# The Impact of Explicit Logic on Re-generating Urban Form

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## PART I : GENERATIVE PROCESSES

In today's computer savvy world it is perhaps no longer interesting to discuss digital tools purely as means in themselves. The growth of abstract exponential systems or the generation of modulated patterns for their own sake simply strain justification in light of real-world concerns such as climate change and economic crises. Still, we pursue evolving digital technologies in hopes that they prompt innovative design strategies and creative organizational, spatial or formal results that align with the changing world and the evolving techno-cultures, which are so rapidly affecting modern life. Parametric tools permeate most contemporary design explorations but the generative techniques are no longer the topic of focus in themselves[1], rather the tools serve as the means towards engaging a more critical architectural discourse. Swapping from generative techniques to generative form in the wake of this renewed criticality seems counterintuitive since the term 'form' in architecture and design is often used derogatively as being concerned more with 'surface' than substance. However, form not only concerns the shape and external appearances of a thing but also and foremost the manner of associating or ordering parts within a given medium in order to achieve an effective result[2]. Establishing and manipulating the large set of variables, parameters, and associations mandated by complex projects, especially at the urban scale, is precisely where today's digital tools can contribute most.

### the Impact of Explicit Logic

While aided with a variety of analogue techniques, design professionals have traditionally dealt with vast amounts of project information in largely implicit ways. Digital technologies have assisted the designer's ability to cope with and manage an increasingly complex array of variables by defining, storing and managing explicit relationships between both information and design elements. Explicit and symbolic logic modelers like Bentley's Generative Components and McNeel's Grasshopper plug-in have had a substantial impact on design at the building scale[3]. Over the last few years there has been an increasing effort, especially from schools of architecture, to explore the use of these tools at the scale of the city. Neil Leach presents a large body of this explorative work on the city in AD: Digital Cities and argues that digital technologies while being used to analyze and understand the operations of cities have also started to transform the city itself by creating overlaps and interfaces between the virtual and the real. However, the most transformative feature of digital technologies is perhaps also how they infiltrate the design process and affect the fundamentals of design thinking.

Like all instruments and techniques, explicit logic modelers create new avenues for exploration that in turn help produce resulting concepts and forms. Explicit logic impacts the design process by asking designers for explicit definitions to what might otherwise remain as implicit relationships. This additional level of organizational input slows the initial design process, in a type of systemic delay[4] and demands a different way of thinking about and structuring design. Associative modelers move beyond both representational geometries and computational code in an attempt to model or simulate the formative principles that define explicit relationships between design elements. Through the use of an iterative process, explicit logic modelers seek formative strategies where a variable but related syntax between elements generates a range of forms instead of a compositional absolute. The inherent flexibility of relationship-based models allows designs to be continually refined towards a contextual specificity that is derived from quite complex arrays of variables.

**Digital Reproductions and Formative Evolutions**

Analogue methods of reproduction encode small but significant errors that distance reproductions from the originals. This uniqueness gives a type of authenticity to the reproduction itself, supports the notion of an origin by not fully replicating the 'original', and creates a finite reproduction process where copies of copies eventually error into 'misreproductions'. In contrast, digital methods of reproduction create duplications without error. Because of this, analogue methods lean either towards achieving exactness or exploring the possibilities of error while digital methods encourage processes of willed variation. Architectural reproductions are of course possible along the entirety of process - from concept to building. While the digital reproduction of photo of a building further increases the potential for dissemination, it maintains many similarities with its analogue or mechanical counterpart. However, the reproduction of digital processes, even something as straight-forward as a CAD drawing, prompts a shift from static representation towards more flexible models or simulations that can be tinkered with, modified and evolved towards new specificities.

