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Apokatastasis Panton: Parametricism in Practice

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ABSTRACT

This thesis aims to address the architectural profession’s response to globalization under the neoliberal post-Fordist networked societal framework as outlined and popularized by Patrik Schumacher. This thesis will explain how the information communications technologies (ICT) Industries have taken over architectural practice with building information modeling (BIM), and have produced a system of managerialism that replaces design with an emphasis on pure economic rationality through the use of tools aimed at flexibility, communication and data management. This thesis calls into question the ICT’s agenda for the built environment, specifically that of the globalized city, and provide a critique on Parametricism (Architecture’s Autopoiesis) by examining one of the theory’s most notable flaws, namely the absence of public agency and the abolishment of the social in both design and design process. This thesis will examine how neoliberal ideals have created the conditions for the fear of acceleration that’s associated with globalization, which have allowed Parametricism to take hold of the discipline and remove the public from the associated planning and design processes, as well as mold them as subjects to the market’s evolutionary and self-organizing principles.

To address this issue, this thesis proposes a method of design that utilizes mass customization and personalization alongside that of a BIM-based framework. The goal of a mass customized approach is to allow a top-down framework that enables bottom-up creative interpretation, improvisation, and execution. This design method is fundamentally participatory in nature while also utilizing advancements in software and technology related to advance manufacturing and data/network integration that are in line with neoliberal post-Fordist production processes, that is, they adhere to the pre-condition from which contemporary large scale built projects are to be built and managed.
This thesis will look at recent trends in collaborative and participatory planning utilizing gaming as a method of knowledge creation and negotiation, a method that better serves as an interface in more abstract and complex decision making processes that involve multiple agents and systems. This method seeks to address current collaborative method’s failures to simulate realistic power negotiations and the modeling of the decision making mechanisms that ultimately shape the physical environments they control.

This thesis aims to explore the condition of power negotiation of this ‘parametric’ contemporary architecture through the design of a multi-use tower and tower fabrication facility in one of the most sought after real-estate sites in Chicago. The tower and fabrication facility will examine how mass customization works in the design of public and social space in this context of neoliberal thought, while also providing a platform for infinite development and capital flow necessary for sustainable physical and social growth that a project of this size and scope would require. This process will simulate the infinite death and rebirth cycles of late capitalism and new theories on sustainable systems, as they seek to mimic the fundamental biological principles of evolution and self-organization, as seen through architecture’s recent adoption of complexity sciences and cybernetics of the ICT’s industries.
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1 INTRODUCTION

“We are facing the emergence of a real, collective madness reinforced by the synchronization of emotions: the sudden globalization of affects in real time that hits all of humanity at the same time, and in the name of progress.” ¹

The Architecture, Engineering, and Construction (AEC) industries are undergoing a series of rapid changes in order to meet our contemporary and future needs. Architecture and its profession do not exist in a vacuum and are heavily influenced and conditioned by other industries, as well as by world and local economy and culture. The diversity of agents and actors involved in built environment projects are increasing, and so is the complexity associated with managing the built environment project. Architects are increasingly turning to Building Information Modeling (BIM) in order to address and manage this complexity. This complexity is subsequently a consequence of neoliberalism’s ideals for the totalizing logic of economically opportunistic valorization, of which architecture has recently adopted as it moves increasingly towards systems of managerialism² and away from design and theory. BIM is such a tool that enables managerialism by replacing the focus of Architecture’s design and critique with that of networked patterns of communication, connectivity, flexibility, mobility, and the lean production trends of other industries more aligned with the technology and business sectors. With this in mind, it could be argued that the architectural profession has lost its purpose as a profession, and has since been overtaken by the information and communications technologies (ICT) industries of which BIM is a

² Managerialism, in general terms, is “a belief that organizations have more similarities than differences and thus the performance of all organizations can be optimized by the application of generic management skills and theory’, in this particular case, these generic management skills are done through data produced by globally networked and ‘smart’ technologies enabled by ICT industries. See, Klikauer, Thomas. “What Is Managerialism?” Critical Sociology 2015, Vol. 41(7-8) 1103–1119 (University of Western Sydney, Australia: Sage Publishing, 2013), p. 1104. http://journals.sagepub.com/doi/pdf/10.1177/0896920513501351
product of, at least at the level of corporate building practice. What this means for architects is that in order to respond to an increasingly globalized and neoliberal post-Fordist networked society, architecture must operate at a more highly competitive level of management and practice in line with these other technology and business sectors associated with communications technology, and it's only through this competition, that architecture has a chance to stay relevant in today's fast-paced and interconnected world. Patrik Schumacher has labeled this transition as the new epochal style of Parametricism\(^3\), with his emphasis placed on the architectural profession finding itself its own niche as distinctly ‘architecture’ within an increasingly embedded and enmeshed aggregate of industries and professions under an overarching ICT framework. There is serious risk in having communication and business overtake design as the primary objective of an architectural firm’s focus and energy, as the need to now operate at a more competitive level places more emphasis on managerialism and its association towards the efficient and optimized completion of a project, rather than the actual design, theory, and critique that architecture has historically prescribed. As data, and more increasingly, big data, finds its way into the digital models and their associated financial models, the emphasis on the quantitative outweighs many of the qualitative aspects of design. There is fear that this emphasis reduces people, environments, and processes to quantifiable metrics, outstripping the need of qualitative and life affirming aspects that are intrinsically embedded in these relationships. There is also fear, according to Foucault’s work on the production of the subject, that these environments will aid in the production of the individual subject, modeled as innately adaptable and responsive, capable of adjusting its conduct and behavior to the ever-evolving conditions of the market as it seeks to exercise its liberty through neoliberalism’s promises and signs of emancipatory self-transformation. However,

instead of this transformation as emancipatory, the self produces a self that has become governable as an economic subject.⁴

As governments increasingly call for BIM mandates on built projects, the quantification of our world slowly starts to emerge as a tactic of management. Neoliberalism in some regard, serves as a particular mode of power invested in controlling the population and directing its conduct through the production of subjectivity, responding in part, to the crises of governmentality, especially concerning complex systems, saying that the logic of the market is the only thing capable of ordering society by means of the ‘market order.’⁵ The state, now reassigned the role of facilitating the operation of the market through policy, gives up the mechanism through which social order is to be maintained. A world reduced to numbers can be more readily be analyzed and complex patterns more easily discerned, that is managed, and in a contemporary world administered by this fear, these risks and damages can be more easily be mitigated rather than properly addressed or solved.

Large scale built projects that address a variety of social conditions and ‘mass’ groups of people, must be products of this explicitly neoliberal condition of architectural practice in order to operate, that is, be financed, invested in, and sustained. The mixed use tower, a building typology that exemplifies all these conditions, provides the means at which to produce efficient and optimized venues for diversity, mobility, and flexibility. The mixed-use tower generally adheres to the ‘typical plan’⁶ as outlined by Rem

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⁵ Ibid., p. 13.

“The ambition of Typical Plan is to create new territories for smooth unfolding of new processes, in this case, ideal accommodation for business. But what is Business? Supposedly the most circumscribed program, it is actually the most formless. Business makes no demands. The architects of Typical Plan understood the secret of business: the office building represents the first totally abstract program – it does not demand a particular architecture, its only function is to let its occupant exist. Business can invade any architecture. Out of this indeterminacy Typical Plan generates character.” Ibid., p. 337.
Koolhaas, applying the rationality of workplace design to that of any design, addressing all these principles as fundamental truths towards its planning, methodology, and more increasingly, its morphology. This thesis wishes to examine, use, and critique these principles using the mixed-use tower as a base template. This thesis also wishes to examine a key difference in this process and methodology through the inclusion of a context specific tower manufacturing facility, which will address conditions of mass customized and evolutionary models of industrial scale production within the mixed-use tower typology.

With regard to the tower, three key principles address the successful financing of such a project. These include: firstly, the remixing of the program by creating a diversified product through market segmentation, that is use the ‘market order’ to attract both capital investment and to mitigate risk in development; secondly the connection to the city, creating a hub of activity and tourism, offering attractions for people of all economic means, and allowing for a continuous flow of activity and spontaneity to emerge; and lastly, the creation of attraction via multiple tiered site venues that offer greater connectivity and context to other city scale activities and events. The idea is to create as many revenue streams as possible to both mitigate risk and account for market fluctuations that could otherwise compromise the development and function of such a project.

The execution of these principles will be done through a mass customized, modular system of design that relates to context specific demands, whether they be economic, environmental, social, or morphological. The tower’s fabrication facility can produce context specific designs that address the needs of the tower as well as the needs of the market. These pre-fabricated designed and engineered components can be lifted and slotted into the tower’s structural frame, depending on market demands, building investment, or client demands, creating a highly flexible, diverse, and adaptive system that emphasizes the continuous flows and activity of its multiple and diverse agents. These pre-fabricated modular components can be anything from individual rooms, façade paneling or envelope systems, to
even the scale of entire floor plates. These components are not permanent or fixed conditions, but rather social, economic, and morphological subsystems that can be removed and replaced as conditions change over time, ensuring that the tower’s program and function are always able to adapt to market and client demands.

