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Parametric urbanism: emergence, limits and perspectives of a new trend in urban design based on parametric design systems

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Abstract

In the last decades there has been an extraordinary advance in the development of parametric design tools. In parametric design, the parameters of a particular object are declared, not its shape. These technologies have been transferred from aerospace and automotive industries to architecture and urbanism, to constitute what is being known as parametric urbanism, a theoretical and methodological procedure developed in the context of the Zaha Hadid Architects' practice. Their large scale urban design proposals have frequently applied parametric design tools. This paper analyses the emergence of this new model of urbanism, in order to identify its limits and to show perspectives to its improvement. In spite of the great potentialities offered by parametric urbanism theories and tools for enhancing the efficiency and quality of urban design proposals, we note that the model is only sensitive to formal, environmental and functional parameters. Space configuration parameters, fundamental to the understanding of urban dynamics as well as to propose new urban forms, are not explored. Therefore, some possibilities of improvement of the model through the introduction of space configuration parameters are proposed, based on the paradigms of urbanity and formality, as formulated by Frederico de Holanda. We argue that the referred model can be improved if spatial parameters are introduced.

In recent years, Zaha Hadid and Patrick Schumacher are developing a series of urban projects with a strong experimental character, exploring on one hand, the typological vocabulary of urban tradition and on the other, parametric design systems, aiming to develop new urban forms or new urban complex geometries. These innovative processes of design have been called parametric urbanism. [1]

Parametric urbanism is based on parametric design systems in which "of a given object the parameters are declared and not its form",[2] i.e. the focus of interest is not the form itself, but the parameters that generate it. These tools, "originally developed in the aerospace and automotive industries as a means of enabling the design of complex curved shapes, have long had strong impact on the building design process,"[3]especially by improving the design and digital representation of building components. In recent years, techniques and technology for parametric design have been gradually and deliberately moved to the town planning, i.e. for the large-scale urban design, arguing that the systems allow rapidly generate different design alternatives from simply changing the values of a particular parameter, and the generation of different architectural and urban

scenarios to be evaluated further by facilitating the decision-making during the creation process.

The parametric design therefore presents essentially a systemic approach [4], because it enables the creation of relationships between the various elements of a system, allowing you to build a real complex of interacting elements - a whole that is characterized by the interrelationships between various constituent parts. But both the elements and their parameters, such as relations between them depend on what the designer wants to list. So when the required elements to meet certain demands are not specifically listed by the designer, the system does not constitute its completeness or presents itself flawed, insufficient to achieve the objectives for which it is proposed.

In the case of parametric urbanism, it is observed that despite the offered potential to increase efficiency and quality of proposals for urban design, the model operates only on formal parameters, environmental and functional, thus, constituting intense urban environments. Though Patrick Schumacher and Zaha Hadid admit in their speeches that "a good urban design should enliven the soil," [5] the parameters with which they work are not sufficient to provide such entertainment. Space Configuration parameters [6], fundamental to the understanding of the dynamics of urban morphology are not exploited by the parametric urbanism, following the principles of modern urban planning, which favoured certain parameters of the urban form and subverts the logic of the morphology of the traditional city, bringing disastrous consequences for urban life [7].

This paper therefore aims to analyze the emergence of this new model of urban planning, trying to identify its boundaries and show prospects for improvement. Initially, we discuss the emergence of urbanism in the context of parametric theories of design and computing, focusing on the history of the development of parametric design tools and their introduction in architecture and urbanism. Then, we present the theoretical assumptions of the parametric urbanism and three urban projects are studied drawn up by Zaha Hadid Architects office between the years 2001 and 2008, highlighting its limitations. Finally, possibilities are proposed for improvement of the model, on a conclusive character, introducing spatial configuration parameters, based on the paradigms of urbanity and formality, as proposed by Frederick of Holanda[8].

1. The emergence of urbanism in the context of parametric theories of design and computation

In the 1980s, there was a breakthrough in the development of digital technologies applied

to architecture, particularly with regard to the tools of Computer Aided Design (CAD) such as software of two-dimensional drawing, three-dimensional modelling, digital animation, and the tools of Computer Aided Manufacturing (CAM), such as Rapid Prototyping (RP) and the machinery of Computer Numerical Control (CNC). CAD and CAM tools fundamentally redefined the relationship between design and production to the extent that integrated the entire architectural process, from design to construction, allowing the projecting and manufacturing of architectural artefacts, using only digital information.

If, on the one hand, the tools of digital generation eliminated several geometric constraints imposed by traditional design systems, facilitating the use of complex geometries or non-Euclidean topological surfaces as NURBS, whose construction without the digital media would be impossible or very laborious to be viable, on the other hand, the computer numerically controlled production processes and facilitated the manufacture of non-standard components with greater speed and accuracy by introducing, in architectural discourse, new ways of production and the notion of "mass customization"[9] in opposition to the notion of Fordist "mass production", which was characterized by the logic of serial repetition of standardized elements, pre-fabrication and assembly on site. These technologies have facilitated the production of buildings, increasingly complex and unique, in terms of their formal or spatial configuration.

Despite the achievements in the development of technologies CAD / CAM, until the 1990s, it was still demonstrated the lack of parametric tools that allow a more interactive digital modelling, enabling modification of a model, once it was generated, to create architectural forms in a flexible manner. According to Javier Monedero [10], until the nineties,

> [...] There was a remarkable development of computational tools in order to present or communicate the results of architectural projects. But there was no comparable progress in the development of tools aiming at helping a project to generate architectural forms in a practical and interactive way. However, the architects who used the potential of these technologies as a direct tool for creation of architectural forms were still the exception. The architecture was still produced by traditional means, using the computer as a design tool. The main reason that explains this situation [...] is that it consisted in a mistake to try and move very quickly, for example, by proposing methods for embedded systems using expert systems and artificial intelligence capabilities when it had not yet an appropriate tool to generate and modify 3D models. Modelling tools available so far were clearly unsatisfactory. The main limitation of these was the lack of appropriate tools to interactively modify the model once it was created. This is a fundamental aspect in any design activity, where the designer is constantly driven to develop and redesign specific aspects of the model, or its general layout, or even return to the original solution which has been temporarily abandoned.

The reality described by Monedero was only be transformed, from the 1990s on, when there occur significant advances in the development of parametric design tools, applied more effectively to architectural design, thanks to the contributions of Robert Aish, Lars Hesselgren, J. Parrish and Hugh Whitehead. Since then, they're ahead of the development of a parametric design methodology for architecture, and together they formed the SmartGeometry Group [11] with the goal of building an intellectual environment for further development and dissemination of these technologies.

Although most of these technologies are still used as design tool for the representation and visualization of architectural design, increasingly, they are exploited as research tools for generating and processing forms in the digital environment - what Branko Kolarevic called " digital morphogenesis ".[12] New possibilities of digital morphogenesis, as well as spatial and geometric configuration, formal features and material systems are emerging in the light of investigations on these technologies, promoting not only transformations in an architectural representation, but also in how we design and produce architectural artefacts. Zellner notes that "architecture is changing, becoming partly experimental investigation of complex geometry, computational orchestration of material production and robotics, sculpture, generative and cinematic space."[13] With this closer relationship between architecture and the computational means, concepts, previously restricted to theories of design and computation have been appropriated by the architectural discipline, feeding the discussion about the emergence of new architectural subcategories. Kolaveric identified a number of architectural subcategories that emerged in recent decades from studies with different digital generation techniques. They are identified as "digital architecture" based on underlying concepts such as "topological space (topological architecture), isomorphic surfaces (isomorphic architecture) cinematic movement and dynamic architecture (animated), animation (metamorphic architecture), genetic algorithms (evolutionary architecture) and parametric design (parametric architecture).”[14]

The term parametric architecture emerges in the literature, so in this context and in the light of a recent approximation between architecture and the parametric design tools. Parametric modelling has changed substantially digital representations of the architectural design and its notion of explicit geometric shapes (clear and watertight) to the notation of geometric parametric models (changeable), allowing even the construction of geometric instruments. This is because, "in parametric design, the parameters are more interesting and less the form, this means the parameters of a given object are declared and not its form."[15] Consequently, when parameter values are to be assigned or changed, objects or configurations are generated or modified simultaneously. Thus, "equations may be

prescribed to describe relationships between models, defining an associative geometry - a constituent geometry in which the objects are mutually interconnected." [16] (Fig. 1) Parametric systems differ from traditional systems of digital design for maintaining the ability of the model to change during the entire design process and to allow for generating and testing large number of versions within a controlled environment designed from a simple change of a specific parameter value. They are really powerful computational tools such as Generative Components (GC) and Digital Project (DP) as well as Maya Mel Script and Rhino Script, among others, that allow the parametric modelling via script.