Although models and simulations still remain subcategories of representation, simulations demonstrate the behavior or characteristics of a system rather than the thing itself[2]. As a type of simulation, associative or parametric modelers focus design attention on the behavior of a system and the relationships between elements, rather than just a description of the geometry or form itself. The explicit logic diagrams (fig 01) present in associative modelers highlight the definition of these relationships, thereby offering a new form of 'representation'. Multiple viewports allow different 'perspectives' of the project to coexist; the script or code, the symbolic or explicit logic diagram, and the more traditional geometric representation. Symbolic logic models, first reproduced in print, at-

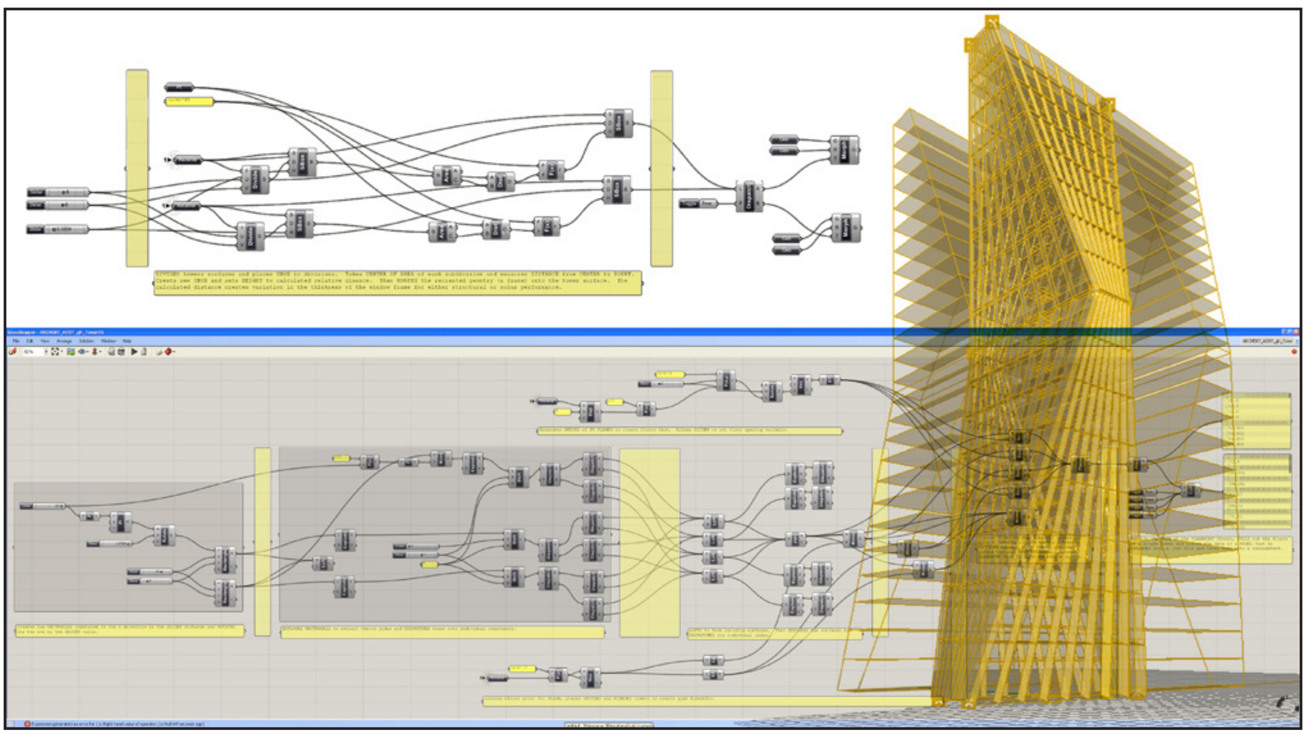

*fig 01: Explicit Logic Diagram, Tower Cluster, 2009*

tempted to show the structural logic behind design relationships. These models are now increasingly disseminated via digital means. Similar to script, these models are either evolved internally or given a new specificity by placing them in different contexts and uses. The fundamental difference with symbolic logic (from raw code) is that its models graphically highlight design relationships, making relationship-based modifications more explicit and instantly accessible to a larger group of designers.

**Design Elegance**

In science, elegance suggests simple and symmetrical relationships found in well-known models like $E = mc^2$ that can explain powerfully complex and parallel situations with minimal means[5]. In this case mathematics is used to explain phenomena in the physical world. The language of architecture is less definitive and often claimed by qualifying particular projects from the built environment. However, the proliferation of the term *architecture* (information architecture, architecture of the web, etc.) pulls the term away from the materiality of the built environment and more clearly defines it as an organizational system. In this manner explicit logic diagrams equate to architecture the way that mathematical notation equates to physics.