An ideal site for the implementation of such a design and its principles would be the site of the Chicago Spire, a failed project to build a 2,000 ft (610 Meter) tower along the shoreline of Lake Michigan in the Streeterville neighborhood of Chicago, within close proximity to Navy Pier. The project, designed by Santiago Calatrava, failed for financial reasons, as the single use program of luxury residential units could not maintain adequate investment during the 2008 economic recession. What was left after the project collapsed was a $50-million-dollar hole in the ground, otherwise the foundation for a super tall tower which has since been left neglected and abandoned until the city’s recent interest thanks in part to recent park development programs.7

The planning and design methodology will utilize a modified BIM framework and implement recent, as well as future developments of generative design related software and principles. A driving factor in the mass customized design to fabrication process that the tower will demonstrate, is the implementation of machine learning and computer vision processes to identify, catalog, and automatically generate template design conditions for any possible scenario, be it joint connections, component assemblies, entire floorplates, or even structural frames. These processes and technologies analyze and optimize contextual relationships between designed components, products, manufacturing and production systems, as well as their associative social systems that are embedded and enmeshed within these relationships in order to better visualize and manage complexity. The template designs

created through this context specific, generative process can be used to design, engineer, or reverse-engineer products and components that address context specific conditions within the design and construction of the tower by means of simulation, including but not limited to: static stress, structural buckling, modal frequencies, thermal stress, thermal transfer, event simulation, non-linear static stress, shape optimization and light weighting, all of which can be directly analyzed alongside that of the project and production cost within the associated BIM model and database. This means that the use and translation of data is of extreme importance and further emphasizes architectures move towards managerialism and complexity sciences and away from traditional planning. Using organized, and unorganized, data as the building information model, machine learning and computer vision based software can navigate, analyze, and optimize relationships between components, assemblies, and information and production systems associated to these relationships. This process is similar in approach to product lifecycle management (PLM) \(^8\) software that’s used in automotive, aerospace and other large scale industrial products or production industries. A key benefit of a database system of management is that component and project data is not solely dependent on one software platform. Real world projects require a diverse number of people, skills, and specialized software/tools, and translating data and information into one software from another, or into a master document or program has always been a problem, and in some cases, all but impossible. A consequence of the methods

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\(^8\) PLM is defined by CIMdata as:
- “a strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information.”
- “Supporting the extended enterprise (customers, design and supply partners, etc.)”
- “Spanning from concept to end of life of a product or plant”
- “Integrating people, processes, business systems, and information”

“It is important to note that PLM is not a definition of a piece, or pieces, of technology. It is a definition of a business approach to solving the problem of managing the complete set of product definition information—creating that information, managing it through its life, and disseminating and using it throughout the lifecycle of the product. PLM is not just a technology, but is an approach in which processes are as important, or more important than data. It is critical to note that PLM is as concerned with “how a business works” as with “what is being created.” CIMdata. “All about PLM.” CIMdata: The Leader in PLM Education, Research, and Strategic Management Consulting. (2017). [http://www.cimdata.com/en/resources/about-plm](http://www.cimdata.com/en/resources/about-plm) [accessed 3/17/2017].
outlined above is the necessity to ‘digitally recreate all things,’ that is, have a digital or formatted data representation of all products and systems that exist in the world.

The design methodology outlined above follows strict adherence to complexity models of which contemporary business is now based. The sciences of complexity are also the new grounds upon which architecture and architectural discourse and practice are to be fixed, as it heralds a progressive and ‘new’ order in which productivity and invention escapes all external disciplinary and hierarchical powers, that is ‘planning’, and is therefore free from critical thought and critique. These organizational models, already employed within the most advanced sections of business, depart from rigid and segmented hierarchical work patterns evident of Fordist era production. Networked patterns of communication, mobility, industrial and immaterial production, research, and marketing are all globally integrated and require these very means of modeling, analysis and systemic steering, all of which are principles of neoliberal managerialism and all of which are being employed and marketed in today’s design and development tools such as BIM. These tools are absolutely necessary for architecture to stay a relevant practice within contemporary global networked societies, as the need to adapt towards the competitive and self-regulating demands of the ‘market order’ necessitates a constant drive towards progress and continual self-transformation. This principle is made manifest in the tower itself through modular and systemic adaptability of both form and function. This thesis calls into question whether the architecture of this system is even that of architecture, but of a post-architectural condition.
ACCELERATION: GLOBALIZATION AND NEOLIBERAL POST-FORDIST

NETWORKED SOCIETIES

Figure 1 Social Networks and Collaborative Problem Solving

2.1 NEOLIBERALISM

In order to understand the context of which this thesis and project takes place, the concept of neoliberalism must be first addressed. Douglas Spencer, in his work, *The Architecture of Neoliberalism: How Contemporary Architecture Became an Instrument of Control and Compliance*, understands neoliberalism as not some “unrestrained, extreme expression of the essential and unchanging ‘nature’ of capitalism,”¹² but as a “school of economic thought that has consciously directed itself, through key individual thinkers, as a project to remake the mentality and behavior of the subject in its own image, as in accord, that is, with a totalizing logic of economically opportunistic valorization.”¹³ A more simple definition is that neoliberalism operates as productive of models and means of power and control through the production of subjectivity,¹⁴ and it does this by means of truth games, or through fundamental truths of its own construct.

Among the fundamental truths that neoliberal thought has constructed are those that state that individuals can achieve only a narrow and very limited knowledge of the real complexities of the world; that the planning of society by the individual is, consequently, an unattainable proposition; that the economic market is better able to calculate, process and spontaneously order society than the state is able to; that the competition between individuals facilitated by equality of access to the market is a natural state of affairs; that the job of the state is to intervene to ensure the conditions of possibility that sustain the operation of the market and to ensure that individuals are rendered adaptable and responsive to these conditions; that is its truths are to guarantee liberty.¹⁵

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¹³ Ibid.
¹⁴ Ibid.
¹⁵ Ibid. p. 2.
These truths work to produce the subjects of its competitive market order by means of the market itself as opposed to forms of disciplinary administration or hierarchical systems of governance. In this case it’s the market that exercises control of the subject, and it’s through the re-modeling or self-transformation of the subject, that these very conditions are sustained. The human subject in this scenario, can be considered as a post-enlightenment being, or one that has forgone critical reflection and rationality in favor of being environmentally adaptive and driven by affect. Architecture plays a very important role in this transformation and reformatting of the subject, as its function prescribed by this condition is that of producing flexible environments that enable infinitely adaptable subjects by means of connectivity, communication, mobility, and diversity.

Douglas Spencer’s claims are influenced heavily by contemporary theorists and practitioners use of Deleuze and Guattari\(^\text{16}\) as well as by Michal Foucault with the creation of the ‘subject.’ Within the context of Architecture, Spencer refers to the works of Greg Lynn, Zaha Hadid, Alejandro Zaera-Polo,

\(^{16}\) Summary of concepts and examples taken from Deleuze and Guattari’s *Anti-Oedipus* – In terms of Capitalism, “the process is analogous to the seduction of individual laborers (desiring machines)* towards the product and eventual capital (body without organs) that they produce. Capital, though entirely produced by laborers, is greater than any one of them taken individually, and even a large mass of them taken collectively. Here Capital appears as primary to labor-power, and ideology becomes the primary reality. The laborers are now willing to defend the capitalist system that oppresses them, therefore the aggregate of capital (Oedipus or any social structure), is continuously breaking apart, rupturing, and rearranging its functions in an attempt to surpass itself and appropriate and re-appropriate all individual forces into its universal structure.”

“Capitalism works so well because it incorporates the antithesis into its structuring, that is, it takes the form of a revolutionary machine, its function to accelerate, increase and speed-up the processes of break-downs and recombination’s, to create ever new codes and arrangements of desiring machines, continually surpassing itself. Each restructuring of itself a form of reterritorialization, not deterritorialization.”

**“an assemblage of desiring machines is not a unity, not a whole, not a totality; the machines are not parts; each functions separately from the others, any can break off at any time or reshuffle to establish new connections, new assemblages. What is novel in Deleuze and Guattari is the eradication of any appeal to totality, to an organism as such. There is as yet no organism, no subject, no Oedipus--or rather, Oedipus is made of millions of swarming mini-Oedipuses, each their own subject. In order to get from the many to the one, something else must happen: the one as a unity that transcends any one of its parts must be produced, and it must be produced by the individual desiring-machines themselves. And once they produce the one (the phallus, the despotic signifier), the one becomes real, so real that it appears as primary to the many”**

Reiser + Umemoto, and Rem Koolhaas to name a few, stating these practitioners often “profess their hatred of hierarchical planning and their enthusiasms for spontaneous ordering and self-organization,” however they all share the same conception of human subjectivity, namely the “nature of the human subject, of its relations to the world around it, and how it should be governed.”\(^{17}\) This understanding of subjectivity has paved the way for architect’s to design and build for the continued expansion of neoliberalism’s ideals within the realms of work, education, culture, and consumption, backed by an economic market that seeks to continually legitimize its management of individuals.\(^{18}\) Not surprisingly the transition to architecture and the built environment is best seen in the recent adoption of BIM as a strategy for design and management of the built world. The key benefits to adopting a BIM related workflow in architecture are the improved platforms for connectivity, communication, mobility, and diversity, all of which coincide with the goals of contemporary architecture under this neoliberal condition. Neoliberalism is the context from which Schumacher’s theory and style of Parametricism participate, Parametricism in general being “the process by which we organize information, approximate the world and visualize its measurements.”\(^{19}\) Parametricism, according to Schumacher, being “the conceptual, formal and computational resources for forging complex, variegated urban order on the basis of parametric logics that allow it to adapt to dynamic market forces.”\(^{20}\)


\(^{18}\) Ibid., p. 2.