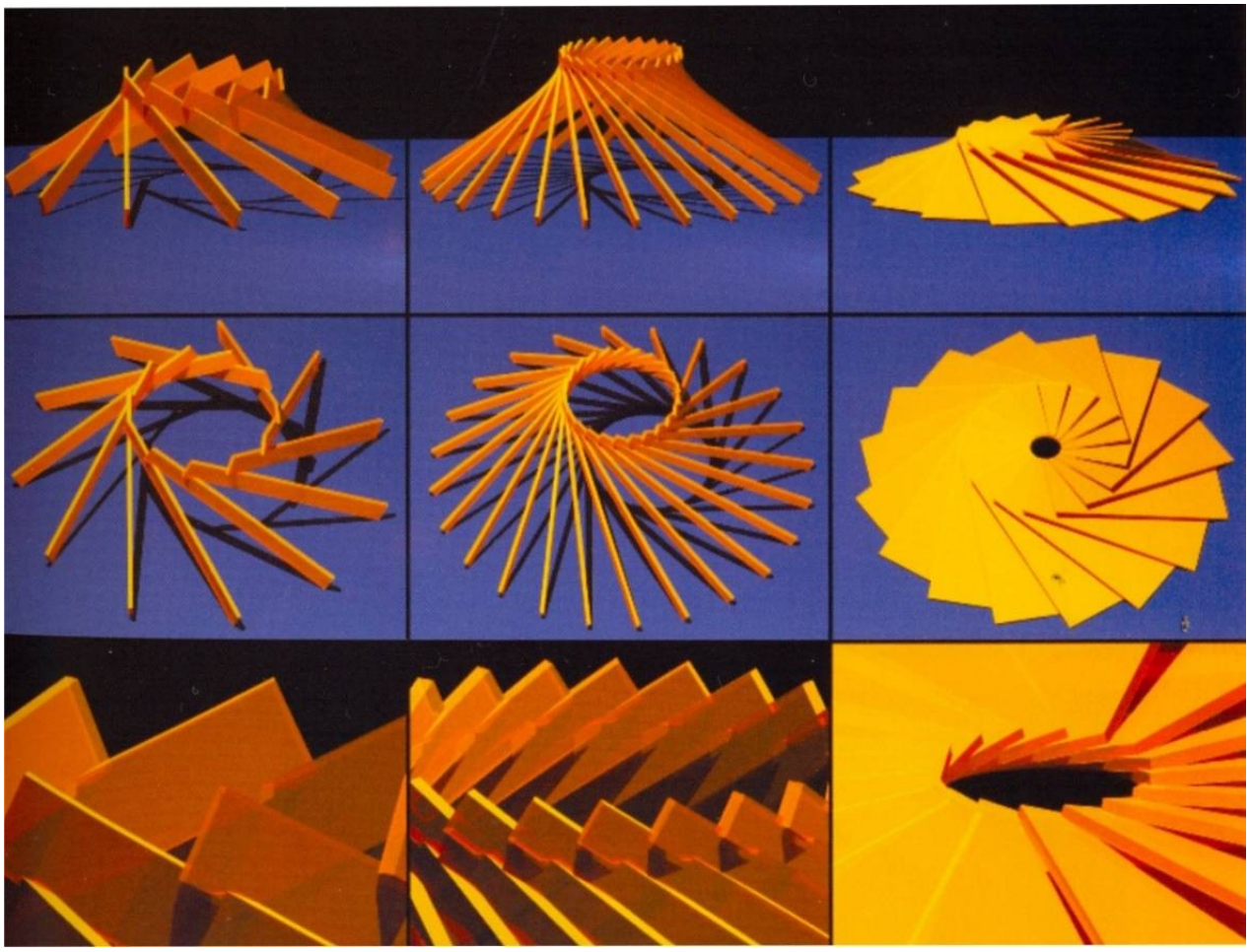

Figure 1. Variations on the same parametric model, distinguished by changing parameter values. Source: KOL AREVIC, 2005, p.153.

Currently, several architectural firms have been using parametric design tools in their design processes. Groups formed by young architects, as SUBDV and DECOI Architects, and other consolidated into an international level, such as Foster & Partners, UN Studio and Zaha Hadid Architects, have been systematically exploring the potential of these tools, either to solve problems of technical-constructive relating to the design and production of building components of buildings, or to resolve questions of investigative order, referring to the architectural process of morphogenesis, for example.

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For a long time, these technologies were restricted to the processes of architectural design. But in recent years, several attempts are emerging to introduce them in processes of urban design. Nicolai Steinø and Niels Einar Veirum [17] , as well as David Gerber[18], are among the authors that pointed out and performed recent experiments with application of technical and / or parametric design technologies in urban design processes. Steinø and Veirum, argue that,

> The application of a parametric design directed to the urban design has great potential to improve the systematic evaluation and subsequent arguments to proposals for urban design carried out in a public arena. The parametric design has long been applied primarily to the architectural project as a way to improve the design of components of buildings of parametric similarities. However, the constituent components of an urban design also share similarities that can be parametrically defined. Aspects such as density, use, shape, space and typology - issues that typically belong to urban design - can all be parametrically defined. Therefore, it is possible not only to perform a systematic process of design, but also evaluate the pros and cons of scenarios with different parametric settings for each parameter. And by applying an appropriate CAD software, it can do this within a time interval that makes the environment more artistic and the aspects of urban design more qualitative.[19]

Although the experiments carried out by the authors are of great importance for the emergence of a parametric methodology for urban design, Zaha Hadid and Patrik Schumacher present, according to our observation, a more systematic approach, both in terms of their theoretical assumptions as in terms of aspects relating to projective practice. This approach was grouped within which they designated as parametric urbanism [20]. Possibly, the highly personal language of parametric urban projects produced by Hadid and Schumacher, sometimes labelled as extravagant,[21] has reflected a certain lack of interest in the critic of architecture and urbanism, in a sense to seek to weave a more accurate investigation, observing the most relevant aspect of the proposals developed by them: the emergence of a new methodology for urban design that allows encompass a wide range of parameters by means of advanced computational tools, to enable the proposition of more efficient urban forms in the various aspects, including

aspects of spatial configuration if conceived in a systemic way, as we shall see.

Despite the parametric urban projects Zaha Hadid Architects are little discussed in literature, the intellectual contribution of Patrik Schumacher for parametric urbanism constitutes a theoretical framework that serves as a substantial benefit not only to understand this new model of urban planning and ratification of its relevance, but also to increase discussions about a possible parametric paradigm that seems to penetrate into various disciplines and practices that involve design problems supported by such technologies. Schumacher proposes to call this new paradigm parametrism [22] - a new style that "emerges from the creative exploitation of parametric design systems in order to articulate increasingly complex processes and social institutions." The author adds: "The parametrism is the new style after modernism. Postmodernism and deconstruction were transient premature episodes. "[23]

In this context, the parametric urbanism, according to Schumacher, would be one of the various agendas of the parametrism, with a focus aimed specifically at urban issues. However, we see that as a model of urban design for the investigation of proposals of new urban forms, urban parametric fails due the tendency to privilege the purely formal, environmental and programmatic parameters, to the detriment of other fundamental parameters for the promotion of urban life, which it hopes to establish.

2. The absence of spatial parameters in parametric urbanism

Parametric Urbanism aims to provide new logic of urban design that operate through the correlation of multiple urban systems as the modulation systems of open and closed spaces, exploring new techniques of formal variation and differentiation, in which nothing repeats itself, and two buildings should not necessarily have the same shape. (Fig. 2, 3 and 4) Furthermore, it uses techniques of deformation, usually through complex curved geometries such as lines splines, NURBS surfaces and deformed grids to articulate the urban fabric of new projects to pre-existing tissue and thereby promote the connection of the urban grid as a whole. These formal codes that Schumacher calls positive heuristics (rules or positive procedures) result almost always in the differentiation of the form. Perhaps it is this quality which is most desired by parametric urbanism. In opposition to these codes, is what Schumacher[24] calls the negative heuristics (negative procedures), which the parametric urbanism avoids, for example, the repetition of standardized elements, the design of Platonic objects and straight lines or right angles, and finally, the projection of familiar typologies, which were very common in the practices of modern urbanism.

The parametric urbanism presupposes that "[...] the urban centre describes a swarm-formation [25] of several buildings. These buildings form a field in a constant state of change, whereby the legitimated continuities connect the multiplicity of buildings."[26] (Fig. 05, 06) According to Schumacher, "[...] the systematic modulation of morphologies of buildings produces powerful urban effects and facilitates the orientation of the field."[27] He proposes the idea of field strength, as opposed to the modernist idea of isotropic empty space and argues that while modernism was based on the isotropic concept of space, the parametrism is based on the fields. According to the author,

> The fields are full, as if filled by a fluid medium. We can think of fluids in motion, structured by the radiation of waves and laminar flow swirls spirals. Swarms have also served as paradigmatic analogues for the concept of field. We would like to think of swarms of buildings that glide across the landscape. [...] There are no platonic and discrete figures with sharp contours. Within the fields only the global and regional qualities matter: biases, drifts, grades, and maybe even clear singularities as irradiation of centres. Deformation no longer means breaking the order, but the record of legitimate information. The orientation in a legitimately differentiated complex field allows navigation along vectors of transformation. The contemporary condition of reaching a city, without arranging hotel reservations or without a map, can instigate this kind of navigation in the field. Imagine there's no more milestone to be fixed, neither axis to follow or boundaries to cross. Contemporary architecture aims to construct new logics - the logic of fields, who arranges to organize and articulate the new level of dynamism and complexity of contemporary society. [28]

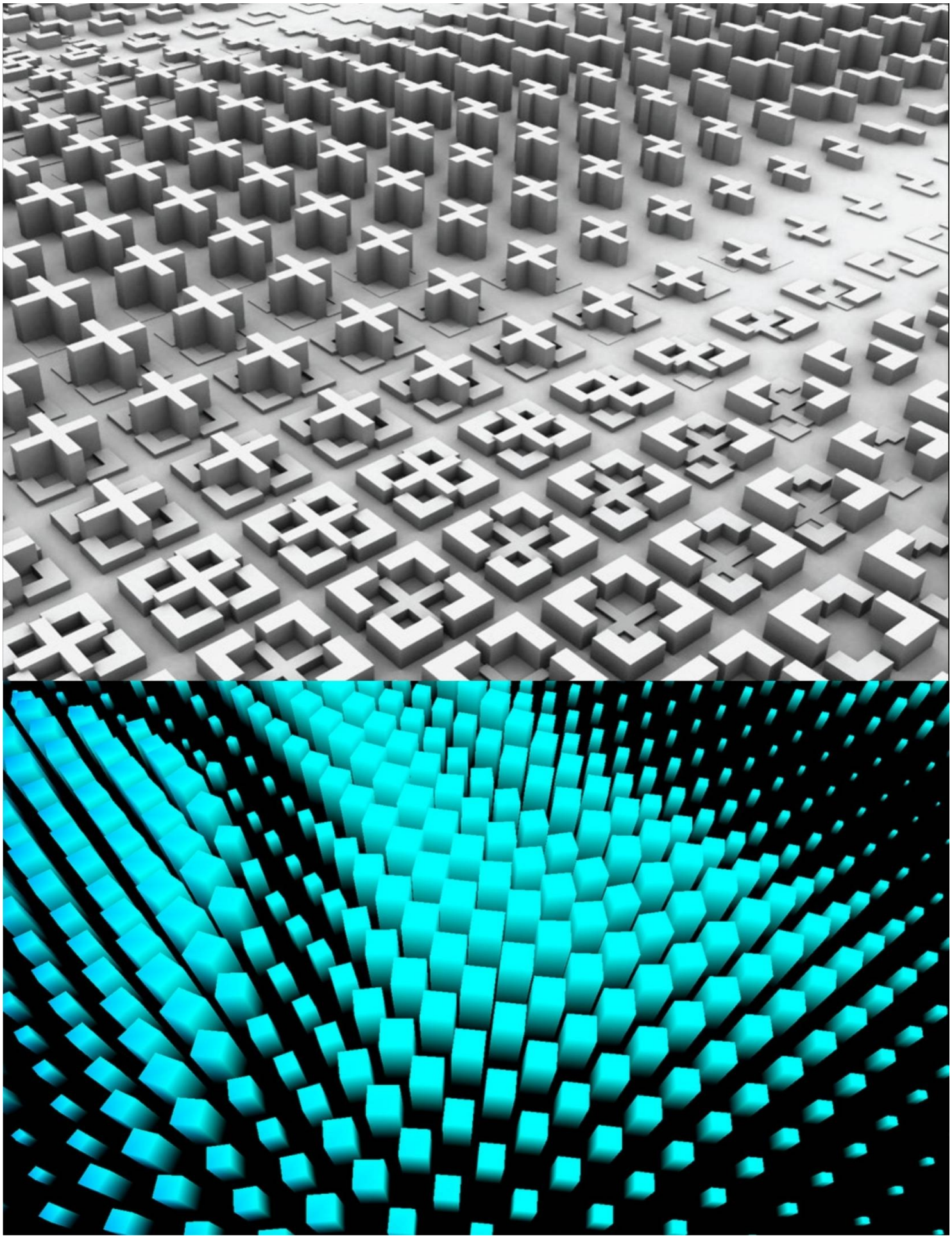


Figure 2. Técnicas de variação tipológica e diferenciação paramétrica. Fonte: WERZ, 2009; WEWORK|4HER, 2009.