Iterative and variable processes, prompted by symbolic and associative models, are more likely than representational methods to achieve an economic balance between complex parameters. Architectural practice may even begin to discuss the elegance of the explicit logic diagram itself, its potential and its variable applications. If so, then building types will increasingly be designed through the use of symbolic formula with, for example, a skyscraper having one set of parametric equations and a box store another. Basically, these formulas are already implied within the functional, organizational and performative criteria required by each project type, but are made more explicit and coherent through symbolic models. These design kernels become the new DNA of building types where designers experiment and push the limits of the model and in other cases breed, evolve and mutate the kernel itself. Akin to the scientific model, elegance is not merely achieved in the resulting design or form but exists in the formulated kernel, the explicit logic diagram, which exists within and between process and design.

## PART II : RE-GENERATING URBAN FORM

In a series of overlapping research projects and design studio briefs, students, research assistants and I worked with the iterative processes of McNeel's Grasshopper and Bentley's Generative Components to develop performance-oriented projects situated in complex urban conditions. As expected the symmetry between the elegance of the explicit models and the resulting designs quickly crystallized. Early in the process, when projects were still unclear, the underlying symbolic model was sprawled and inefficient. As the ability to use the program and the understanding of the design logic progressed, the symbolic models simplified, but simultaneously became more powerful in their ability to produce meaningful iterations and elegant design solutions.

However, earlier and earlier in the design process we discovered a need for increased levels of information-driven input. Growing concerns over climate change have obviously necessitated an increased interest in sustainable design and sustainable urbanism, yet because of an adopted environmental aesteticism, sustainable design has not yet fully altered the morphological and typological consequences of architectural space with the same influence that, for example, the industrialized technologies of the modern movement did[6]. So we began exploring the external environment as a catalyst for providing new spatial organizations and urban morphologies. Our pursuits in this area purposefully engage the climatic conditions but refuted the typical approaches of carbon conservation. Instead, we adopted to engage the Intergovernmental Panel on Climate Change's (IPCC) challenge of seeking adaptive strategies that utilize new approaches and technologies which address vulnerabilities and new conditions occurring because of climatic challenges. Not that we were disinterested in reducing carbon consumptions but we were more interested in the social and architectural ramifications of the possible form-generating parameters like the 'technology' variable in the IPAT equation (Environmental Impact = Population x Affluence (or consumption) x Technology) than in the reduction of the affluent uses of carbon.

**Adaptive Environmental Strategies**

In the wake of London's housing shortage, the London Development Agency (LDA) together with the Greater London Authority (GLA) and the Mayor of