2.2 THE COMPRESSED AND ACCELERATED WORLD

Fear is increasingly conditioning many decisions in how to now best proceed in terms of large scale ventures, be it anything from governance of the state, to the built project. This is often due to increased complexity in both the production and management processes involved, and the inability of humans to properly deal with or handle the levels of complexity involved in these scenarios. The proposition that humans can have little knowledge of the world, their view being too limited and narrow to grasp its workings and its meanings, is fundamental to neoliberalism and is one of its many ‘truths.’ Friedrich Hayek, a proponent of neoliberalism, claimed that “we cannot and need not be aware of the rules that govern our social order. These rules – the ‘natural laws’ of traditions, institutions, customs, and conduct – have evolved over the course of time without ever having been products of conscious design by human minds.”21 Planning, or conscious rational design, “leads to dictatorship because dictatorship is the most effective instrument of coercion and the enforcement of ideals...”22 “Instead of ‘conforming’ to our knowledge, the world demands that we submit to the innate ‘knowledge’ of the market, to its capacity to spontaneously order our lives and facilitate our freedoms.”23 The problem with the removal of planning however, is that the human loses relation to the thing in question, its reality becoming separate from our perception of the world and how things operate, instead becoming a fundamental truth and taken as ultimate truth – a universal law – effectively eliminating critical reflection and critique. The inner dimension of our relation to the process and workings of the thing is left out of the equation, and all that remains is the outside surface of affect, effectively compressing, or removing a dimension of understanding and knowledge from the world.

22 Ibid., p. 18.
23 Ibid.
Philosopher and planner Paul Virilio however, attributes this fear to the shrinking of the earth by means of a different process, saying that “space is dwindling, compressed by instantaneous time “of which he is referring to the speed of real-time tele-communication technology offered by phones and computers that’s transmitted by waves.24 He claims “in acceleration, all we can do is manage and administer this fear instead of deal with it fundamentally” and that administration of this fear is “politics without a polis; the administration of people who are no longer home anywhere.”25 This is partly because fear is now an environment, as well as the new culture of our globalized world. States are increasingly tempted to create politics regarding the orchestration and management of this fear, combating contagious stock crises, faceless terrorism, and lightning pandemics, as the state’s traditional prerogatives are now eaten away.26 No longer can the state ensure one’s physical safety. What we have is a condition where the lone individual can cause a global pandemic crisis. Virilio states that “fear and its administration are now supported by the incredible spread of real-time technology, especially the new ICT or new information and communications technologies”27 with its rampant proliferation thanks to the real propaganda of media coverage, many of which is now algorithmically defined to isolate and group like-minded individuals on a networked platform, providing them with tailored coverage determined by keyword searches and pattern recognition. Virilio claims that this “combination of techno-scientific domination and propaganda reproduces all the characteristics of occupation, both physically and mentally.”28 BIM is one such product of the ICT industries and a key driver in the formation, visualization, simulation, and management of the globalized city. It is a product made specifically for management and mitigation of risk, and one that seeks to connect architects, engineers,

25 Ibid.
26 Ibid.
28 Ibid.
clients, and stakeholders to a more manageable and adaptive system. The software is promoted and targeted towards individuals and corporations that hold considerable financial and political power, those who can pay for large scale development and infrastructure. By this time, most large corporations are already invested in BIM processes of development and delivery for their built projects.

2.3 THE GLOBALIZED CITY

The current phase of the world economy ascended from information technologies and is associated with increase in the mobility and liquidity of capital, mainly in terms of flows. The international economic system values privatization, deregulation, and opening up of national economies to foreign firms resulting in a weakening of the national and the strengthening of the global. Saskia Sassen argues this process of reterritorialization around the network of interconnection is what’s driving new urban and capital growth resulting in a new type of city, the global city. The global city places emphasis on the actual work of managing, servicing, and financing a global economy, or more precisely the networked economy. This networked economy is characterized by cross-border networks and specialized divisions of function and services among cities, as opposed to international competition, with the localized ‘city’ the physical product of these global economic forces. 29

Cities mark a strategic site for transnationalization of labor and the formation of translocal communities and identities, and along with the de-nationalization of urban space and the formation of new claims made by transnational actors, helps call forth the question of who is ‘making’ the city. With such an increasingly complex system of dynamic processes and claims, one could argue it’s no longer the corporations, the government, or its citizens, but a combination of all agents and actors catering to an

underlying element of fear associated with keeping everything from imploding. Virilio attributes the de-nationalization and delocalization process to acceleration dominating accumulation, resulting in the destruction of the mechanism of production. “The acceleration of reality is eliminating the accumulation of products, but also of goods, habits, and people.” 30 The mantra of just-in-time stock ensures almost no stock, only the flow of goods. The ‘here and now’ also no longer has any meaning anything under delocalization, with the ‘here and now’ operating at too great a cost and therefor is no longer of any value. Sassen objects to this complete declocalization, rather thinking it as more a relocation of traditional good and service labor and replacing it with high-level professionals in high profit specialized goods and services, where speed is the object of value. These highly specialized service firms are more engaged in more complex and globalized markets and are more subject to agglomeration economies which favor the complexity of services, operation in uncertainty, and speed of transaction. This transition is precisely what’s taken hold of the architectural profession with its adoption of BIM as a primary production tool, as it is a product catered to precisely this scenario. BIM delocalizes the built environment from its geography and culture and re-localizes it within the collective intelligence of the globalized network, namely that of the cloud, and provides it a direct link to the global financial networked economy.

Figure 2  Ju 87 Stuka, The backbone of German air support for the blitzkrieg assaults against Poland, France, and the Soviet Union. 

3.1 BIM

AEC projects are undergoing rapid transformation in how they are designed, engineered, built, and managed. New technologies have not only allowed the realization of these goals, but now offer tools to better deliver a greater ROI for firms of all sizes in these industries. BIM (Building Information Modeling) is one such tool for better managing complex projects that require collaboration across numerous industries, firms, and stakeholders. The underlying principle of BIM is that design teams develop an intelligent, 3D model of their project that lets all those involved gain a deeper understanding of how the building will perform in both design, development, and construction.

Architecture firms are increasingly under pressure to adopt BIM as a strategy in a hyper competitive global market. Most firm leaders understand the BIM process has fundamentally changed how buildings are planned, designed, constructed, and operated and is a major point of contention within the profession. Firms are increasingly encouraged to move away from CAD-based 2D design which lack the intelligence and connected, interoperable workflows provided by a BIM related process, which by contrast offers more efficient analysis, collaboration, simulation, and visualization.

At a base level, BIM allows increased visualization and documentation. Construction documentation is automatically generated as an output of the 3D model, however the true benefits of BIM rely on a deeper multidisciplinary function that enables coordination with MEP and structural design models. When everyone on the extended team is involved in a BIM project, benefits include reduced time, increased quality, and reduced risk.

BIM for some time now has been widely considered the new standard practice among architecture firms. Although more widely adopted and entrenched in larger firms, smaller firms on the fence as to whether the time saving and error reduction of BIM outweighs the learning curve and cost of adoption, are starting to implement BIM strategies out of necessity in order to compete for clients. Only
a small population of people (clients) can afford the cost and management of a built project, and many of the largest clients have already been exposed and involved in BIM related processes and services. Take Gensler (largest US architectural firm) for example. Their clients represent: 2,771 clients spanning every market sector and a planet’s worth of cities and regions, 42 of the 50 top-ranked Fortune 500 companies, 18 of the highest-grossing law firms globally, 9 of the top 10 technology companies in the US, 20 of Interbrand’s 23 Best Global Brands, 9 of the top 10 commercial banks in the US, 8 of Fortune magazine’s 10 best companies to work for in the world, and many others. Gensler utilizes BIM for every project, and all of their clients have been exposed to BIM related processes and workflows. Repeat clients/business are how architecture firms survive and make a profit, and clients who enjoy the benefits of BIM projects lead not only to more repeat business, but a greater chance for referrals.

“As of 2012, 70 percent of architects in North America surveyed by McGraw-Hill Construction report that they have adopted BIM in some form.” BIM adoption has proved slower with regards to smaller firms with a report from an AIA survey in 2014 revealing that “Among one-person firms, a mere 22 percent use BIM, and just 37 percent of firms with fewer than nine employees use BIM” while “BY 2013, more than 80 percent of firms with more than 50 employees used BIM, and more than 60 percent of firms between 10 and 49 employees had also turned to BIM.” This adoption of BIM is essential for winning work in today’s market, and for most architecture firms, winning work means competing in a bidding process. “49 percent of architects’ report that marketing new business is a top benefit of BIM” The projected influence of BIM’s impact on the AEC industries is a given, and even those not working in BIM will be impacted by the BIM process in the near future, especially as adoption grows worldwide.

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35 Ibid.
Delivery of a project is now directly correlated with the level of investment in design collaboration among all parties involved including multidisciplinary teams and project stakeholders. BIM adoption in the UK is also increasing at an extreme rate with 58% of architects using BIM now, 86% projected to use BIM within the year, and a staggering 95% expected to be using BIM within three years.\textsuperscript{37} What’s more is that “28 EU member states can recommend, specify, or mandate the use of BIM for publically funded construction and building projects in the European Union as of 2016”\textsuperscript{38} while the “UK, Netherlands, Denmark, Finland, and Norway already require the use of BIM for publically funded building projects.”\textsuperscript{39}

The increased and projected adoption of BIM can be attributed to four primary trends concerning the AEC industries, those being: The AEC industries are entering an era of connection, project delivery is becoming more collaborative, cloud-based collaboration is increasingly enabling BIM processes, new project delivery models, and the desire for connectivity, and the cloud has finally come of age,\textsuperscript{40} all of which have a huge impact on how design professionals now carry out work, freeing them up to work with anywhere, anytime access on any device. While the modeling portion of BIM might need a workstation for efficiency, the Building Information does not, and can be accessed, analyzed, and integrated across multiple project teams and data management systems. The AEC industries have increasingly become more outward, focusing on true collaboration with external parties with the speed, efficiency, and freedom provided by cloud based services. “The ability to work in a collaborative cloud environment makes you an attractive partner to other AEC organizations,”\textsuperscript{41} with 81% considering this at some level when making project team selections, and of that, 28% require it.”\textsuperscript{42}