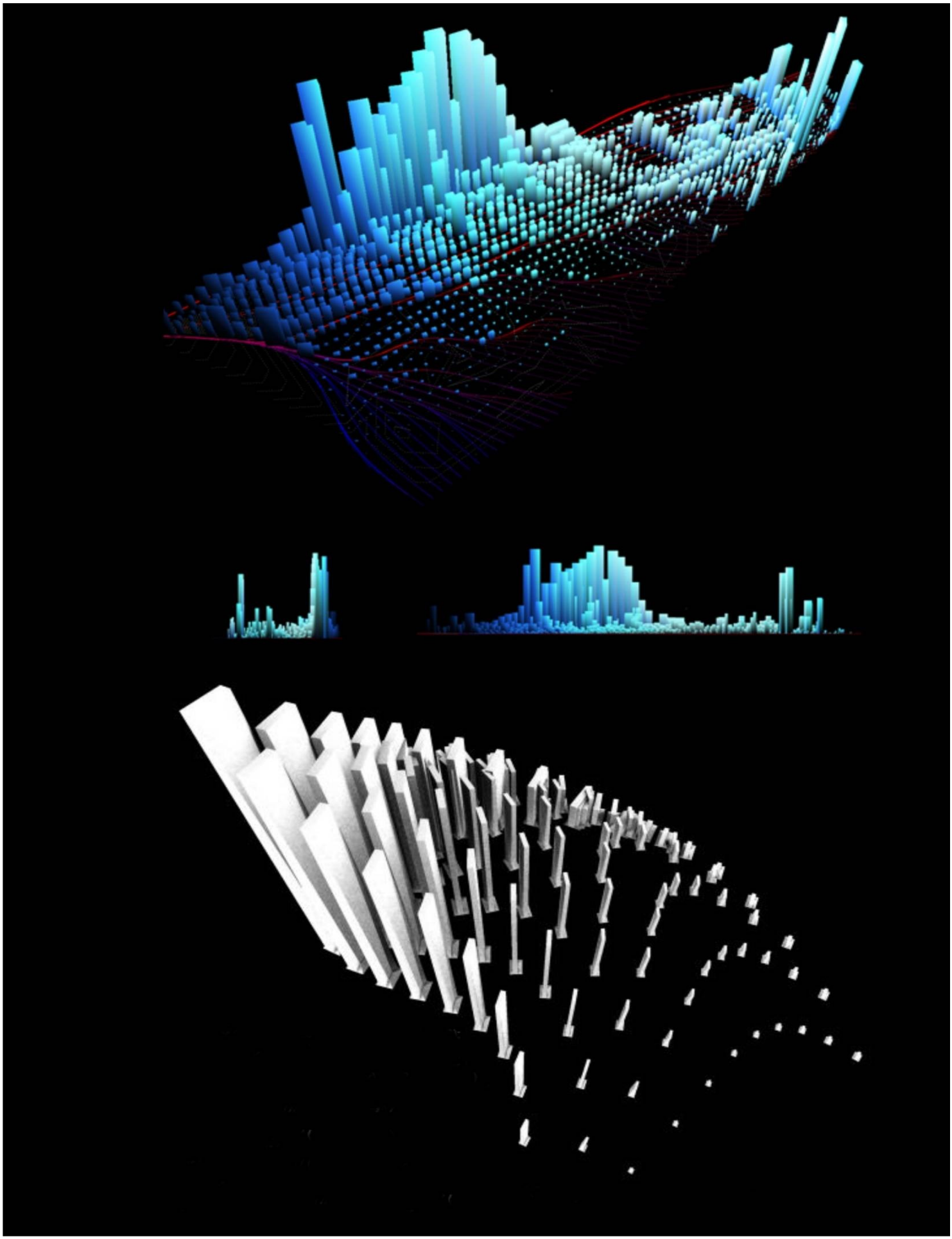


Figura 3. Técnicas de proliferação de edifícios, empregadas pelo urbanismo paramétrico.

Fonte: WEWORK|4HER, 2009

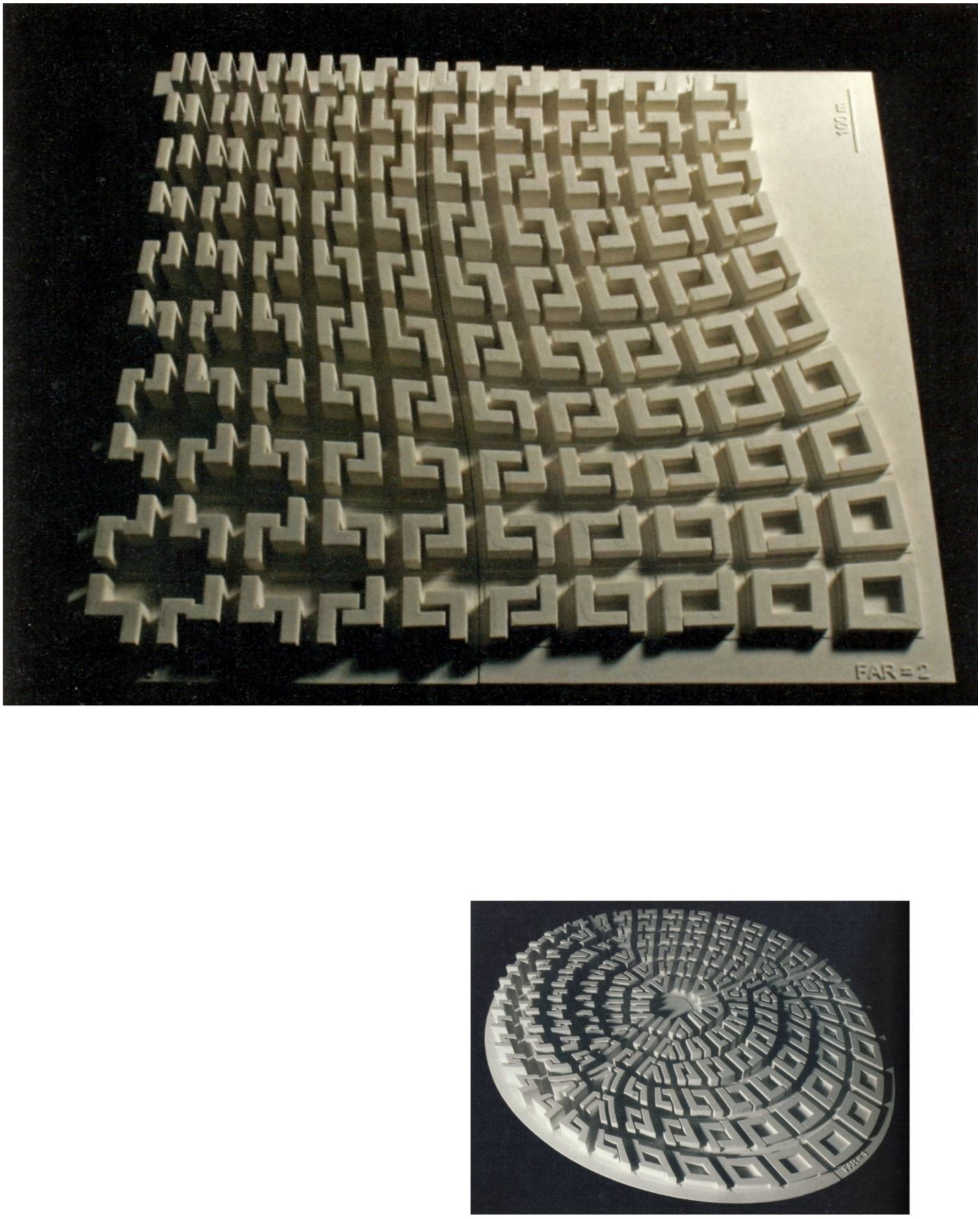


Figura 4. Técnicas de deformação de *grids*, utilizadas pelo urbanismo paramétrico para o desenho de malhas urbanas. Protótipos desenvolvidos por Max Von Werz. Fonte: LEE e JACOBY, 2006

Figura 5. *Swarming Formation*- Formação de um cardume de peixes. Assim como as formações de exames de abelhas, os cardumes (acima) inspiram o urbanismo paramétrico. Fonte: SOUZA, 2008.