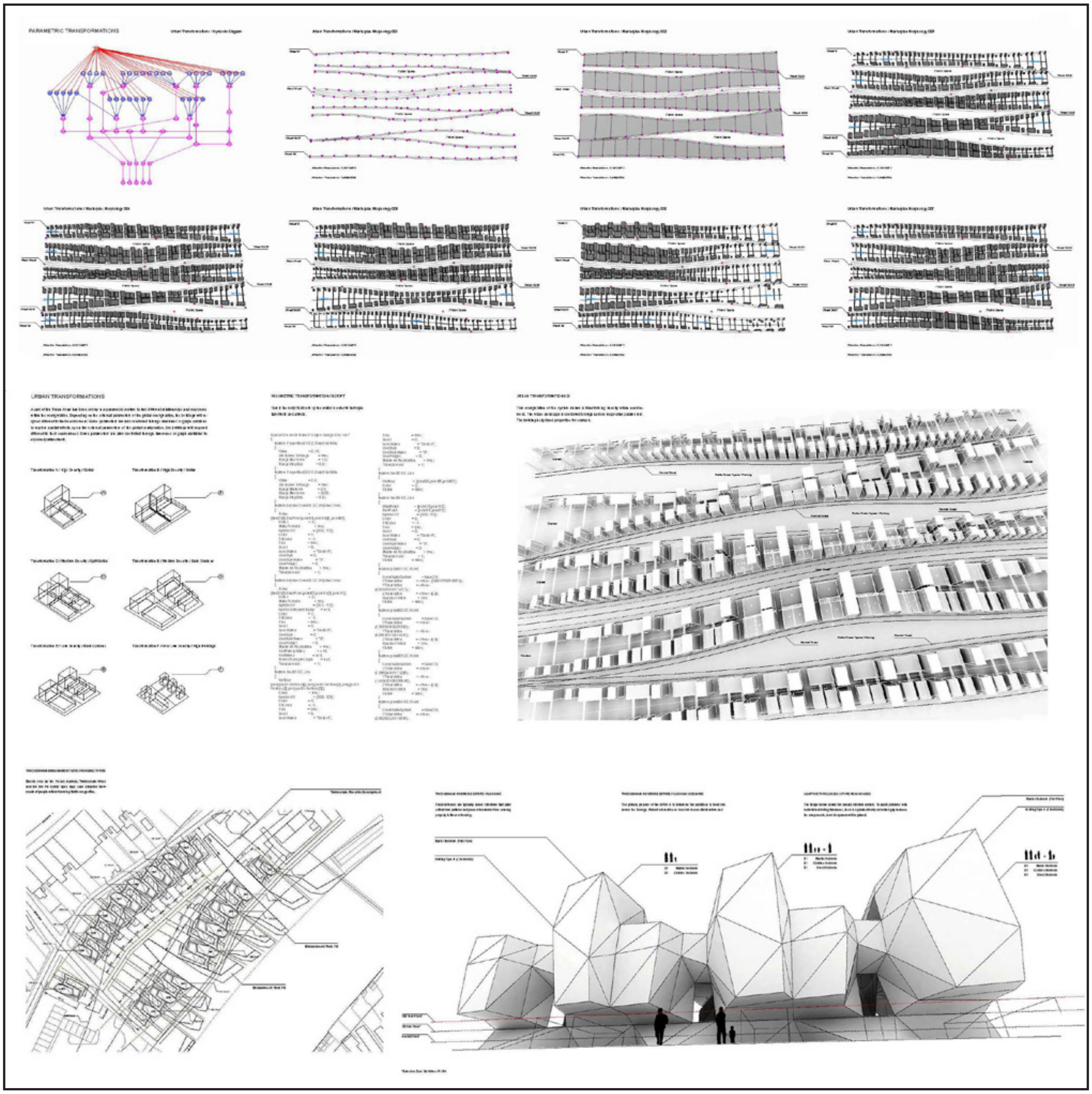


*fig 02: Christopher Robeller, Terrace House in Thames Valley Flood Plain (student project), 2007*

London has pledged to promote the construction of over 30,000 new homes a year. Additionally in December 2007 the LDA, the Homes and Communities Agency (HCA) and Communities and Local Government (CLG) jointly published the North London Development and Investment Framework Prospectus (NLDIF) alongside the Comprehensive Lea Valley Development Plan (LVDP). The frameworks establish development strategies which maintain London's current green standard while promoting density within community centers and strategic developments. A large part of the strategy explores the increasing need for single family homes since development in recent years has been focused primarily on one and two bedroom apartments alongside smaller developers busily converting single family homes into subdivided flats.

Coupled with the scarcity of land in London and the Mayor's pledge to build homes, the LDA have highlighted tracks of 'developable' land which are primarily located within known and problematic floodplains. However the UK, in particular the area along the Thames River, has been increasingly susceptible to flood. The LDA is marketing a misaligned affect of the new homes - where its development plans and published brochures promise iconic homes with smiling families but the reality facing those home owners is probably that of uninsurable, unsellable homes stricken by annual floods. In LDA's pursuit of marketing happiness it, refuses to readdress the performance of the typical house and instead chooses to publish and promote iconic English houses that sit firmly on the floodplain constructed with brick-like materials and pitched roofs.

Rather than refuse all strategies for developing the floodplains we investigated sustainable methods of development with semi-controlled watersheds and the allocation of particular tracks for flood pools and wetland retention. The LDA maintained an attitude of development through infrastructural mitigation whereas our goal was to explore the adaptive morphology of the single family home itself. Rather than build the traditional English home as planned for the sites, something as simple as alleviating the direct ground contact of the main living spaces in the homes could potentially save billions of pounds in future damages and fundamentally readdress the spatial and typological configurations of the dwellings. A mitagatory strategy would propose a floodplain development by altering the floodplain itself through landfills, dams, etc., thus erasing possibilities for the extreme environment to affect the design of the developments. Adaptive strategies for this type of site are more akin to floating structures, plinth developments, or stilt-based dwellings[7]. The simple act of raising the building from the ground suggests changes to the spatial and organizational morphology that the mitagatory strategy plainly avoids. Beyond performance criteria, the critical moments for designers and students to engage are the social and political effects created by raising the traditional dwelling from the ground, the morphological and organization implications to the dwelling itself, and the cyclical temporality of a sometimes flooded (but usable) dwelling within contemporary, affluent societies.

