter. They can then be welded together with minimal on-site grinding. The outer structure of the station entrance is divided into conical segments which are unrolled and then cut in sheet metal by a laser or plasma cutter. Using a cone rolling machine the cut parts are then rolled into segments that are thereafter welded together. The interior roof and wall panels are made of vacuum formed panels that are sprayed with fibreglass to give stability. These panels are formed over a positive mould made of biodegradable polystyrene routed on a CNC controlled router.

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193 - 194. Châtelet metro station Paris designed by Hector Guimard 1900
The entrance canopy is a 1980s reconstruction using the original wood models from the St Denis factory.
Photograph for this Thesis by FL.
REFERENCES AND GEOMETRY

An obvious reference is Hector Guimard's design for the Paris metro entrances, (illus 193). A reference for the form of the outer structure of the entrance is the curvature on the Rue Agar apartment houses by Guimard (illus 34). Ernest Hecher's ironwork on the balconies of his Paris Apartments (illus 43) and Pace Bogadol's residential house in Strasbourg (illus.136) have served as references for the platform doors.

References for the use of colour gradients are the facade of 124, rue Beaumarchais offices in Paris attributed to Georges Chedanne (1905) and the colour gradients of Viktor Horta's stairways in Hotel Tassel. Integrating lighting sources in order to enhance the design refers to the lighting armatures of Peter Behrens (illus 82).

The geometries in my design focus on the counter curve, seen in the three dimensional geometry of the entrance structure and platform doors. Non parallel lines converging in a focal point are used both in the entrance canopy and in the sheet metal connecting the pipes supporting the interior roof panels.

196. Principal sketch of panel fastening and coloured LED lighting.

195. Alternative suggestion for station entrance, with a clear form branding.


197. Rendering showing of coloured lighting on weight panels.

Connection between conic segments and 3D bent pipe with flanges for fastening glass panels.

Line drawing from Rhino 3D model. Image processed in Adobe Illustrator. By FL.
599. Platform doors with 3D bent steel pipes connected with sheet metal spacers.
Rhino 3D model, rendered in Vray. Image processed in Adobe Photoshop. By FL.
200. Possible lighting effects on sealing panels
Rhino 3D model, rendered in Flamingo. Image processed in Adobe Photoshop. By FL.
201. First sketch for three dimensional conical pip ending over entrance to metro station.
202. Tool path for cutting sheet metal for three directional conical elements on Metro station entrance. Nurbs surface unwelded in Rhinos 3D.
203. Welded 1:2 mock-up of conical welded pipe over station entrance with integrated lighting fixture. Sand blasted sheet metal covered in clear 2 component lacquer. By FL.
204. Welded 1:2 mock-up of conical welded pipe over station entrance with integrated lighting fixture.
Sand blasted sheet metal covered in clear 2 component lacquer. By FS.
205. Section trough station from entrance to platform. Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:200. By FL.

207. Section of metro station, platform and entrance canopy
Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:100. By FL.
208. Section of metro station, platform and entrance canopy

Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:100. By FL.
209. Plan of metro station, showing ticket hall and platform
Drawing produced in Autodesk Revit from Rhino 3D model. Original scale 1:200. By FL.
230. Longitudinal section through metro station showing ticket hall and escalators to platform
Drawing in AutoDesk Revit from Rhino 3D model final processing in Adobe Photoshop, original scale 1:100. By FL.
GOETHEANUM, Führungen und Besichtigungen. Dornach.