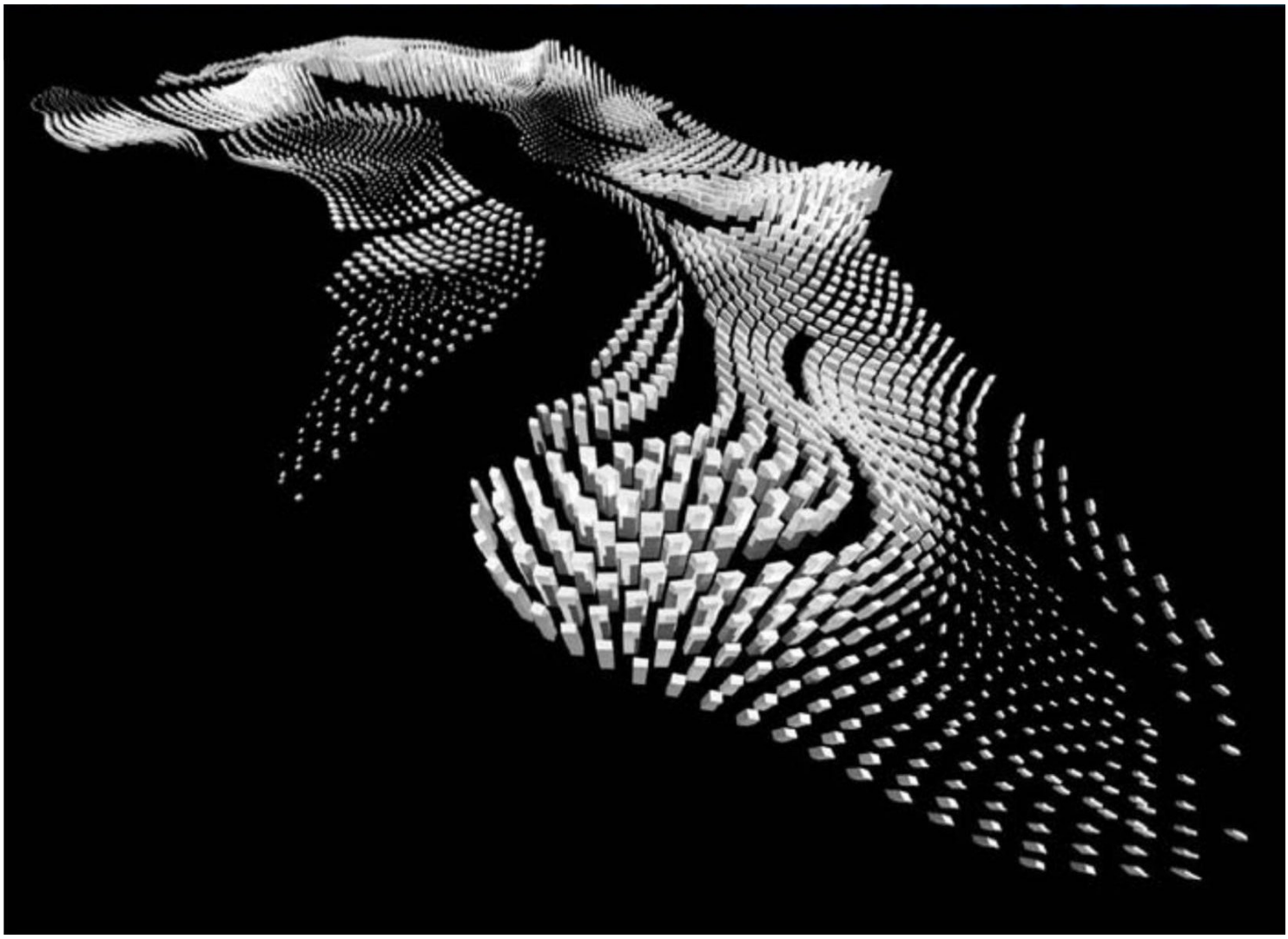


Figura 6. Modelo do projeto urbano desenvolvido por Zaha Hadid para a região de Thames Gateway, em Londres (abaixo). Fonte: HADID ARCHITECTS, 2009.

Parametric Urbanism excels, so in the notion of field, which can be understood as a third different approach to the notion of space after modernism and postmodernism, as observed by Peponis: "While the space as a concept which underlies the major streams of modern architecture, would refer to abstract and homogeneous extensions that can be freely arranged, the place, as a concept that inspires criticism to modern conditions would relate to specific situations and qualities that must be recognized and consciously cultivated. "[29]

Table 1. Different approaches to the notion of space for different urban conceptions.

MODERN URBANISM	POST-MODERN URBANISM	PARAMETRIC URBANISM
Emptiness	Place	Field
" Abstract and homogeneous	"[...] Particular situations and qualities	"Fields are full, as if taken by a fluid

extensions that can be freely organized" (Pepone, 1989). " Isotropic voids or unstructured gaps (Schumacher, 2008b).	that must be recognized and consciously cultivated "(FRAMPTOM, 1980 apud Pepone, 1989)	medium: liquid in motion, structured by waves and streams. They are fields of force "(Schumacher, 2008b).

It is interesting to note that although Hadid and Schumacher are developing a series of urban projects since the early 2000s, only the most recent projects seem to present a more evident methodology for parametric urban design, in that it incorporates the theoretical parametric urbanism in a more systematic way. In this article, we analyze only three of these projects on the basis that in the documents investigated we only find reference to application of parametric tools in urban plans drawn up for Singapore, Istanbul and London. Regarding the parametric tools used in these projects, although the literature does not clearly register which ones, it is clear that the Maya Mel Script is the used programming language, since according to Fischer & Bhooshan, members of ZHA Computational Design Research Group [30], "The project group uses resources in the Maya script to generate models that respond to changes in environmental parameters."[31]

Moreover, it is quite clear through speeches observed that the parametric urbanism, as proposed by Hadid and Schumacher is only sensitive to the formal parameters, environmental and programmatic. According to Schumacher, innovation can only be achieved because "the scripts allow you to program design tools to handle a large number of parameters and create a design sensitive to the formal parameters, functional and environmental."[32] Therefore, we analyzed the three urban projects mentioned above, identifying how these parameters were explored and, somehow, the configuration parameters of the space were applied. It is understood by formal parameters, those defining the urban form, tissue design and build masses, in addition to its geometric aspects; by functional parameters, those relating to urban uses; by environmental parameters, those relating to environmental and physical data of the place where such urban projects are inserted; and by spatial parameters, those concerning the structure and morphological properties of the urban object, for example, the units of space (convex, linear) and their properties of accessibility and visibility (Fig. 7), and the interface between open spaces and continuous (streets, squares, etc..) and closed (buildings) (Fig. 8). [33] The dimensions and highlighted spatial properties are key variables for the design of urban assets, a central goal explained by the main articulators of parametric urbanism, insofar as

the spatial units are convex and linear dimensions of local and global urban system. According to the structure of these dimensions and the interface between open and continuous spaces and enclosed spaces, overriding conditions are operating toward the integration between the various users of the city. [34]

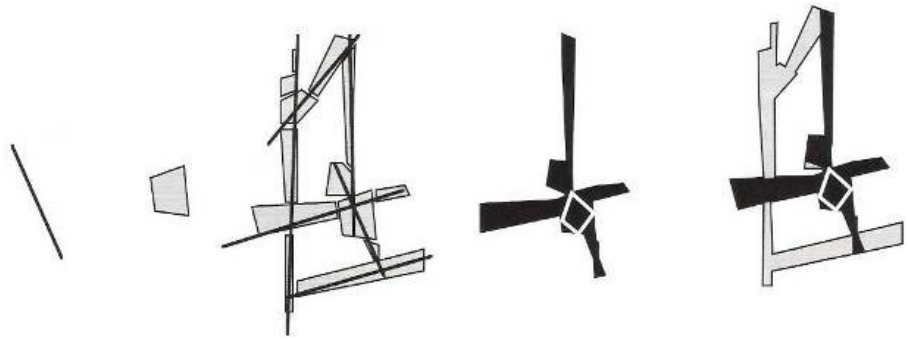


Figura 7. Dimensões do espaço: linha axial, espaço convexo e campos visuais Fonte: HANSON, 1998.

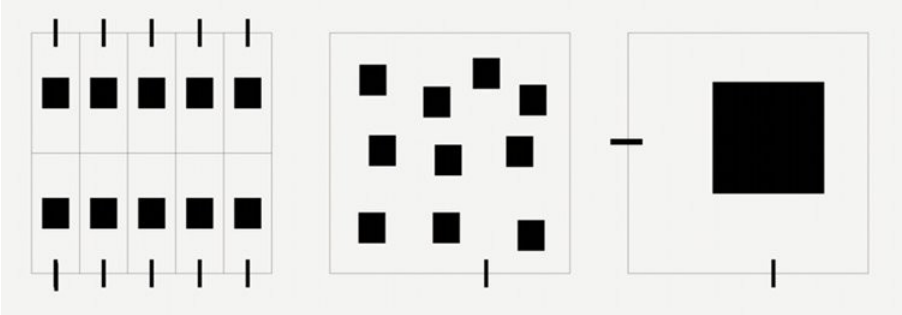


Figura 8. Diagrama interface entre os espaços abertos e fechados

a) One-North Masterplan (2001-2021)

One-North is an area of around 200 hectares situated in an industrial area part of a technology corridor of Singapore, between the business centre of the town, east, and the Nanyang Technological University and other industrial parks in the west. In 1996, the Singapore government felt the need to develop an innovative space in the area, aiming to create a community to "live, work, learn and play."

> "To promote an innovative community, inclusive and vibrant, with economic and social resources for future intellectual workers, the One-North Masterplan will be led by four strategies: [1] Mixed and dynamic use. The strategy aims to create a balanced combination and a distribution of activities. A great mix of uses and programs within the One-North will promote the social, cultural and economic vitality which in turn encourages dynamic urban activities throughout the day. [2] Seamless connectivity. The physical connectivity in the One-North is provided through a network of roads and well-connected nodes that integrate public transport and not impede foot traffic. [3] Constant revitalization: This is an ongoing process of revitalization and renewal in which it is important to maintain the vitality of the development of One-North over the years. Whereas the flexible zoning will allow the One-North to respond to market changes, the adaptive reuse

> and construction of new buildings will allow the urban design incorporates the heritage site in the development of One-North to preserve local history and culture of Singapore in the landscape urban in development. [4] Original identity: This uniqueness is enhanced by drawing from the intrinsic strength of the site, the holding of its undulating topography to create a unique urban effect and the interrelation between free and built layers of unprecedented environment. "[35]

Zaha Hadid won the international competition sponsored by the Jurong Town Corporation (JTC) with a large urban project (Fig. 9) due to be built within twenty years. This project explored a pioneered method of parametric design applied to large scale urban design. According to Gerber, "aiming to overcome the limitations of the methods of urban design standards, the group Zaha Hadid Architects sought to devise and develop a new methodology and tool to address the problem presented by the competition."[36] Given the amount of actors involved in the process and the data to influence the project, the group was "confronted with the need to manage a large database that required a quick view of modifications."[37] The group sought then to develop a design method that was, in fact, parametric, in which the figures and three-dimensional digital model were directly linked in a way that influences and changes the behaviour of another. The result was a “pseudo parametric design tool” [38], incorporating data such as area, density, flows, formal and contextual constraints, among others. The tool will read and parse these numerical data in spreadsheets, tables, graphs and three-dimensional models.

"One North is designed to overcome the physical isolation of the site through the provision of infrastructure and a space strategy that emphasized the connections with the surroundings."[39] The integration between the programmatic and formal parameters has sought to promote the movement and activity on the street. The key principles of the project focused on creating a business park that emphasized the diversification of uses, a vibrant urban atmosphere, guided by a grid of waved buildings and nodes of intensities. Thus, the urban design characterized by a mega-urban form smoothly waved like a dune, whose aesthetic intention is to convey a sense of cohesion. At the same time enabling a high degree of aesthetic cohesion, the strategy provides a wide variety of built-volume (high, low, wide, and narrow) governed by two forces of unification: a smooth grid and a waved roof surface. The elastic curvilinear geometry of the designed streets and paths facilitate the articulation with the urban tissue of adjacent areas, in addition to the production of a great variety of setting land division. The parametric and topological properties gave to the model the necessary flexibility to adapt and change at any stage of the project development, but ensuring the maintenance of its consistency and formal character.