**Urban Computations**

Working between the master plan and the individual housing unit, we investigated arrays of terrace homes along with whole streets and neighborhoods while simultaneously exploring the potential for parametric modulation within this series. Using Bentley's GC and working with a typological hybrid, we established a single terrace house as a component and began to explore the modulation of the terrace (fig. 02) in terms of performance, site specificity and potential size customization. The overall result of modulation was not too different from the rows of terraces already existing in London where the progressive modulation arises from different construction periods, developers, and progressive alterations. However, our series, shown in the top of figure 02, had a distinctly field-like cohesion, but with an amplified variability that the existing terraces lacked.

With the symbolic (explicit) logic model established, we began to optimize a variety of simple parameters: 1. roof pitches to maximize potential solar collection, 2. area calculations to determine layouts and room divisions, 3. street/terrace re-configurations, 4. drainage corridors, 5. views, 6. density, 7. ground topography, 8. building footprints and ground contact (or raised above ground). By exploring the iterations of these simple performance-oriented criteria we were able to generate familiar, yet radically different urban forms which maintained an urban coherency but allowed for both the individual customization and serial modulation of houses. The simple parameter of changing the houses' vertical positioning in relationship to the ground created a vast array of morphological variations within the terrace type. This generative change in typological form had a simple but profound impact on the houses' potential performance in relation to future floods. Additionally, the alteration of the houses' ground plan condition produced new typological forms with profound social and spatial consequences. Outside the realm of pure computation of form we were now set to discuss the qualitative effects and sociological affects of these serial modulations and explore the internal differentiation and spatial individuality which were evolved through morphing serial parameters in response to environmental conditions.

**Re-Generating Urban Form**

My use of generative computation and parametric modeling coupled with issues of climate and performance-oriented design, increasingly led to more situational and contextual considerations which, in turn, led to the exploration of larger, more urban conditions. Like climate change, shifting populations and increased urban densities necessitate increases in formative design exploration and research. According to the United Nations Population Division, over 60 percent of the world's population is projected to live in urban areas by the year 2030. As the world's population continues to shift into and mandate the growth of our urban areas there is an increased interest in balancing urbanism as an evolutive process while maintaining the ability to design and achieve coherent urban forms. In traditional practice, the continual flux of urban conditions brought on by growth and ongoing societal change, along with the polarization of architecture and planning, results in a lack of coherency[8]. Traditional methods which rely solely on an implicit logic simply lack the ability to incorporate the diversity of requirements and large array of organizational variables needed to redefine city planning and refine urban form.

Urban form is simultaneously an action - engaged in both informative processes and formative strategies – as well as a formal and qualitative resultant. Informative processes serve as independent variables that help shape or inform the relationship within the design equation while formative strategies define the actual equations. The overall equations then affect the way that the independent variables are processed and produce a variety of results for the dependant variables and resulting forms. To deal with this type of complexity, we must go beyond modern approaches which rely on binary operations (like form and function) and recognize that we live within a complex, poly-variable world. Parametric thinking is prevalent in the sense that we must learn (computationally or not) to work with the relationships between an increasingly complex array of variables. Design becomes the act of balancing these relationships with minimal means and striving towards elegant solutions.

**Analogue Parallels**

While the techniques for manipulating these associations have evolved with the use of computers, a majority of formative strategies are not actually derived from contemporary digital processes, but are akin to analogue methods of form finding. The use of analogue computations in architecture is perhaps most familiar in Gaudi's chain models for the Sagrada Familia and Frei Otto's experiments at the Institute for Lightweight Structure in Stuttgart. Frei Otto's experiments with form finding machines are directed primarily through an interactive material intelligence aimed towards the exploration of minimal forms. Arguably, the more interesting experiments are those which seek to explore the logic of the machines themselves and produce patterns of self-organization. Otto and Rasche's studies of 'optimized path systems' (fig. 04) used material interactions to produce organizational and informational results, which dealt more with the association of parts than the development of a specific shape or minimal structure.