\textsuperscript{39} Ibid.
\textsuperscript{40} Ibid.
\textsuperscript{41} Ibid.
\textsuperscript{42} Ibid.
With an increased emphasis on collaborative workflows, a BIM model contributes to streamlined collaboration and reduction of risks with more accurate scheduling, project planning, and budget estimation. Visualization also helps reduce risk of client’s expectations with that of reality, and the proliferation of recent BIM to VR software and service development such as IrisVR, InsiteVR, and V-Ray further expound on the importance of establishing an accurate representation of reality from both an aesthetic and financial standpoint. Visualization of the project also includes how owners better understand, participate, and manage project scope. “A 2015 SmartMarket report from Dodge Data & Analytics found that: 85% of owners found that BIM increased their ability to participate in the design process, 90% found that BIM produced better construction documents, 70% found improved ability to plan construction, 78% found an increase in their ability to manage project scope, and 91% found an increase in ability to understand the design.”43 Of owners that use BIM on projects, 93% feel that their projects meet their quality expectations and the same percentage found that BIM improved the quality and function of the final design.44

Not only does BIM provide the client and owner with clear project visualization, but improves the quality of work by those involved. “Of architects that use BIM, 74 percent found that BIM improved project outcomes, and 89 percent reported that BIM improved the quality of the final design.”45 This translates to smoother collaboration with consultants and multidisciplinary project teams, even at the level of construction where “98 percent of contractors think that BIM improves the constructability of the final design.”46 This is thanks to one of BIM’s strongest factors, which is the fact that changes ripple through the model automatically and update for every document and drawing that references them. This novel feature saves substantial time and eliminates the need to rework, leading to better business value in

44 Ibid.
time saved translating directly to enhanced margins, fewer errors, fewer change orders, and reduced risk.

3.2 THE BIM MARKET

"The world BIM market is expected to reach $11.7 billion by 2022 at a CAGR of 21.62% over 2016-2022."\(^47\) Increased ROIs along with substantial time and money savings have led to the software tool becoming exceptionally popular among end users, most notably architects, however the increased nature of collaboration in the AEC industries have facilitated its subsequent adoption in engineering and especially construction with regards to commercial and infrastructural projects. Increasing government mandates regarding BIM are also projected to increase its adoption worldwide.

Market growth can be attributed to enhanced data communication and coordination among stakeholders as well as increased ability to manage data at remote servers with improved user inter-coordination provided by cloud based solutions. These data driven solutions help promote an increasing desire and need for green buildings through the use of simulation while also help to promote effective prefabrication techniques dependent on data exchange. While the world BIM market is segmented based on solution, software development type, end user, vertical, and geography, the adoption rate among commercial and infrastructural projects, owing to increasing mandates in accordance to government regulations, is expected to spike considerably.

What’s worth pointing out is that at the end of the day, BIM is not necessarily an architectural design tool, but a business and data management tool under the Information and Communication Technologies

industry, that is, the value comes from the ability to efficiently and effectively navigate the complexity of what a built project entails, with architecture being only a small fraction of the overall process. This highly differentiated view on function and role with regards to scope and service, is exactly what people like Patrik Schumacher address when talking about Parametricism in accordance to the architectural profession.

3.3 ICT’S OCCUPATION OF ARCHITECTURE

“A blitzkrieg is a military and technological phenomenon that occupies you in the blink of an eye, leaving you dumbfounded, mesmerized.” 48 All of a sudden, the architectural profession has been occupied. The profession has put up very little resistance in this takeover, almost seeming to embrace the transition, accepting the jump to cloud-based data management platforms as eventual fate and even destiny, leaving behind design foundations and thinking for communications and data management tools, a move that still has many completely taken unaware because they view it blindly as progress, or more precisely a means to survive in today’s highly competitive markets. The occupation of progress “places us under surveillance, watching us, scanning us and evaluating us and it is increasingly present” 49 always making us think there are updates to be made and that we are always behind and is a product of globalized stress and fear. This has caused many to make the jump to BIM, as traditional tools and methodologies cannot offer the same product and service as one shared and worked on by collective intelligence and diverse specialized multidisciplinary teams. BIM is not a design platform, but a business and data management tool, a software and service provided by the ICT industries for managing complexity for today’s built projects. Many architects don’t realize this. Firms uneducated in BIM or not

accustomed to large scale projects involving many separate teams and services only view it as a
different form of CAD (as a drafting tool), updated for today’s practice. You cannot fault a firm for
jumping on board the BIM bandwagon though, as the benefits towards the profession are remarkable in
terms of running and managing a business whose purpose is to deliver absurdly complex services under
increasingly shortening timeframes.

Figures such as Jean-Francois Lyotard condemn the model by which ‘Parametricism,’ made
possible through collaborative tools such as BIM, operates, claiming the ideology of Schumacher as a
new ‘terror,’ one in which we are turned into subjects of a system, unquestionably molded to the
demands of the market, demands which are derived from evolutionary order and facilitated by self-
organization.

Contemporary network society demands that we continuously browse and scan as much of the
social world as possible to remain continuously connected and informed. We cannot afford to
withdraw and beaver away in isolation when innovation accelerates all around. We must
continuously recalibrate what we are doing in line with what everybody else is doing. We must
remain networked all the time to continuously ascertain the relevancy of our efforts.50

Not only is this ‘molding’ to demands evident within architectural theory and discourse, but also in its
practice and management, effecting the very worker and his or her tools of production. The removal of
Antagonisms is paramount to the efficiency in communication and cooperation needed for a system to
operate as self-organizing. This removal of antagonisms is echoed in both the removal of critique from
the discourse, and the removal of old and outdated tools and methods from the practice. The
architecture firm will be forced to adopt BIM in order to fundamentally operate and continue work, or

50 Schumacher, Patrik. “The Historical Pertinence of Parametricism and the Prospect of a Free Market Urban
else be outstripped of its ability to function within today’s needs and processes, an explanation as to why BIM *needs* to be adopted in regards to concerns of governance in today’s day and age.
Figure 3  Ouroboros

4.1 PARAMETRICISM AND FREE MARKET URBAN ORDER

A vital capacity of architecture, according to Patrik Schumacher, is its ability to manifest societal trends, such as the technological, socioeconomic, and political. Architecture cannot however, substitute itself for the political process. It can only “react with sufficient unanimity and collective vitality to dominant political agendas that have the real power of a tangible political force behind them”\textsuperscript{52} and architectural discourse must “develop innovative architectural responses to these historical transformative trends.”\textsuperscript{53} Debating politics within architecture can never make architecture a participant in the political controversies themselves, and can only lead to an identification of manifest political trends. The trends identified by Schumacher, the “advancing processes of post-Fordist restructuring, globalization, market liberalization, and democratization” are the political and socioeconomic premises of his self-proclaimed epochal style of Parametricism.\textsuperscript{54} Parametricism operates within the demands of post-Fordist flexible specialization, with its spatio-morphological ordering compatible with forces of market driven urban development.

“Parametric urbanism posits its vision of the bottom-up emergence of a complex variegated urban order whereby different geographical, climatic, industrial and cultural specificities of development sites become the starting point for the self-amplifying, path-dependent emergence of legible urban identities.” \textsuperscript{55}

This method seeks to critically challenge the failure of top-down planning, casting it as no longer economically viable and instead promotes a method that is inclusive of market-led urban land use allocation that also aims to highlight the underlying social complexity of unique urban identities. Under


\textsuperscript{53} Ibid.

\textsuperscript{54} Ibid.

\textsuperscript{55} Ibid. p 20.
globalization, these urban identities are subject to ‘white noise sameness’ and gentrification processes and Parametricism is partially a response to capitalize on the reterritorialization of those
deterritorialized through urban displacement, be it actual or mentally displaced as in the case of Virilio’s philosophy of speed. This method also seeks to critically examine architectures’ self-proclaimed role as a profession, or what architects really do and what they should be doing. Schumacher argues for functional differentiation based on societally reinforced distinctions. He argues that “Society can parallel process, (through collective intelligence) a much more complex and accelerated evolution via the co-evolution of autopoietic, functional subsystems that stimulate each other’s evolution without being subject to a single master discourse” and that the evolved complexity of world society and world division of labor cannot be totally de-differentiated.56 A reality of 21st century world society is that de-differentiation would imply a crippling loss of productivity, time, and capital and that actors who want to survive, need to know precisely what it is they are doing, that being said, there is no room for politics and activism in architecture since those would be differentiated, specialized and professionalized domains.

Functional differentiated societies mean the architect is ultimately only answerable to his client, and it is the client, obliged by political imposition, to take care of all stakeholder’s interests that are considered politically relevant.57 BIM platforms help reinforce this distinction, by giving the client an equal seat in the design process, as the societal, financial, and political distinctions are increasingly prevalent design factors that need to be addressed and help give shape to manifest physical and material form.

57 Ibid.
Parametricism calls for a self-regulated system, that “within the given legal and political constraints, the market regulates the programmatic allocation of land resources to the effectively demanded social uses as anticipated by entrepreneurs.” 58 This is in effect an update of the modern movement, one that takes into account contemporary conditions and of globalized society and economy, its key distinction being ‘post-Fordist network society’ over Modernisms ‘Fordist mass society.’ 59 Schumacher claims this movement is the only truly innovative direction within contemporary architecture, and that by now, the movement has “sufficiently demonstrated its capacity to credibly aspire to become the universally recognized ‘best practice approach to architectural and urban design globally.” 60 This in in no small part thanks to BIM’s takeover of the practice and its influence on project management and outcome, offering a platform of differentiation, specialization, and a means of effective communication and collaboration in response to globalized affects.