Although the main objective of the proposal has been "[...] design for the [promotion of] vitality, in other words for the [promotion of] urban interaction [40], "the explored parameters to ensure such levels of interaction were only programmatic and formal. To plead for density, mixed use and overlapping patterns of movement, this strategy seems to be based, though not overtly, in the ideas of Jane Jacobs. [41] Jacobs defended the environment of richly used streets, connected and accessible, with a mix of features and high densities. The principles advocated by Jacobs has been recognized and adopted in several proposals for planning and urban design since the 1960s. However, according to Peponis, this type of strategy "cannot [itself] guide the development of architectural design of urban areas" given "the absence of a clear understanding of the configuration properties which rely on the patterns of overlapping dense and mixed uses." [42]

b) Kartal_Pendik Masterplan (2006)

Kartal_Pendik Masterplan (Fig. 10, 11 and 12) is a project of urban renewal for an abandoned industrial area, located in Istanbul between the regions of Kartal and Pendik, which are situated at the confluence of major infrastructure such as roads that make connection between Istanbul and other European and Asian countries. The area was designed to be a new centrality for the city by offering business centres, residences and cultural facilities like museums, opera houses and theatres, and spaces for leisure activities, e.g., marinas and tourist hotels. The group Zaha Hadid Architects departed from the proposal to incorporate the existing urban infrastructure, articulating the connections of the main routes identified in the urban regions of Kartal, west, and Pendik, on the east. The integration of cross connections (east-west) with the longitudinal axis (north-south) of highways sets a soft mesh that forms the underlying structure of the project - an elastic grid that extends and contracts to adjust to urban conditions and topography of the place.

Vertically, the elastic grid is extended to form the townscape of the area. In some regions the grid amounts to generate a network of towers in the open landscape, while in other areas it is inverted to become a denser mesh, cut through by streets and in other cases it may fade away completely to generate parks and open spaces. That is, by its flexibility, that the grid allows the introduction of various build forms, allowing different patterns of density, such as: (a) a situation where a network of multi-storey towers could emerge or (2) a situation where a set of urban blocks could be prepared, in the manner of Cerdà, shaping the perimeter of the court and with a central courtyard. The built typologies proposed by Hadid responded to the demands of each of the seven urban districts in the proposed project. The strategy is therefore a dynamic and flexible system for the

generation of urban form, balancing the need for a recognizable image and a new environment with a sensible integration of the new urban structure with the pre-existing city that surrounds it.

It is interesting to note that investigations of Zaha Hadid and Patrik Schumacher recover the grid as a structure base for ordering the urban territory. This is not a Cartesian grid as the built environment that characterized many modernist urban projects, but a kind of topological grid that deforms to adapt to different circumstances and urban topography, i.e., the physical and environmental field. However, there was no significant orientation or conduct of these deformations by spatial variables of configurational nature, both with respect to the deformations of the horizontal plane about the vertical extrusions, to look for patterns of greater or lesser ease of access, favouring therefore, the allocation of dependent uses on movement of people or, conversely, requiring greater isolation. The processes of coordination between the existing and proposed urban fabric are made without the mutual effects are observed, as evidenced aspects of urban form at the expense of spatial relations.

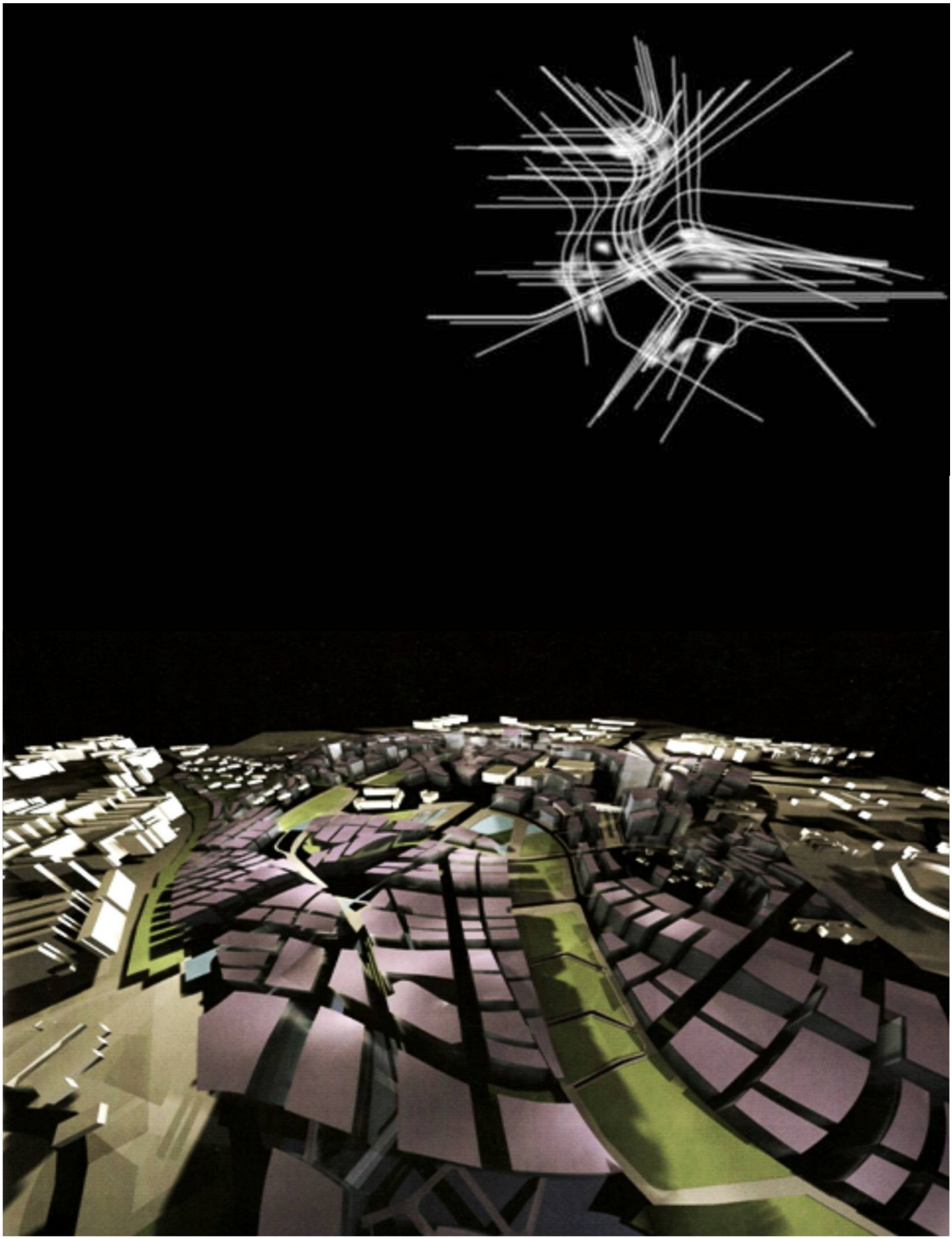


Figura 9. One-North Masterplan. Acima: Diagrama do padrão de vias curvas projetadas para articular-se com o tecido urbano pré-existente. Abaixo: Forma urbana ondulada cortada pelo padrão de vias curvas. Fonte: HADID ARCHITECTS, 2009

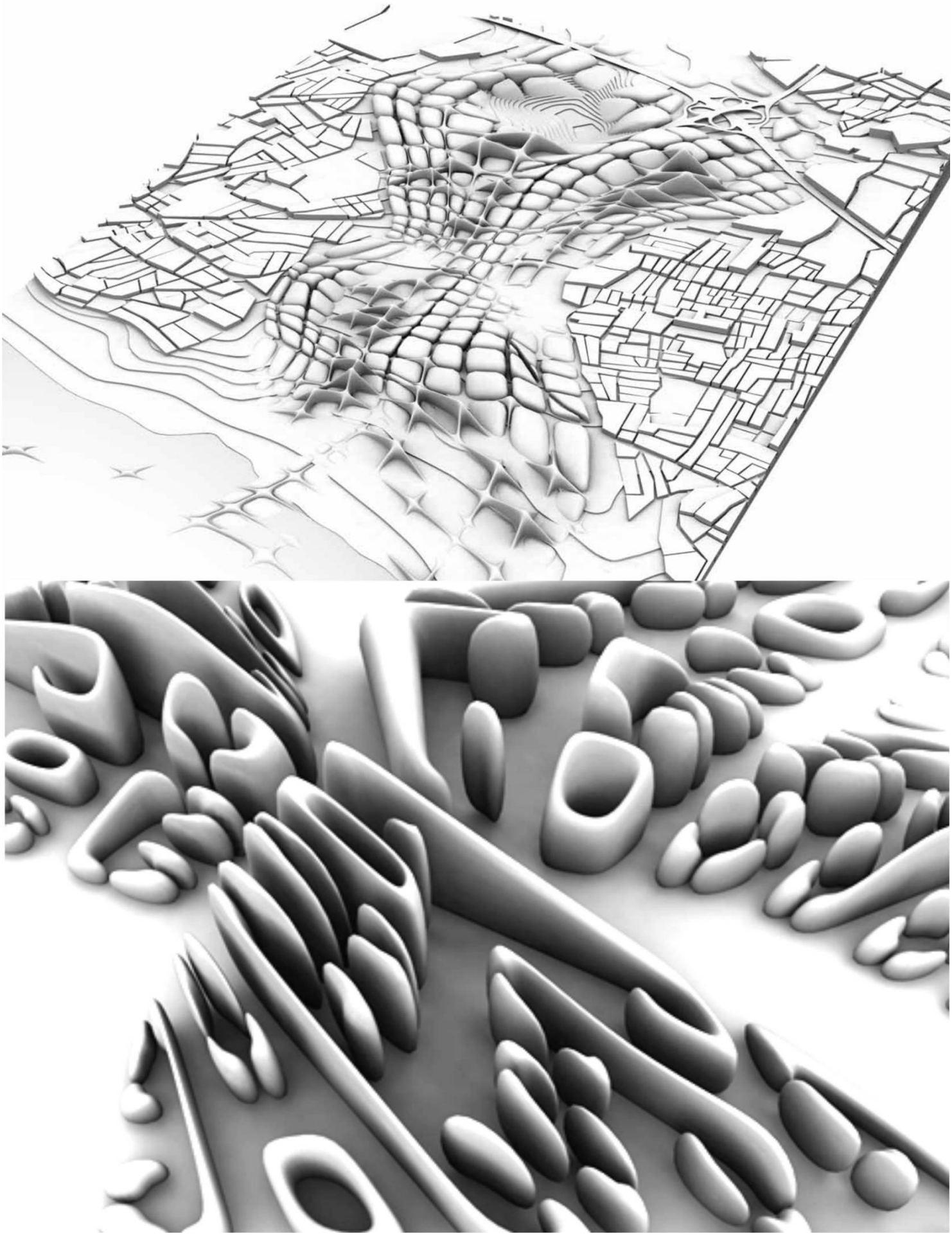


Figura 10. Modelo urbano do Kartal-Pendik Masterplan, em Istambul. Fonte: GA DOCUMENT 99, 2007.