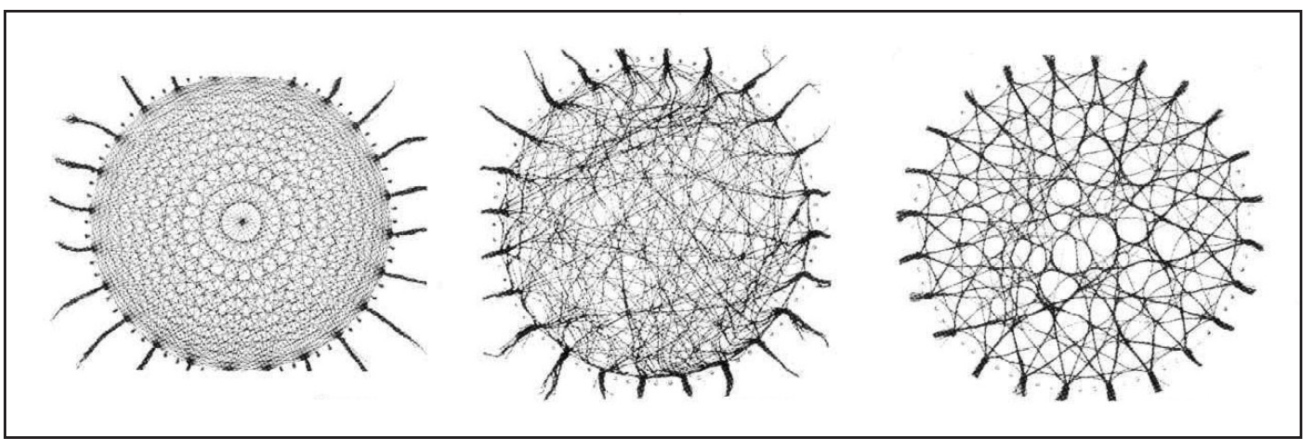

fig 03 Frei Otto and Brodo Rasch, *Finding Form*[9] (1995), p69

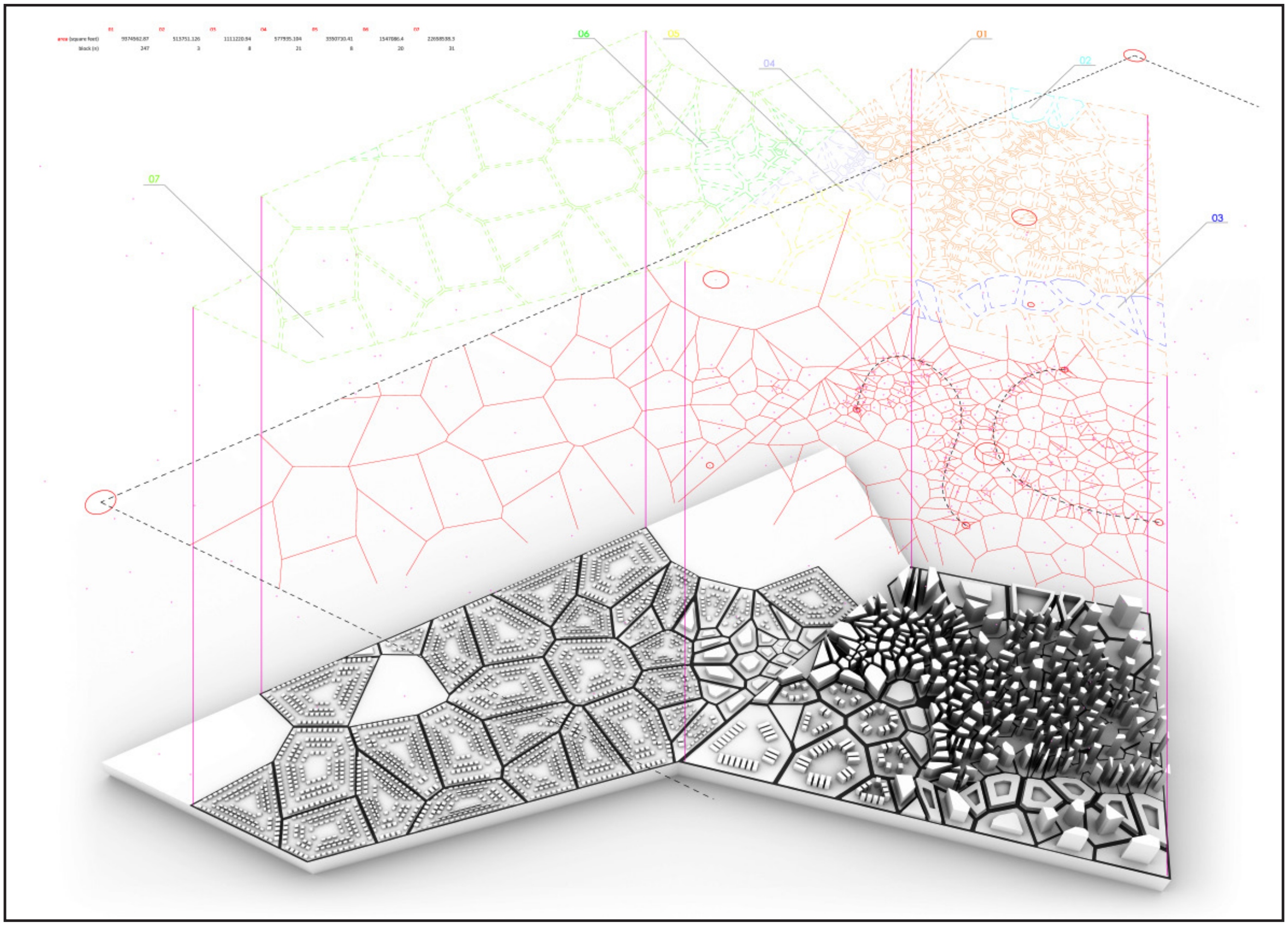


*fig 04: Instant (Para)City, current research project –output variation 21.3, 2009*

Frei Otto's optimized path system experiments demonstrate a cohesive, non-linear organization, suggestive of an urban formation and circulation system. Though the experiment was performed using analogue techniques, the computational logic is clearly embedded. The model on the left (fig. 03) shows pure geometry based on direct connections between each point on the periphery. The centre model then increases the length of the strings and shows indirect connections between each of the points. While the model on the left shows a rigid and fixed organizational quality, the centre model seems to lack any form of organization. Model three, on the right, produces a material interaction between strings through wetness, the slack is removed from the strings as they stick and quickly cluster around centres of aggregation. This model offers a very interesting parallel to urban form generation because it has a semi-controlled organizational quality; there is coherence but diversity – arguably two variables that successful urban forms contain.

**URBAN.NET / / Instant (para)City**

Urban network (URBAN.NET) strategies implement distributed rather than either centralized or decentralized organizational strategies. The Jeffersonian grid, common to US road and land networks, promotes specific network concepts while impeding others. Partial limitations also arise from the overuse of linguistic binaries such as 'urban' vs. 'suburban' rather than attempting to understand cities as distributed modulations of function, density, building type and organizational variation. Avoiding the pursuits of a singular urban core, URBAN.NET // Instant (para)City (fig. 04) attempts to find potentials within current conditions and proposes distributed 'urban' patches to serve as nodes that infiltrate and connect otherwise disparate parts of