BIM and Parametricism favor the quantitative world view of big data and data driven solutions. These methods seek to resolve purely quantitative problems at the expense of the qualitative. Self-regulation, automation, and the mathematization of reality leads one to question the possibility of exobiology or life outside of life and calls into question the advent of an extra-humanity, to coincide with our already present extra-world, the digital cyber-world, of which BIM partially operates from. Virilio argues that our quantitative obsession is leading us to a qualitative revolution,61 and that the trend of design activism and participatory design are in fact outcomes of this, however Schumacher claims this revolution is already a lost battle and a false pretense at the level of architecture and urban

59 Ibid.
planning as indicated by where the profession currently operates and its current ties to globalized networked economies.

4.2 CRITIQUE

The great fear in all this, is that things are now too complex and enmeshed with one another to truly understand or govern anymore, and therefore cannot be approached philosophically or politically, the speed of their manifestation has rendered them as fate and destiny and unable to be analyzed critically. Chantal Mouffe confirms this belief in The Return of the Political were she claims that we are unable to envisage the problems facing our societies in a political way due to the uncontested hegemony of liberalism, “which has re-installed a rational and individualistic belief in the availability of a universal consensus as the basis for liberal democracy, negating antagonism and conflict.” 62 What she is really trying to address here is the inability to comprehend the pluralistic nature of the social world, and the inherent conflicts in that system that make it work, conflicts that no rational system can ever interpret or solve for.

Teddy Cruz uses this argument as the basis for offering up a counterpoint and critique of Schumacher’s Parametricism regarding the architecture of neoliberalism. Schumacher’s Parametricism runs off the notion of architecture as an autopoietic system, or a system that is capable of reproducing and maintaining itself, and the issue here is that that notion fails to take into account the social aspects that make architecture exist, which fall outside of the formal and historical references of architecture that Schumacher uses. One of the sore points of Schumacher’s theory, according to Cruz, is the goal of parametric architecture “to give aesthetic order to the visual messiness of the neoliberal city.” 63

63 Ibid.
argues the primary flaw in Schumacher’s argument is how he has envisioned the neoliberal city as simply “an object that needs to be stylistically unified” and that it “ignores the fact that the actual havoc that neoliberalism has exerted upon the contemporary city in the last decades of the economic boom is not just a visual phenomenon but an actual institutional process that produced a violent blow to our economic. Social, and natural resources.” 64 Cruz quickly points out the that Schumacher’s project, “smoothly aligns itself with the power of a neoliberal political economy of urban growth that has been characterized by an antipublic agenda, engendering unprecedented urban asymmetry and socioeconomic inequality,” 65 and that the main problem with the neo-avant-garde architectural agenda is its “overt indifference to the societal and urban conflicts that could in fact be critical content to investigate and deploy new architectural parameters that can problematize the politics of aesthetics and close the gap between social responsibility and artistic experimentation,” 66 both of which are absent from an autopoietic system that seemingly tries to nullify the conflict of the other.

Current trends in the autonomy in architecture can be argued as the byproduct of this indifference to socioeconomic and political material. The aesthetic relativism of the speculative commercial logic of hyper-capitalism lends itself towards the creation of a “postmodern nightmare,” one in which the unifying principles of Parametricism seek to displace through a return of top-down autonomous and self-referential processes. Throughout history, the avant-garde utopian vision, of which Parametricism is a part, “has always been to give formal order to the chaos of social difference by imposing structural and compositional strategies that somehow will bring the political, cultural and aesthetic unity to a society run amok,” 67 but is based on modernist logic that fails to take into account the necessary complexity of parameters of social difference that make any current global system

64 Ibid.
65 Ibid.
66 Ibid.
67 Ibid.
function. Cruz therefore argues Parametricism as the “official architectural face-lift of neoliberalism, as it unifies the Universalist consensus politics of neoliberal global capital, into an apolitical formalist project of beautification, whose relentless homogeneity hides any vestige of difference, and the conflicts that are at the basis of today’s urban crises.” 68

While products associated to BIM offer collaborative and communicative processes, those avenues are channeled strictly toward financial and management strategies, and make no effort to engage any social or cultural parameters into their design methodologies. A key selling point of these products is to reduce conflict and streamline processes, rather than open them up towards the debate and negotiation often associated open systems of urban social complexity. The only logical outcome of such closed and self-referential systems is the further striation of socioeconomic inequality and violence. Cruz concludes that “one of the most relevant and critical challenges in our time is the problem of how we are to restore the ethical imperative among individuals, collectives and institutions to coproduce the city, as well as new models of cohabitation and coexistence in anticipation of socioeconomic inclusion,” 69 all of which are factors that are absent from today’s BIM processes and ICT’s privatized industries of which the global city is designed and managed.

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69 Ibid, p 192.
Figure 4  Almere Oosterwold: do-it-yourself urbanism\textsuperscript{70}

5.1 A NEW COLLABORATIVE CITY MODEL

There has been some recent work attempting to level the playing ground with regards to large scale architectural and urban development. The question of whether cities should be planned top-down, as in the case of modernism and its preceding movements, or bottom-up, as in the case of design activism and Parametricism’s claims remain to be seen. Proposals for a new model of planning, one that enables “an understanding of cities as open systems whose agents act on them simultaneously from below and above, influencing urban processes by their interactions with them and with each other,” 71 calls for a method that identifies complexity and parametric design principles, but allows for societal involvement and participation at all levels that enable and promote the variables of conflict and negotiation. This new collaborative urban development process is a “combination of collaborative planning (which already embraces various agencies and derives decision-making from negations between them) and collaborative design (whose existing methods rely on rule-based iterative processes which control spatial outcomes)” 72 and seeks to address the current shortcomings of both these methods in the failure to properly address and simulate realistic power negotiations in the evolution of the environments they plan, and the inability to properly model the decision making mechanisms of the environments they control.73 To coincide with this development, the use of gaming as a method for negotiation and knowledge creation stems from an interest in its potential of encouraging and allowing the development of collective intelligence that is derived from real lives of players, rather than dissociative quantitative databases of numbers and statistics derived from machines and sensors. Gaming at an urban scale enables players with conflicting interests to have the opportunity to develop compatible and even shared visions, a process that in fundamental in the relationship and establishment

73 Ibid.
of communities in the long term. The foundation of an open system design process could help increase social coherence and local agency at levels that Parametricism’s autopoietic networks cannot, due to the additional metrics of engagement in different actors and agencies. A more socially democratic system however still suffers the same fate to Virilio’s laws of speed, and will be more subject to failure in the context of globalized networked processes due to its inability to function at the level of instantaneous.

5.2 SHORTCOMINGS

Collaborative city planning is still a relatively new discourse, with few examples that made it past the research phase and into the actual processing and execution of real city planning projects. The goal however is that every new case test and proves the applicability of these methods to a specific urban complexity, while challenging the methods ability to adapt and interpret new features tailored to each unique condition. Current research in BIM associative processes are using a very similar logic in new adaptation techniques associated to generative design, chief among them being Autodesk’s Design Graph, which is an experimental software that seeks to provide machine learning capabilities of cloud based data mining and management towards formal and aesthetic design related principles. 74 Again, the goal is to have the collective intelligence of all design and engineering professionals using the service to create a database of design solutions that can be interpreted, learned, and applied by the algorithm to suite each and every unique design condition, however this data centric design method is extremely exclusive to only those of which who pay for and use the service, negating the public and all non-design or engineering fields of knowledge favoring instead the functionally differentiated approach as Schumacher described. BIM’s interest in facilitating communication exclusively operates at levels of

highly specialized and differentiated professional roles, with major oversight to opening up design
associative processes to the public domain. Government mandates and proprietary software availability
seek to create a closed system, for the benefits of being easier to manage and to increase the efforts to
mitigate risk and fear in an increasingly globally networked and enmeshed world.
MASS CUSTOMIZATION AND PERSONALIZATION IN DESIGN AND CONSTRUCTION

Figure 5  Innovative joint technologies, multi-material mix and large-scale use of aluminum: The new body shop at the Porsche plant in Leipzig is one of the most modern and innovative facilities of its kind in the automotive industry.  

6.1 WHAT IS MASS CUSTOMIZATION AND PERSONALIZATION?

The primary goal of mass customization is to design a top-down framework in order to enable bottom-up creative interpretation, improvisation, and execution.\(^7^6\) This fundamentally aligns with Parametricism’s goals in establishing a bottom-up emergence of complex order, however it provides an additional platform of collaborative design and planning methods whereas Parametricim’s growth is only self-referential. Mass customization as a movement within the AEC industries is a response to building and construction’s embeddedness in economic trends, and seeks to provide an offering that meets the demands of each individual customer while still being produced with mass production efficiency. Mass customization is also a response to globalization. The market for products and services catered to individualistic needs is a result of the delocalization under globalization and a byproduct of neoliberal policy. This delocalization is not just at the level of global cities, but part of a greater crises in population growth and the general mass displacement of individuals and communities in our contemporary era. Stakeholders in these projects are increasingly forced at extensive and unprecedented rates to acknowledge and improve diverse and conflicting objectives. Stakeholders demand to enhance cost, efficiency, and economic sustainability of constructions, while the market demands that function, performance, quality, comfort, and social sustainability increase. Building professionals demand the reduction of energy consumption, lower ecological footprints of building processes, and decreased carbon emissions, while designs demand aesthetic values.\(^7^7\) All of these conflicting agendas produce problems and conflicts that need to be resolved in the completion of a project, and all of these gaps in communication take considerable time and money to resolve. BIM as a


platform helps address many of these issues, and is a key framework for future mass customization practices to emerge as it partly relies on global network economies to identify a wider range of potential markets. “The ability to manage a value chain from the customers’ point of view determines the competitiveness of many companies,” 78 with this in mind, it’s more often than not the customer who determines what the business is. Many firms and industries, both product and service, are increasingly faced with the uninterrupted trend of heterogeneity of demand79 resulting in manufacturers being forced into making project portfolios with increasingly diverse variants. This means many companies increasingly have to process customers’ demands individually, a key issue Mass Customization seeks to resolve by offering flexible manufacturing services that allow for a reduced tradeoff between individuality and efficiency. Modern ICT technologies allow for increased interaction between customers, workers, services, and manufacturers, and is paramount in the establishment of effective systems of collaboration that rely on shared platforms, models, and data, BIM being a primary example.