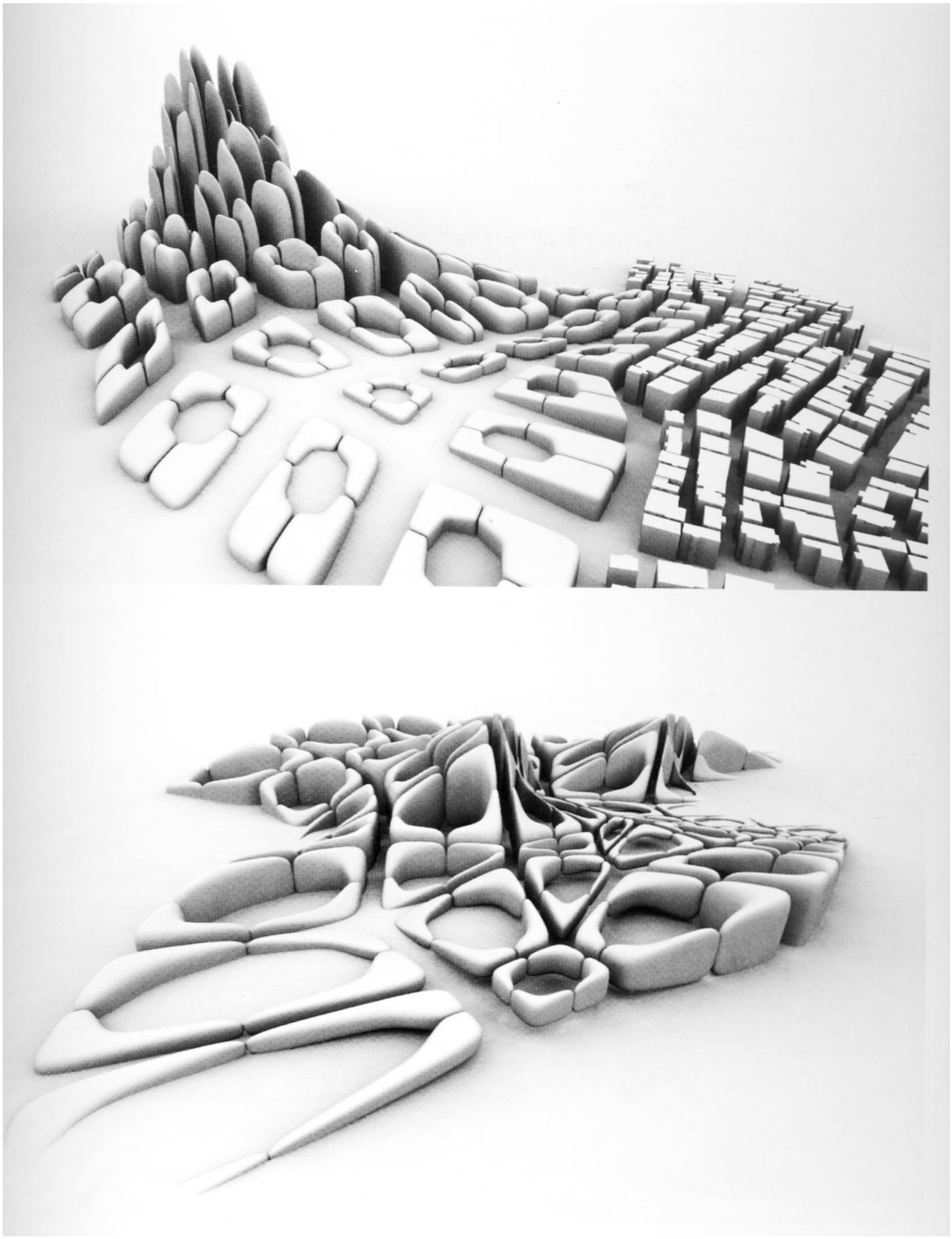


Figura 11. Detalhe da malha urbana do Kartal-Pendik Masterplan, que comporta formas edilícias diversas. Fonte: GA DOCUMENT 99, 2007.

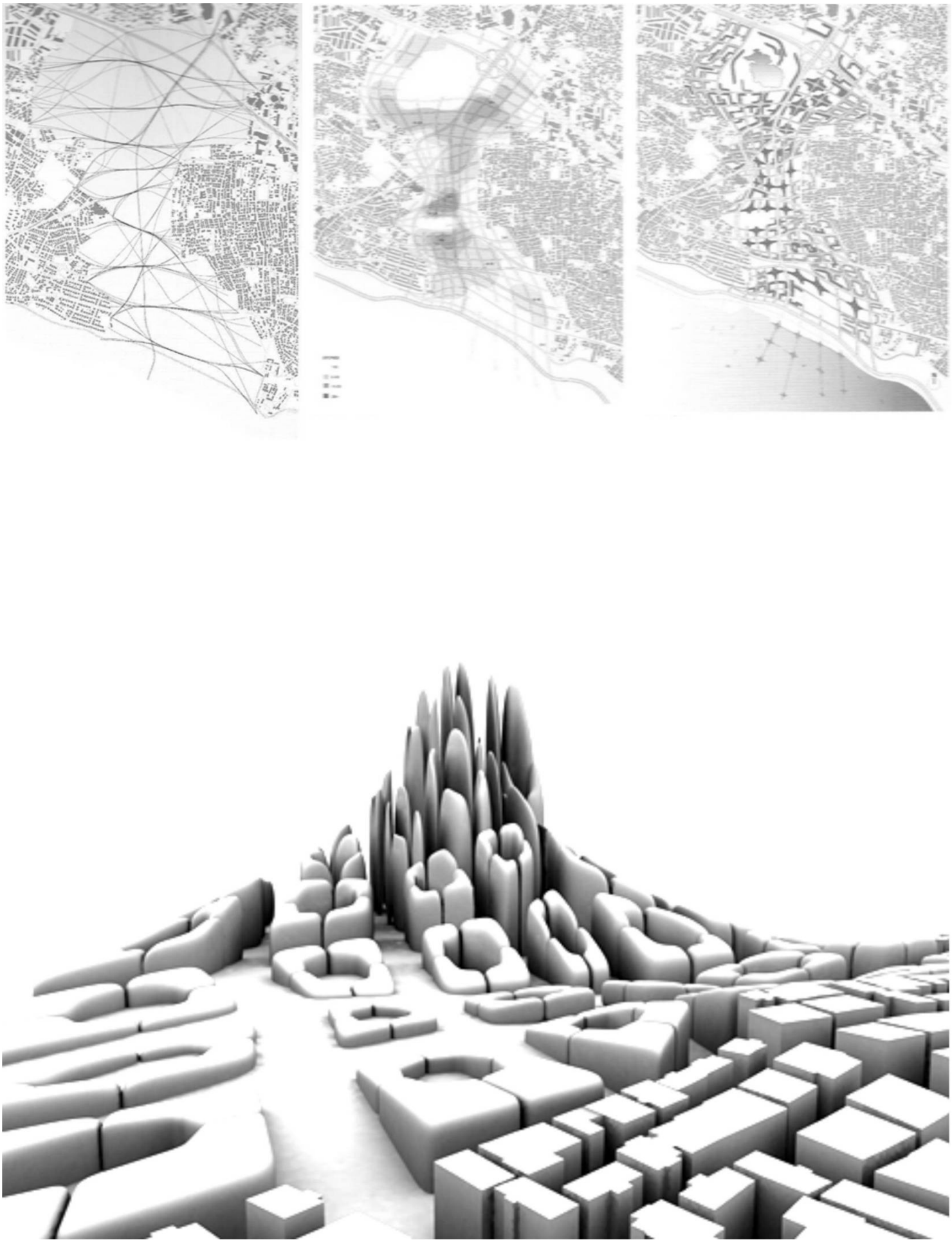
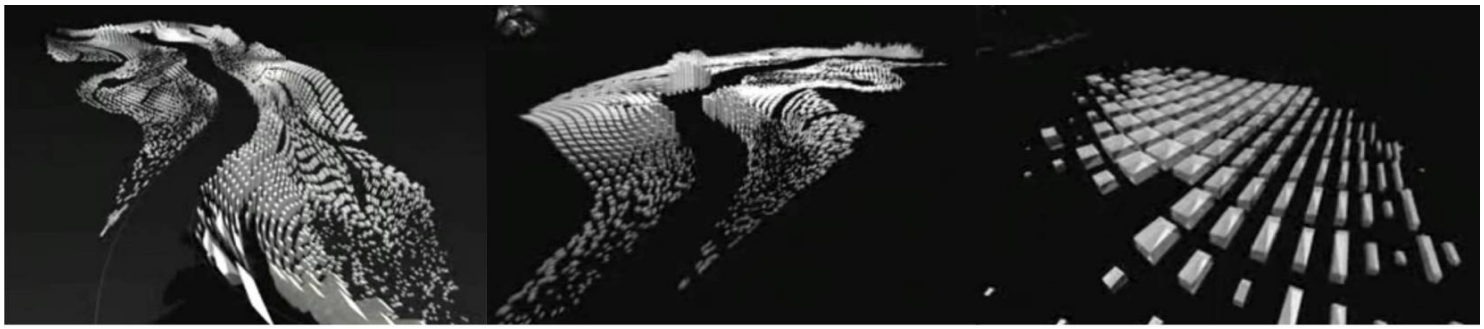


Figura 12. Kartal - Pendik Masterplan, em Istambul. Detalhes do plano urbano com articulação do sistema das vias propostas com as vias existentes e, abaixo, o perfil do projeto urbano na paisagem da cidade. Fonte: GA DOCUMENT 99, 2007.