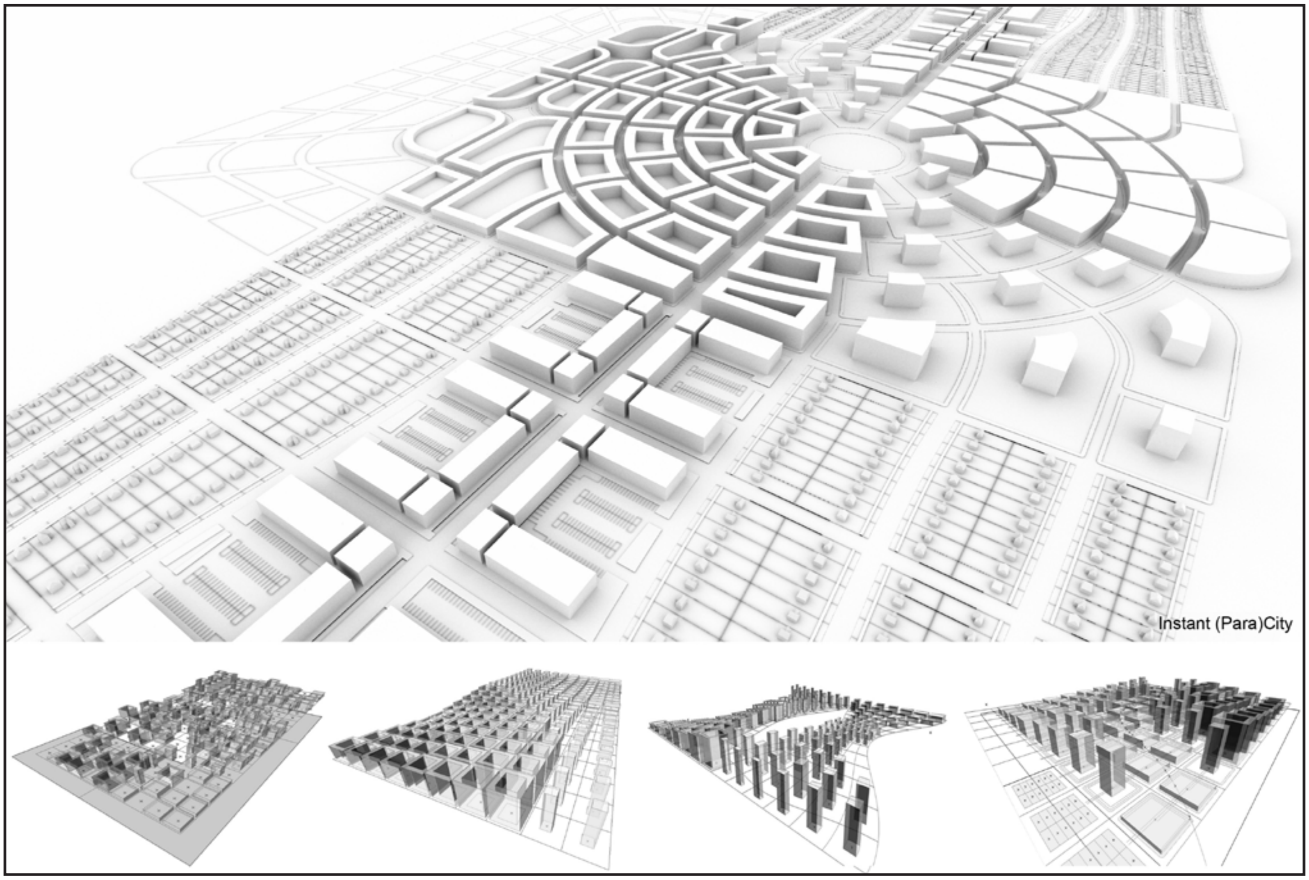


*fig 05: Instant (Para)City, current research project – output variation 12.1 with iteration samples, 2008-09*

the modern city. This patch approach both shuns the utopian tabula rasa and adopts the notion that the most sustainable approach towards a perma-cultural urbanism must contend with and work around the vast amounts of (pre-environmental) building and infrastructure that already exist.

URBAN.NET//Instant (para)City is a parametric-based set of explicit logic subroutines which allow the rapid iteration of urban landscape visualizations and simulations. By altering contextual sliders, a large array of possible urban configurations are produced – from the slightly more typical (fig 05, output variation 12.1) to the more speculative (fig 05, output variation 21.3). Output variation 21.3 seeks to explore similar cohesive heterogeneities as found in Otto's optimized path systems. Instead of a material interaction establishing the cohesive organization, the digital city formation contains internal rules of spacing, density, cohesion, packing allocations and building setbacks informed from external information, such as view corridors, zoning influences and density guides. Because the rules are set to also form the more typical urban array (fig 01), there is a somewhat entrenched believability to even the more speculative outputs.

**Parametricism and Urbanism**

Just as Michael Dennis's lectures suggest that the proliferation of the personal office photocopier led to the rise of Postmodernism, one readily observes the growing impact that the desktop computer is having on design. Patrik Schumacher suggests that the new global style for Architecture and Urbanism is Parametrism[3]. Parametric models allow for a mutable form of design that manages complex relationships between variables and allows for the optimization of a project throughout the design process. This is not purely process-oriented, as these situational variables provide information contexts against which these optimizations are constantly evaluated. In this way digital techniques become a means towards an end, rather than means within themselves. Both the seasoned designer and the fledgling student are, in this way, charged with engaging a more critical and continual evaluation of the design outcomes.

## ENDNOTES

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