Working definitions of mass customization continues to evolve over time as scope increases and/or decreases with investment in different markets and industries towards mass customized solutions, however the general idea remains the same. Tseng and Jiao (2001) offer one of the most comprehensive definitions, that being “The technologies and systems to deliver goods and services that meet individual customers’ needs with mass production efficiency.” 80 Dell offers one of the best examples of successfully implementing mass customization into the very basis of their products and services. A key factor of Dell’s growth and success is based on the firm’s “ability to produce computers on demand, meeting precisely the needs of each individual customer and then producing these items with no finished goods inventory risk.” 81 Here is an example where the product is made after payment,

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78 Ibid.
79 Ibid.
80 Ibid.
81 Ibid.
not prior, and avoids all the risk associated to inventory and accumulation. Current architectural practice typically has pay associated to the adequate completion of design phases, as budget and cost estimation revolves around time associated for basic services, those being Pre-design/Programming, Schematic Design, Design, Development, Construction Documents, Bidding and Negotiation, and Construction Administration. A mass customized and more differentiated agglomeration process of building would result in a very different model, with each part now approached as a design build project and subject to different forms of management and cost associations. Models which have had considerably more success are shown in industrial products and ICT communications services, where statistical modeling and data analysis are more prevalent.

6.2 PRINCIPLES

Within the last two decades, mass customization has emerged as a dominant business strategy due to its interpolation with emerging ICT technologies, affording customers the ability to get what they want, when they want it. As a business paradigm, mass customization provides an attractive business proposition. Value can be added by directly addressing individual customers’ needs while also utilizing resources efficiently without the incurring extra costs associated to variation and unique products.82 Under mass production, competition was based on price and conformance to dimensional quality. Mass customization operates differently, with profit now associated to a set of organizational capabilities that can supplement and enrich existing systems, these being solution space development, robust design processes, and choice navigation,83 with success now determinant on the combination of these

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83 Ibid, p 18.
capabilities into meaningful and integrated ways, creating value from serving individual customers differently.

6.2.1 SOLUTION SPACE DEVELOPMENT

Mass customization is reliant on identifying the idiosyncratic needs of its customers, specifically the product attributes along which the customers’ needs diverge the most.\textsuperscript{84} This is in contrast to mass production, where producers must focus on serving universal needs shared by all its target consumer base. Once the attributes of divergence are identified, a business can define its solution space, that being a clear delineation of which products or services they can offer as well as that which they cannot. Matching the options of this solution space with the needs of the target market is crucial, with data associated to needs such as preferences, desires, satisfaction, motives being fragmentary and often subjective among large numbers of customer’s preferences. The processes used to traditionally collect this data can also be extremely costly and complex in nature, often taking the forms of focus groups, conjoint analysis, customer surveys, and complaints, methods which are not often best suited for finding the best option. This is where data mining and statistical modeling of ICT technologies reigns supreme, by offering adaptive and predicative methods of extracting customer experience intelligence. This is done by continually looking at customer’s transactions, behavior, and experiences, and by analyzing that information to establish an understanding of customer preferences, a method best exemplified by social media and user generated content, a process which offers unlimited (generative) refinement as long as the product exists. It is worth noting that mass customization does not mean limitless choice, as there is no optimal working structure to support the breadth of unlimited options and products. Physical goods are limited to local and/or global constraints and are determinant by ability to source materials, labor,

\textsuperscript{84} Ibid.
technology, and capital. These parameters however, can be factored into an integrated product delivery system and can be generatively used as a design aid under BIM platforms.

6.2.2 MODULARITY AND ROBUST DESIGN PROCESS

Modularity is an essential aspect of mass customization, with each module serving one or more well-defined functions of the product, these being available in several options that deliver a different performance level depending on context. This system of modularity demands compromise, with not all notional customization options routinely offered, but only those that are consistent with the capabilities of the process, the given product architecture, and the given degree of variety. 85 “The product family approach has been recognized as an effective means to accomplish an increasing product variety across diverse market niches while still being able to achieve economies of scale.”86 Product families can be seen in many industrial and consumer products, and is an underlying principle in BIM associated software, Autodesk’s Revit being an example that explicitly uses the term ‘Family’ for its (modular) digital model components. This is also the general principle behind object orient programming from which Revit is derived, a method of programming where programming objects (modules) are used to form additional objects and are arranged based on hierarchies, in which a single object (either variable or function) can be used in several but related ways, effectively creating a system where code can easily be reused or interchanged depending on the application or context. 87 When applied to a mass customized system, modular product family structure in association to its designed solution space,

86 Ibid.
becomes one of the foremost competitive capabilities of a mass customization company. This competitive advantage can primarily be seen with regards to the additional added benefits of speed and adaptability of service, offering greater advantage in globalized networked markets and economies when speed is an object of value.

“A core idea of mass customization is to ensure that an increase of variability in customers’ requirements will not significantly impair the firm’s operational efficiency.” A key principle is to allow the capability to reuse or recombine existing organization and value-chain resources to deliver customized solutions with high efficiency and reliability. Customization associated to craft, or traditional artistic production are often associated with significantly higher cost than mass produced or mass customized models, as both the products and processes need to be reinvented for each individual customer. The flexibility a company needs to serve its customers individually needs to be counterbalanced by the additional cost of increased complexity, and increased uncertainty in business operations.

6.2.3 IS MASS CUSTOMIZATION FEASIBLE?

Practical application of these technologies that have proven successful at an architectural level are low-income housing models. Not only does this model center on a customer’s lifestyle, preferences, and needs, but also has flexibility to adapt towards the geographic factors associated with site conditions. There is opportunity in this model to produce baseline products optimized to perform within an environmental context, and flexibility enough to have the fully customized ‘architectural’ object.

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89 Ibid.
Developers have recognized a potential market for transitioning this customized housing typology to high-rise apartments, however this approach would seek to eliminate the geographic location factor, instead opting for the automotive development approach that is centered on design-process-related guidelines and project specific default procedural steps. Project modularization and configuration at an architectural scale would also, much like automotive development, need to re-conceptualize system products and deliveries within the industry by utilizing a “configure to order”, or “engineer to order process.” There are very few examples of this however in the building industry, and most companies engaged with this transition have voiced concerns over ill-defined implantation/transition processes and lack of operational methods necessary for successful implementation of system process/delivery methods.\(^91\) System products, while flexible and adaptable at the component level, also need reliance on module and configuration systems, both of which go against the widely different geographic factors associated with architectural projects. A systems delivery approach towards building facades represents an altogether different scenario, and has successfully been implemented in Kieran Timberlake’s Levine Wall.\(^92\) The project was completed in seven weeks, with façade units arriving on site already pretested and preassembled, and without need for further on-site work or modification. The delivery could also be coordinated with the rest of the standardized construction process to ensure proper construction sequence and to minimize on site storage and assembly.


\(^{92}\) Kieran, Stephen and James Timberlake. Refabricating Architecture: How Manufacturing Technologies Are Poised to Transform Building Construction. (McGraw-Hill, 2004). 140. “The design problem was to provide the most transparent wall possible on a site in the middle of a dense block of introspective masonry buildings. Energy code requirements were met by an active, unitized, pressure-equalized, double-skin curtain wall. The façade comprises an external double-glazed glass unit, a circulating air cavity with integral electronics and blind, and an internal single glazed unit. The cavity acts as a plenum through which room return air is circulated and extracted by the HVAC system. The intermediate blind reflects incident radiation and, along with the inner glass unit, keeps the room at a comfortable temperature.”
ARCHITECTURAL CASE STUDY: FOUNDATION LOUIS VUITTON

Figure 6  Construction work underway at Frank Gehry’s Foundation Louis Vuitton, Paris.93

While there is expressed interest of this model at the Developer level in order to capitalize on an emerging market of housing, the architectural project, as characterized by Gehry Partners’ Foundation Louis Vuitton, addresses altogether different issues of the mass customized, high precision project with emphasis on façade design, engineering, and information workflows. The project “required the development of a 3D concurrent design system that could synchronize hundreds of participants.”

High-precision design tools are quickly moving from the merely analytic and generative to the more simulational, and near real-time optimizations provide the promise of reactive feedback of unprecedented richness. Digital models become repositories not merely of geometry, but of conceptual and material rules for building simulation that can interact immediately with the designer’s intent.

Simulation in accordance to material laws is just a small part of this self-optimized building information modeling platform. The real benefit is seen during project execution, where a wide spectrum of disciplines, all of which require different and specific technical geometric considerations, rules, and logic, can simultaneously work towards their specific digital definition in concurrent design, while still being able to dynamically test and share information/data workflows within a single, intelligent, self-documenting model. This process is realized in the design challenge of the façade, which is comprised of numerous mass customized glass and concrete panels set to specific curvatures. The fabricator, Sunglass, developed a large scale parametric glass mold that would allow for precise bending of glass sheets into cylindrical geometry. The façade design however, was freeform and not cylindrical, so Gehry technologies, in order to achieve the desired effect, “developed tools to find the best-fit cylinder for each of the 3,500 freeform shapes – fitting these 1 x 3 meter (3.3 x 9.8 foot) cylinders to within 5

95 Ibid, p 84.
millimeters (0.2 inches) of the design surface.” The 3D model required to achieve this was embedded with the fabrication and geometry rules necessary for optimization, making the Foundation Louis Vuitton a forerunner project for embedded generative intelligence and simulation. Most generative models of this nature in the past have largely been used for design exploration, with limited parameters associated to design feasibility, however Gehry Technologies recognized and included factors such as machine processing and fabrication, both of which often have decisive impacts on the design geometry. This means that each component must be given dozens of parameters and associated to an entirely flexible parametric system in order to get necessary feedback for simulation and analysis. A design process such as this requires extensive collaboration with engineers to work through and test numerous details, which in this case are automatically and generatively produced.