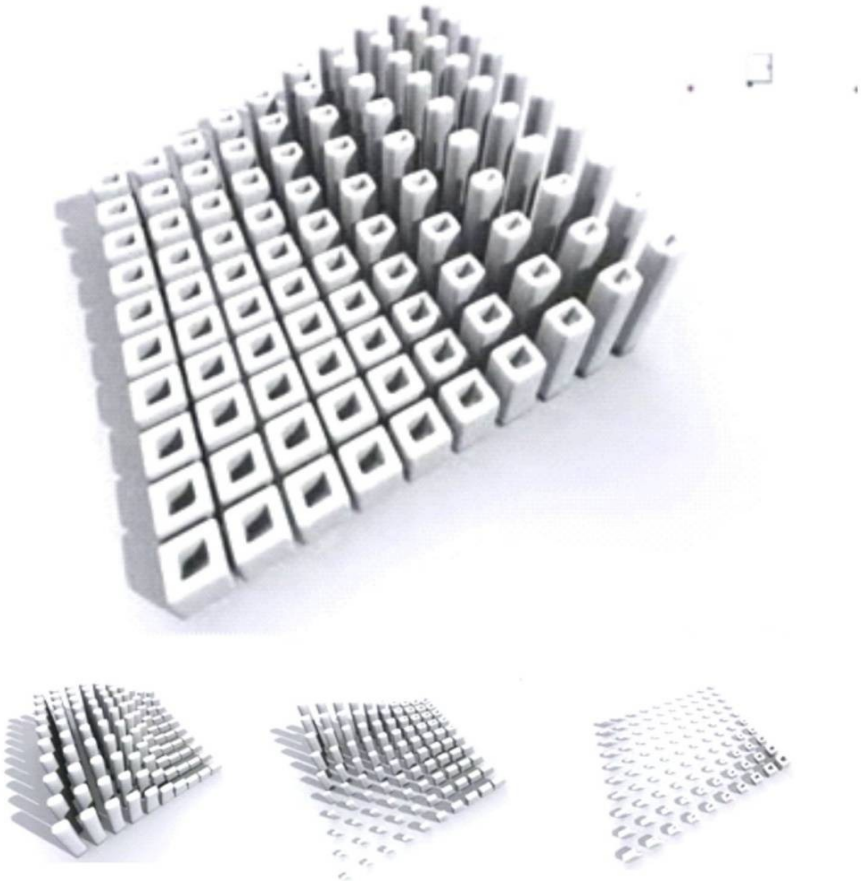


Figura 13. Thames Gateway Masterplan. Detalhes da modelagem urbana (acima) e os ensaios com modelo computacional (abaixo). Fonte: HADID ARCHITECTS, 2009

c) Thames Gateway Masterplan (2007)

The Thames Gateway Masterplan (Fig. 6:13) is a plan for an area cut by the River Thames and spreading to East London. Zaha Hadid and Patrik Schumacher took the area as a proving ground for developing new ways of solving problems of large-scale urban projects. They were using a series of digital parametric design techniques to develop a proposal for the urban renewal area. Through a survey of architectural typologies in the history of urban development and architecture of London, they have identified and examined four main building standards: individual villas, high-rise towers, slab-shaped buildings and city-blocks (isolated houses, towers, buildings formed of flat plate and urban blocks). They associated these types of four different geometric elements, namely: point, line, plane, and volume. From this, they programmed a computer modelling software to design and permute these four building types under the Thames Gateway area, investigating how they could be scattered in the landscape.

Later, Hadid and Schumacher set the model to suit conditions in the area and used it to speculate in terms of possible forms of future development. They tested multiple combinations of different building standards types, often fusing them to create hybrid structures. The result is a complex urban field with a variety of build forms. Although the project has not been carried out, which prevents us from evaluating parameters of a programmatic nature, among others, it was displayed at the exhibition Global Cities held at the Tate Modern in London in 2007 under the title of Parametric Urbanism - Form Informing Urbanism. The exhibition consisted of an animated sequence that showed the evolution of the urban model. Although they have been focused the purely formal parameters, the possibilities of the tools of parametric design applied to urban design have been exploited to the maximum through techniques of parametrically controlled proliferation, logical self-organization (or swarm-formation) and building networks of interrelated parameters. This model has given the flexibility to cope with the rapid succession of design changes, since changing the parameters of a given object it became easy to quickly view in the virtual model a great number of versions, with no need for the repetition of the same elements, but which facilitates decision-making during the design process.

Despite the potential to increase efficiency and quality of proposals for urban design, town planning parameters as well as modern urbanism and the recent urban theories and approaches, from Rossi to Koolhaas, does not exploit spatial parameters. According to Holanda, the spatial dimension or the "space is the syntax of urban settings, system of barriers and permeabilities to movement of people on the ground," [43] and added, "the physical barriers and permeabilities on the floor (syntax) overlap rules of use (semantics)

that add symbolic meaning to the syntax of the place and help to form - produce and reproduce - patterns of social interaction."[44]

Virtually every recent urban theories neglect the spatial dimension of urban object, both in terms of its local and global properties. According to Peponis, "the recent approaches to urban design do not solve the question of how to design specific areas or local areas, while taking into account the global patterns of streams, of centrality and of differentiation, which gives the urban space its distinctive cultural character."[45] After all:

> The experience of environments genuinely urban relates to the meeting, although not necessarily to the interaction, between people, mostly unknown, that may be identified as belonging to different social classes, status, race or ethnic origin; also refers to exploitation of which is not customary, and by knowing other lifestyles, though these they do not participate. Building in the urban environment means dealing with this mixture of familiarity and difference; it also means to establish a more orderly way that is in itself in a broader context that influences the juxtaposition of the how the form will become intelligible. These interactions do not happen simply because cities are dense and diverse and diachronically occupied. They occur on the basis of overall morphological properties of urban arrangements. Thus, space can be seen as the most distinctive and persistent dimension of urban culture because it not only expresses, but overcomes the classifications established by the structure and the social discourse, including the classifications of architectural types. [46]

The parametric urbanism, therefore, does not escape this rule, since it does not exploit spatial parameters of configurational nature to instruct design decisions. Spatial configuration parameters could be introduced into the model to ensure the proposition of urban layouts that could better withstand an integral relationship between occupation (from the definition of ideal locations for different activities) and the movement of pedestrians and vehicles, to ensure the vitality of urban areas. Configurational properties, e.g., connectivity between spaces, accessibility, public-private interface and visual fields contribute to the distribution and location of activities and urban dynamics. Depending on these parameters, the urban area may have a higher or lower rate of urban life, or better, to be more "urban" or more "formal". This is what Holanda identified as "paradigms of the urbanity" and "formality,"[47] the presence of two socio-spatial paradigms in the urban structure of cities. Thus, it is suggested here that the parameters involving the paradigms and the formality are transformed in the prospect of being easily incorporated into processes of parametric urban design.

3. Prospects for improvement from the paradigms of urbanity and formality as spatial parameters of urban design.

Frederick Holanda, professor at the University of Brasilia (UNB), has been devoted to studying and understanding the logic of human settlements and its implications in the use of space. In doing so, the author approached the space syntax, a configurational theory of architecture, proposed by Bill Hillier and Julienne Hanson. [48] The space syntax [49] assumes that "the spatial organization of human, whether in the form of settlements, whether in the form of buildings, is to establish patterns of relationships consisting of barriers and permeabilities of various kinds."[50] For Holanda, "these barriers and permeabilities are, in fact, physical sanctions of a system of meetings and restrictions that constitute the society, both at the level of settlements as at a level of buildings." [51] The space syntax, the author says:

> [...] target primarily the establishing of relations between the spatial structure of cities and buildings, the spatial dimension of the social structures and broader social variables, trying to reveal both the logic of architectural [and urban] space at any scale, as the spatial logic of societies. In doing so, the movement of pedestrians has occupied a privileged place in relation to the study of spatial form of the city. Even if the traffic of pedestrians is literally a byproduct of a research program with other goals, namely, by understanding the morphology logic of urban networks. [52]

To investigate a specific phenomenon recurring in the history of human settlements, the "spaces of exception", [53] Holanda suggested that the various types of settlements identified throughout history can be characterized as the range of positions between two polar tendencies: the "paradigm of urbanity and formality." Space of exception is a type of settlement that is within the paradigm of formality, in which social arrangements are highly segmented, heavily insulated, ceremonial and hierarchical, and characterize relations of power. At the extreme opposite is the paradigm in city life of urbanity which encompasses intense citizen participation and free expression of differences, identifying it with universal values closer to a democratic society. According to Holanda, "the words formality and urbanity are interesting because [...] simultaneously communicate ideas about the physical space - and thus the spatial patterns - and ideas on human behavior - and therefore the spatial life and social life."[54] This is because:

> Formality comes from formal, on the form - outer boundaries of matter that comprises a body, and gives this character a setting, one particular aspect - but this in a way that is spontaneous, that sticks to established formulas, conventional. Formality is also an express way to proceed, what is usual, routine. In turn, urbanization obviously refers to the city as a physical reality but also to the quality of courteous, friendly, on the continuous negotiation between interests. [55]

Holanda examined and confronted the morphologies of the settlements: Mayan and Hopi, in America; Zulu and Ashanti, in Africa and in Feudal Europe, French chateaux and Italian

city-republics, besides studying seventeen areas of the Federal District, including Brasilia. He based his analysis in a series of variables that relate to spatial patterns such as "percentage of open space on the total space, convex medium space, the number of entries per convex space; % of blind spaces; m2 of convex space per entry ; linear feet of the islands perimeter per entry, network economy; integration; intelligibility, form the core integrator. In addition to variables related to life space as: variety of labels; density labels, patterns between spatial labels and relationships, relations between the labels themselves, the real presence of open spaces; predictability; arrangements in the relationship between internal spaces and external spaces ; spatial extent of the arrangements, arranging casual versus formal arrangements. The measures taken of the variables of the spatial patterns were based on the construction of maps of barriers, convexity and axially. [56] To compare the variables among themselves, he translated each found interval on a scale 1-5, corresponding to a maximum of formal urbanity, respectively. The author concludes that:

> [...] The creation of the paradigm of formality has consistently been characterized by: maximization of open space on the total area of the settlement, increased average convex space, lower number of entries for convex space; higher percentage of blind spaces, the increased surface square meters of open space per entry, a larger number of linear meters of islands that define the convex spaces, for entry, both meshes extremely regular and highly irregular (as opposed to a middle ground on this scale of variability), again an extremely shallow or extremely deep axial structure (as opposed also to some middle ground on this scale of variability), low intelligibility measurements; core integrators that are now concentrated or in the periphery or in the centre of the system, and not irrigate the settlement as a whole. Unlike the paradigm of urbanity is constituted by opposite trends in all categories.[57]

Although these paradigms represent opposite tendencies of a theoretical model, in many cities we can find the two types, i.e. urban networks have degrees of urbanity and formality in a continuous scale. The variations in the mesh structure the manifestations in public space and the most suitable locations for different purposes, such as civic and daily activities. By promoting joints, deformations, differentiation and proliferation of different building standards in the urban structure, parametric urbanism observe the variables of spatial patterns, so, without considering the implications of new forms designed for urban living. However, the spatial variables employed by Holanda can be easily converted into computationally manageable parameters [58] in order to facilitate its introduction in a parametric methodology of urban design in order to propose more efficient urban layout, and in order to be better able to support an integral relationship between the occupation (from the definition of ideal locations for different activities) and the movement of

pedestrians and vehicles, to ensure the vibrancy of urban areas.