The design process of the façade recognizes the limitations of material properties, resource procurement, and localized machining tool processes and knowledge, and factors them into a digitally embedded model of information that can be referenced and utilized by numerous disciplines depending on their role or engagement with the project. The Foundation Louis Vuitton realizes BIM to its maximum potential as both a design, engineering, construction, and collaborative tool. Programs such as Autodesk’s Revit provide a BIM platform that many architecture firms are starting to adopt and incorporate into design and collaborative workflows, however the geometrically embedded relationships of the model to manufacturing are non-existent. Revit relies on standardized construction and industry standards, which are still reliant on previous knowledge base/experience and 2D CAD associative design processes. This decision is mainly to encourage “off the shelf,” product design implementation rather than labor/time intensive mass customized processes of which the architectural profession and industry is still behind/lacking in. This is especially realized in Revit’s lack-luster geometric modeling toolkit, along with a conceptual modeling family that lacks many proper free-form geometric tools necessary for complex surfacing, let alone panelizing or detailing. McNeil’s Rhinoceros
(Rhino) and Grasshopper fill in the CAD model to fabrication niche quiet well, as it caters towards designers and architects more than computer scientists and engineers, making it a widely popular platform for geometric rationalization and optimization of complex form, especially for smaller to medium sized projects.

The Foundation Louis Vuitton characterized parametric architecture as system, sub-system, and component assemblies, highlighted through the generative detail in order to provide actualized physical geometric complexity. Today’s non-Euclidean geometries are far more complex than standard orthogonal constructs at a mathematical and information level. Each scale of complexity, whether its line to arc, to plane to sphere, as so on, needs to have more degrees of freedom, more memory, more information professing, and greater degree of complexity in tools in order to actualize these geometric forms. Greater geometric descriptions need more higher-order factors, nodes, and data, indicating that complexity is proportional to the numbers of parameters necessary to describe it. Despite all the processing power in the world however, there still is a degree of difference from a 3D digitized model to its complementary physical counterpart.

As complex as curved-surface mathematical descriptions are, their physical analogues are infinitely more so, for while the complexity of a geometric surface is on the order of the number of its control points, the potential complexity of a physical surface is as high as the count of its molecules.\(^{96}\)

Materials processing could then be regarded as such that its aims are to lower the natural worlds complexity in order to align its behavior to those geometries for which we have traceable models and numerical solutions. When dealing with non-Euclidean geometries, the intersection of multiple geometries bears the weight of offering the greatest degree of parametric factors associated to solving

\(^{96}\) Ibid.
that form. And when dealing with complex façade design and form, that weight is positioned on the system, sub-system, and component assemblies that constitute the façade assembly. In most conventional architecture practice, the component detail is developed downstream of form, and is also often developed independent of construction means and methods as a way of protecting design intent from idiosyncrasies and constraints of procurement. For standardized and conventional architecture, it’s not that great a challenge to switch out basic elements such as columns for wood, concrete, and steel options. Non-Euclidean geometry however must be realized with greater care given to these component assemblies due to the shortened distance of the relationship between form and production. While the mass customizable option offers freedom to critically address, analysis, and explore individual issues in greater detail, most clients can’t afford this solution, or will opt to choose a cheaper means of representation and construction.
Figure 7  Tower and Podium Concept
8.1 PROCESSES IN COMPLEXITY

The design methodology of the tower and the fabrication facility will take into account the outlined principles of Neoliberalism in post-Fordist networked societies by using a modular, mass customized system of industrial fabrication under a modified BIM framework. These principles will be applied to the mixed-use tower typology in order to address the adaptability and flexibility of such a system with regards to program, function, and building morphology. The idea again, is to establish a database in order to efficiently optimize and manage the transfer and use of data, rather than the design of a building per-se, as this methodology and process place emphasis on the design and management of systems over conventional planning and aesthetics. A building design under such a system will physically change, adapt, and evolve based on the self-regulatory order of the market, meaning the actual ‘look’ of the project will be in constant flux as it adapts to both societal and economic forces. For this particular example however, this thesis will examine the ‘style’ and ‘form’ as a function of power and control of Parametricism associated with the neoliberal ideals outlined above. These ideals will be manifested in both the component design as well as planning, insofar as ‘planning’ being a function of economic flow and risk mitigation. This thesis, while recognizing the autopoietic system of Schumacher as beneficial towards this project being distinctly within ‘architecture’ and architectural discourse, the reality and conclusion drawn from this research indicates this project as a post-architectural product, and one that would benefit more from other disciplines for it to be truly aligned with the principles outlined above.

What must first be mentioned in regards to this approach, however, is that much of the software, technology, and processes for a parametric method as outlined above, are still in development and not commercially available, and thus will unable to be implemented in the design process of this thesis. This thesis has primarily focused on projected trends of which a variety of industries are moving
towards within both product development and research, however commercial products relating to a
generative design for this specific scenario are yet to exist. That being said, the importance of computer
science, data management, and data analysis are becoming increasingly important skillsets for an
architect’s repertoire. This is made evident by the successful implementation of tools such as the
Grasshopper plug-in for McNeal’s Rhino, as well as Dynamo for Autodesk’s Revit, within commercially
successful architectural designs. These are scripting tools that utilize a graphic user interface to simplify
scripting for those not educated or familiar with standard computer programming languages. While this
thesis will not explicitly use these tools for the design of the tower or overarching project, they will be
used in conjunction with other software to optimize data flows and information when needed. Tools
such as Grasshopper, while powerful in their own right, shine when they establish connections with
other more powerful or highly specialized software by sharing parameters between the platforms. This
can be done by writing to an external excel spreadsheet or word processor document, which can then
be parsed and translated depending on platform, meaning changes on one platform will automatically
update and effect parameters within the other.

As complexity between, software, parameters, and designed components increases, the need to
shift towards a product lifecycle management (PLM) platform increases, implying that the architectural
project should now be managed as would an industrial mass produced product. A key difference here
however, is that recent improvements in manufacturing and construction services allow for a mass
customized solution, as opposed to strictly mass produced. BIM can be characterized as a PLM solution
designed distinctly for the architectural profession, with one of the end goals being the production of
construction documents and drawings. This process however still follows strict adherence to traditional
business practices within the profession, and are fundamentally limited by that approach. Many of the
works of architecture characterized under the ‘style’ of Parametricism can fundamentally not be
represented or designed within contemporary BIM platforms. Instead, these projects must be solved
using modeling and design platforms intended for engineering disciplines, as they offer the necessary tools and processes for simulation, machining and fabrication of the complex geometries and assemblies of which these projects are composed. Advancements in generative design, cloud-based management, and machine learning solutions are currently being developed for these engineering-based platforms, and not for BIM-based platforms. Elements that have been historically characterized as ‘architectural,’ be it columns, cornices, or curtain walls, are rendered out of an ‘architectural’ context under this system of management and methodology, these being conceived of instead as elements of product design and engineering. Elements and principles of architectural design are rendered redundant or obsolete, as the needs of these elements will arise when or if they are needed within the system, and not through any form of formal planning. For this reason, Autodesk’s Fusion 360 was chosen as a platform for all component design within the project, as it represents a cloud-based design, simulation, engineering, and manufacturing platform. A history-based parametric modeler such as Fusion 360 will allow for component design templates that are flexible and adaptable to spatial, assembly, and process specific contexts within the project.

While the component design will cater towards engineering and manufacturing flexibility, conceptual and schematic design will be based around speed, utilizing combinations of animation software and videogame production engines for quick process development and visualization. This foundation is necessary to block-out as many iterations as possible, which can then be re-worked and remodeled with precision in other platforms. This process is also in some ways representational, as videogame design represents one of the most successful examples of mass customization within commercial products. Most level design in videogames are based around modular design principles with customized props or game assets that all adhere some form of modular logic. ‘Grey-box’ geometry represents design constraints that products can then be designed to. This process allows artists or architects to generate extremely detailed environments by re-using work in different contexts.
throughout the game environment, with the ability to later adapt or change any of these objects parameters. As long as these assets and components are saved and organized properly, they can function as base template for design that can deviate in form or style, but still adhere to the basic constraints of the environmental logic and characterization. Principles of mass customization in games have even translated over to user-generated content, with most game engines and even some individual games offering marketplaces for the exchange of user-made items and objects for real-life currency. With recent advancements within manufacturing technology and processes, this user-made and customized approach of digital content creation can be translated to features and products of the built environment. We are already seeing this with product design, as technology such as personal 3D-printers and desktop CNC machines are becoming more affordable to individuals and smaller businesses. A benefit to this approach is that building components can more quickly be sketched out and virtually simulated within these platforms, and the data can then be transferred as design templates to platforms such as Fusion 360, where the base mesh will be used for reverse engineering a designed component that will function appropriately within that particular space and context. Architectural elements need not be strictly architectural in nature, but can now be embedded with systems and systems produces in order to optimize efficiency, cost, or other design variables. Engineering platforms such as Fusion 360 allow for customized geometry or components to be designed seamlessly to the constraints of other existing products that might make up an assembly or component.
It must be noted that the implementation of all these principles within a single design process would be extremely difficult, and in an ideal world would require a great number of people and project teams of specialized skillsets and knowledge. This is a condition of adhering to neoliberal ideals as outlined above and would require the complete reworking of the standard architectural firm’s business model and practice in order to accommodate such diverse work. The example of Gehry Partner’s Foundation Louis Vuitton can be described as a prototype for this method, as the success of that building was not the work in and of itself, but the platforms of collaboration developed in order to allow for hundreds of specialized teams to work together on the project. The methods outlined above are also only successful if large groups of people contribute to these processes. This principle is similar to that of Google’s search engine, which gets better and more accurate the more that people use it. With a data driven approach to design, this can be translated to the built environment and products within our world, these products becoming more adapted to standardized use or even to an extreme extent, cultural and traditional context that’s dependent on local knowledge and industry.
Figure 9  Tower and Podium Section
8.2 MAXIMIZE SITE PROFIT