4. Conclusion

Whereas "to give visual form to the city is a special type of design problem and, moreover, a relatively recent problem," as Lynch[59] says, it is natural and legitimate for the latest advances in digital technologies applied to the project, which in which fit the parametric design tools, have approached both the architecture and urbanism in recent years, and in particular the processes of urban design. As Menges said "the design [or the project] emerges as a discipline of the artistic process as a way of abstracting [conceiving] and evaluate possible alternative configuration, scenarios and achievements without having to physically perform and test each possible solution."[60] In this sense, to bring closer the tools of parametric urban design to the design processes, investigations of Hadid and Schumacher show themselves to be quite relevant, considering the fact that these tools have the flexibility to explore multiple alternatives in an interactive digital environment, allowing the comparison of different options and choosing the most appropriate solutions whatever are the parameters and performance criteria.

However, as we have seen, the parametric urbanism, as well as much of the recent urban theories, neglects the spatial parameters of a configurational nature. Since building in the urban environment requires setting a form, and hence the establishment of patterns of relations consisting of permeability barriers - physical sanctions against the system and constraints that constitute the society - the variables or spatial parameters underlying the spatial patterns cannot be neglected. Apart from the eminently formal, environmental and programmatic parameters, involve the process of architectural design, the urban nature of configurational parameters must also be considered in any project or proposed intervention in the city as a way to ensure better performance of the Urban arrangements, to promote better distribution of activities and establish patterns of movement of pedestrians and vehicles, or urbanity. Incorporating these parameters, the parametric urbanism has great potential to consolidate itself as a systematic methodology of urban design.

Thus, the parametric urbanism could build a more systemic approach, considering the urban design not as a product derived exclusively from the shape, function or environment, but as a product of relationships between the various elements of a more complex system that is the town itself, composed of places and individuals, among others. The parameters of form, function and environment must be interrelated to the configuration parameters of the space.

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Notes

[1]The term parametric urbanism comes from parameter, a term that can refer both to the entire element whose value range changes from solving a problem without changing its nature, the more technical or mathematical sense of the word, but also to any factor determining a threshold of change and / or that restricts what can result from a process or policy, or what serves as a control to a certain action. In the latter, the meaning is the nearest boundary or border. In most of this work, we will employ the term in its more technical or mathematician sense.

[2]KOLAREVIC, 2005, p.253.

[3]FERRE, 2007, p. 51.

[4][04] This approach regards the design of systems defined by Bertalanffy (1977) as a complex of interacting elements; it would be through the inter-relationships between the parts that the whole would be characterized as such.

[5] MARCUS, 2008.

[6]Configuration parameters of the space are being investigated by Bill Hillier and Julienne Hanson since the 1970s (HILLIER; HANSON, 1984; HILLIER, 1989, 1993, 1996). Hillier and Hanson have been devoted to study how the spatial organization manifests itself socially and how space affects social organization. For Hillier, the movement of people across space is in direct connection with the spatial configuration of the urban network. The configurational structure of urban networks involves movement patterns and contributes to various forms of occupation, of course, independent of attractors (HILLIER et al, 1993).

[7]It is noteworthy that, in the 1920s, Walter Gropius investigated architectural and urban solutions to the problem of housing in modern cities, aiming to make better use of urban land. Gropius focused on formal parameters and environmental considerations as verticality (number of floors of buildings), open area ratio x built area, orientation of buildings and insulation and lighting conditions. He took as a starting point for his investigation to so called rule of Heiligenthal.

[8] HOLANDA, 2002.

[9] MITCHELL, 1999 apud KOLAVERIC, op. cit., p. 255.

[10] MONEDERO, 1997.

[11] For more information about the SmartGeometry Group, see:http://www.smartgeometry.org.. Accessed: June, 2009.

[12] KOLAVERIC, op. cit., p. 255.

[13] Zellner, 1999 apud KOLAREVIC, op. cit., p. 251.

[14] KOLAREVIC, op. cit., p. 251.

[15] Ibid., P. 251.

[16] Ibid., P.253

[17] Steinø & Veirum (2005) observed that in recent years, various forms of parametric approach have been introduced in urban design strategies such as: (1) Functionmixer by the Dutch office MVRDV, (2) Dynamic Myllypuro Masterplan by the Danish Architect Robert Haff-Jensen, and (3) an urban project produced by Lykke-Olesen in his doctoral thesis. According to the authors, although these examples provide relevant contributions, constituting a useful basis for formulating a systematic parametric approach to urban design, they focus only on quantifiable data and ignore what is most important - which are the various parameters to be adjusted and why a fundamental prerequisite is needed for all design decisions. In order to identify possible prospects for the development of urban design as a parametric methodology for urban design, the authors conducted a workshop with students and made a provisional methodology for parametric design, including spatial and programmatic parameters such as density, space and usage, beyond the formal parameters as: Cartesian geometry / organic, regular / irregular / or dense / sparse model high / low, among others.

[18] Gerber (2006) investigated how the computer systems have altered the design methods of urban design projects, from three projects that apply parametric processes, aiming at the design of its formal characteristics. They are: (1) Space Alliance, a study for a business centre in central London, developed by the author under the DRL - Research Design Laboratory at the Architectural Association School - under the direction of Brett Steele, (2) One North Masterplan, the project of developing a technological centre of 200 acres in Singapore and (3) Smart Cities, a research on mobility and intermodality coordinated by Prof. William J. Mitchell, under development at the Media Lab at the Massachusetts Institute of Technology (MIT).

[19] STEINØ; VEIRUM, 2005, op. cit., p.679.

[20] Although the term parametric urbanism appears for the first time in literature in the text Towards a Parametric Urbanism by architect David Gerber, originally published in 2006 by French magazine Anomalie Digital, in this work we will assign it to Zaha Hadid and Patrik Schumacher. Patrik Schumacher is a PHD by Klagenfurt University, co-director of the DRL (Design Research Laboratory) of the Architectural Association School in London and partner of the firm Zaha Hadid Architects since 1988. In 2005, the term now appears as parametric urbanism research agenda of the DRL. View: SCHUMACHER, P; VEREBES, T.; SPYROPOULOS T., Obuchi, Y. DRL Course Guide 05-06. Architectural Association School. London: 2005. Available at: http://www.aaschool.ac.uk/aadrl/ABOUT/DOWNLOADS/parametric_urbanism_briefs/parametric_urbanism_briefs.pdf. Accessed: August, 2008.

[21] In Urban Texture and Space Syntax: some inconsistencies, Ratti (2004) makes brief reference to urban projects of Zaha Hadid using the term 'extravagant' after questioning the application of Space Syntax in current projects for urban design: "[...] can it be assumed that they will be nonetheless present in any design option? In the Zaha Hadid's masterplan, or in other extravagant and pattern-free schemes? "

[22] SCHUMACHER, 2008b.

[23] Ibidem.

[24] Ibidem.

[25] The idea of swarm-formed- originated possibly in the investigation of Craig Reynolds, an expert in computer graphics. In the late 1980s, Craig Reynolds created a computer model (called boids) to simulate the behavior of flocks of birds. In the model, each BOID is represented by a pair of wings that obey the three rules: (1) maintain a minimum distance in relation to other boids and objects in the environment, (2) adjust their speed to that of other boids and (3) move toward the centre of the collection of other boids in your neighborhood. The investigations of M. Reynolds were described by Mitchell Waldrop in Complexity: the emerging science at the edge of order and chaos. It is noteworthy that, in his seminal text From Object to Field, Stan Allen suggests that the architecture could approach such investigation and begin researching "possibilities of more fluid approaches. The condition of the fields in the architecture offers a chance to address the dynamics of use, crowd behavior and complex geometries of bodies in motion "See: ALLEN, Stan. From

object to field: architectural design. London: Offices, 1993, p. 29-30.

[26] SCHUMACHER, 2008a.

[27] Ibidem.

[28] SCHUMACHER, 2008b.

[29] PEPONIS, 1989.

[30] The ZHA Computational Design Research Group is a research group originally established to conduct computational research for the office Zaha Hadid Architects.

[31] FISCHER; BHOOSAN, 2008.

[32] Ibidem.

[33] HILLIER; HANSON, 1984.

[34] Idem, 1996.

[35] See: ONE-NORTH. JTC Corporation. Available in http://www.one-north.sg/aboutus_masterplan.aspx. Accessed: January, 2009.

[36] GERBER, op. cit., p.155.

[37] Ibidem, p.157.

[38] Ibidem, p.157.

[39] Ibidem, p.157.

[40] Ibidem, p.157.

[41] JACOBS, 1961

[42] PEPONIS, op. cit.

[43]HOLANDA, 2003, p. 35.

[44] Ibidem, p. 25.

[45] PEPONIS, op. cit.

[46] Ibidem.

[47]HOLANDA, op. cit., p.125.

[48] HILLIE; HANSON, 1984.

[49] The special syntax has been the subject of intense discussion in academia, particularly with regard to two aspects that underlie it. First, regarding the relationship between space and behavior, such as posed by Lawrence (1987) points out that a space system can provide similar support to different social expectations. Second, in relation to the limitations in their methodological procedures of representation, description and analysis space. At this critical field, we highlight the contributions of Teklenberg and Timmermans (1993), discussing the mathematical procedures used to compose and normalize the measure of centrality called integration, key in the space syntax, and the latest from Carlo Ratti (2004) , which points its inefficiency in providing a precise analysis of certain aspects of regular urban grids. In the last decade, however, several investigators broadened considerably the range of procedures describing the urban form and buildings of which must be highlighted the Visual Graph Analysis (VGA) (TURNER, 2001) and the line of continuity (FIGUEIREDO, 2004; FIGUEIREDO; AMORIM, 2005), which overcome some of the paradoxes presented and broaden the field of configurational investigations.

[50] HILLIER & HANSON, 1984 apud HOLANDA, op. cit., p. 96.

[51] Idem, op. cit., p.96.

[52] Idem, op. cit., p.92.

[53] Idem, op. cit., p.126.

[54] Idem, op. cit., p.125.

[55] Idem, op. cit., p.125-126.

[56] The map of barriers is represented not only by the barrier constituted by buildings or isolated set of buildings, but also by gardens, pools, differences in level or any obstacle that restricts movement. The map of axiality or simply axial map is the key instrument in the parsing of space. It represents the configuration of open spaces and continuous urban fabric, through its accessibility and visibility lines (axis lines) and their connections. It is mainly based on this representation one obtains measurements of the syntactic properties

of space. The convexity map is obtained by inserting spaces in the system of open spaces of the city's smaller number of larger convex spaces. The convex space can be understood, therefore, as a "place", a separate section of a street or a square, for example.

[57] HOLANDA, op. cit., p.126.

[58] A parametric model based on the variables investigated by Holland was developed in the dissertation, entitled Parametric Urbanism: Parametrized Urbanity developed by Robson Canuto da Silva, under the guidance of Professor Luiz Manuel do Eirado Amorim, the authors of this article. The dissertation was developed at the Graduate Program in Urban Development, Federal University of Pernambuco. This article is a byproduct of investigations undertaken during the preparation of the dissertation.

[59] Lynch (1997), preface.

[60] MENGES, 2006, p. 46.