The tower design of this thesis takes advantage of this collaborative approach, by having a flexible and adaptable program that can self-organize and evolve based on the input of various diverse actors and agents. The tower’s function will self-organize to conditions that allow it to perform optimally, conditions being anything from generating revenue to providing maximum comfort and safety to the public. In most cases however, the construction of such a project would be marketed towards a client that can afford it, so the generation of capital would be a primary factor in performance and consequently, the form and function of the project. Three key factors that would drive the success of such a project within the context site of the Chicago, would be the creation of a diversified product, connection to the city, and the creation of attraction. This would entail the creation of diversified venues, services, and attractions that would cater to the public of varying economic means, while also supplying high-budget specialized services for private interests and investors. Low budget, privatized services would not yield a great return, and would carry minimal weight within preliminary design and planning. The site has access to the Chicago Riverwalk, which hosts a myriad of free amenities to locals and tourists alike. What was once an abandoned site in the city has now been completely re-developed to house small businesses, encourage activity, and help connect people to the city and its ongoing park development projects. The Chicago Spire site is in extremely close proximity to this redevelopment, and due to the city’s interest in promoting its parks program, would be a key attraction to capitalize on as the site now draws heavy crowds. Chicago’s Navy Pier would function in a similar manner, being an established city attraction the pulls in large numbers of people yearly. The tower design would thus seek to establish visual and physical connections to encourage flows of both people and money throughout the site and its surrounding neighborhood, encouraging further redevelopment that would aid in the evolution and diversification of the adaptable and flexible project. The fact that the tower, sticking to the original Spire’s proposed 2,000 ft. height, will be a ‘super tall’ tower, aids in establishing connection
and capital flow throughout the city. A sky-deck at 2,000 ft. has the potential to pay for the development and construction costs of the entire rest of the building. There are already precedents for this within the city. The John Hancock Observatory has an estimated $10 million in annual ticket sales after the unveiling of its tilt attraction and *The Ledge at Willis Tower* an estimated $25 million in annual ticket sales since its opening in 2012.\(^{97}\)

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Figure 11 Tower with integrated construction platforms
8.3 BIGNESS

There is pragmatic reason for the 2,000 ft. ‘Large’ in this context, is a condition of return-on-investment. Rem Koolhaas addresses the ‘Large’ of architecture in his essay on Bigness, claiming it as a post-architectural landscape, a condition of after-architecture, a condition where architecture has given up control over to complexity.

...only Bigness instigates the regime of complexity that mobilizes the full intelligence of architecture and its related fields. One hundred years ago, a generation of conceptual breakthroughs and its supporting technologies unleashed an architectural Big Bang. By randomizing circulation, short-circuiting distance, artificializing interiors, reducing mass, stretching dimensions, and accelerating construction, the elevator, electricity, air-conditioning, steel, and finally, the new infrastructures formed a cluster of mutations that induced another species of architecture. The combined effects of these inventions were structures taller and deeper – Bigger – than ever before conceived, with a parallel potential for the reorganization of the social world – a vastly richer programmation.\(^98\)

Bigness allows for the unique condition of allowing anything to happen, or instigating the possibility of infinite potential. Programmation is vastly richer because programmation can be whatever it wants to be as long as there’s space for it. Koolhaas is quick to point out that such mass “...can no longer be controlled by a single architectural gesture, or even a combination of architectural gestures.”\(^99\) This contradicts Schumacher’s unified style, as it addresses the complexity of infinitely competing agents. Style isn’t so much as unifying as is the overall affect produced over the autonomy of its parts under Bigness. Bigness is a condition (an end condition?) of neoliberal architectural ideals in its pursuit to

\(^99\) Ibid., p. 499.
demand interaction, flexibility, mobility, and un-hierarchical planning (freedom). It is the city, it coexists with the city, it allows for the conditions of collaborative city planning, while also disavowing those same conditions.

Bigness destroys, but it is also a new beginning. It can reassemble what it breaks. A paradox of Bigness is that in spite of the calculation that goes into its planning – in fact, through its very rigidities – it is the one architecture that engineers the unpredictable. Instead of enforcing coexistence, Bigness depends on regimes of freedoms, the assembly of maximum difference. Only Bigness can sustain a promiscuous proliferation of events in a single container. It develops strategies to organize both their independence and interdependence within a larger entity in a symbiosis that exacerbates rather than compromises specificity.100

Bigness has been criticized as re-establishing architecture as an agent of exclusion, negating the possibility of fostering inclusive congruency101. It cannot exist within or relate to the city, but instead aspires to be a city in and of itself. Koolhaas has expressed that neoliberalism is neither good nor bad, but has created a new condition for architecture, and one that works extremely well within the avant-garde’s target market.102 Bigness however, is not necessarily limited to physical size and appearance, but also scope of process. Networked societies and globalized conditions of management also constitute a form of Bigness in their complexity. This bigness is transparent, but very much applicable to the production of paradox as outlined by Koolhaas, creating the condition of incomprehensibility that’s characteristic of neoliberalism. This project functions in a similar regard, being a product of the Bigness Koolhaas describes.

100 Ibid., p. 511.
102 Ibid.
Figure 12 Bigness
8.4 SMOOTHNESS

Smoothness is another function, like Bigness, that defines architecture under Parametricism. Smooth space entered architectural discourse with the adoption of Deleuze and Guattari, who use the term “as a condition of topological complexity and ‘continuous variation.’”\(^\text{103}\) It is a nomadic realm of invention, difference and becoming through which the subject might drift, and represents the abolishment of planning and hierarchical order, enabling a mode and method of freedom and possibility. Concepts such as ‘smoothing’ and ‘folding’ resonated with the freedom newly emerging computational design platforms could contribute to architecture. These new computational modeling platforms allowed architects to break from the rigid and imperial practices of CAD-based design and development, and with it re-conceptualize progressive social agendas within the discourse.\(^\text{104}\) Greg Lynn, an early adopter of these computational modeling platform conceptualized smoothing as a method for architecture to escape the ‘dialectically opposed strategies’ of complexity and contradiction. “The smooth would serve as a new way of handling ‘difference’ in architecture, one that would bypass the logics of both homogenization and exacerbation.”\(^\text{105}\) This smoothness seeks to liberate architectural form and thought from the violence of difference as seen under post-modernism and deconstructivism by means of blending antagonism and difference out of existence. The architectural Deleuzism of smoothing coincides with the post-political neoliberal ideal by “renouncing critical opposition, and any possibility of occupying a position of resistance.”\(^\text{106}\) “It can only endorse what ‘works well within the framework of existing relations,’ and can only find its validation in making these function more effectively through the managerial ‘cunning’ of organizational complexity.”\(^\text{107}\)


\(^{104}\) Ibid.

\(^{105}\) Ibid., p. 54.

\(^{106}\) Ibid.

\(^{107}\) Ibid.
morphology of smoothing is often represented as being shaped, modeled, and deformed by environmental or unseen forces. Morphing is the logic of continuous variation, and an architecture “compliant to, complicated by, and complicit with external forces in manners which are: submissive, suppliant, adaptable, contingent, responsive, fluent, and yielding through involvement and incorporation,”¹⁰⁸ are subject to the production of similarly yielding subjects of compliance.

Figure 13 Bending deformation of design components
8.5 MORPHOGENESIS

The formation of elements and components are conditioned by principles of both Bigness and smoothness. Monolithic designed components are required to decrease failure associated to an overabundant condition of possible joints and connections. The monolithic component is a designed system that integrates engineered solutions into the form and structure. Building systems and utilities are therefore, designing within the architectural element and not in association to it. Bigness is illustrated in the scope and complexity of these components, and smoothness in the interconnected
blending of diverse designed solutions. Generative design and simulation tools such as those found in *Fusion 360* and Autodesk’s *Within*, are examples of form genesis and optimization solutions that work within design parameters. These processes of simulation output a template mesh that can be designed to or later incorporated within pre-existing designed components or conditions. This ensures a smooth transfer of geometry and efficient functioning of disparate systems within what would otherwise be a complex ad-hoc assemblage of contradictory components without such methods. Design of this nature requires extensive knowledge of reverse engineering practices and time, as each component now carries with it the design and process complexity of an automotive component. This would imply that designs would be further broken down into specialized teams that focus energy on one particular piece rather than the whole. This coincides with the functional differentiation of both Schumacher and the process of globalization.

The designed components of this project are rendered as both fluid and mechanical, a representative and conditional constraint of not being able to implement the methodology described above. The sinuous and fluidic systems and components represent the development and formation of biological systems that evolve and adapt to contextual relationships within an organism. The remnants of machining and assemblage processes are blending into the totality of continuous and adaptive surfaces and transitions, creating conditions of compliance to forces unknown or incomprehensible. The components and assemblages now take on principles of evolution and self-organization similar to that governing the entire tower and represent a complex negotiation of diverse forces that can only be addressed through the networking, flexibility, and adaptability offered by ICT platforms, ones that architectural practice *must* towards under these conditions.
Figure 15 The smoothing of design components
BIBLIOGRAPHY


