Beyond Models

Digital Tools for Urban Design as Mechanisms for Better Planning Practices

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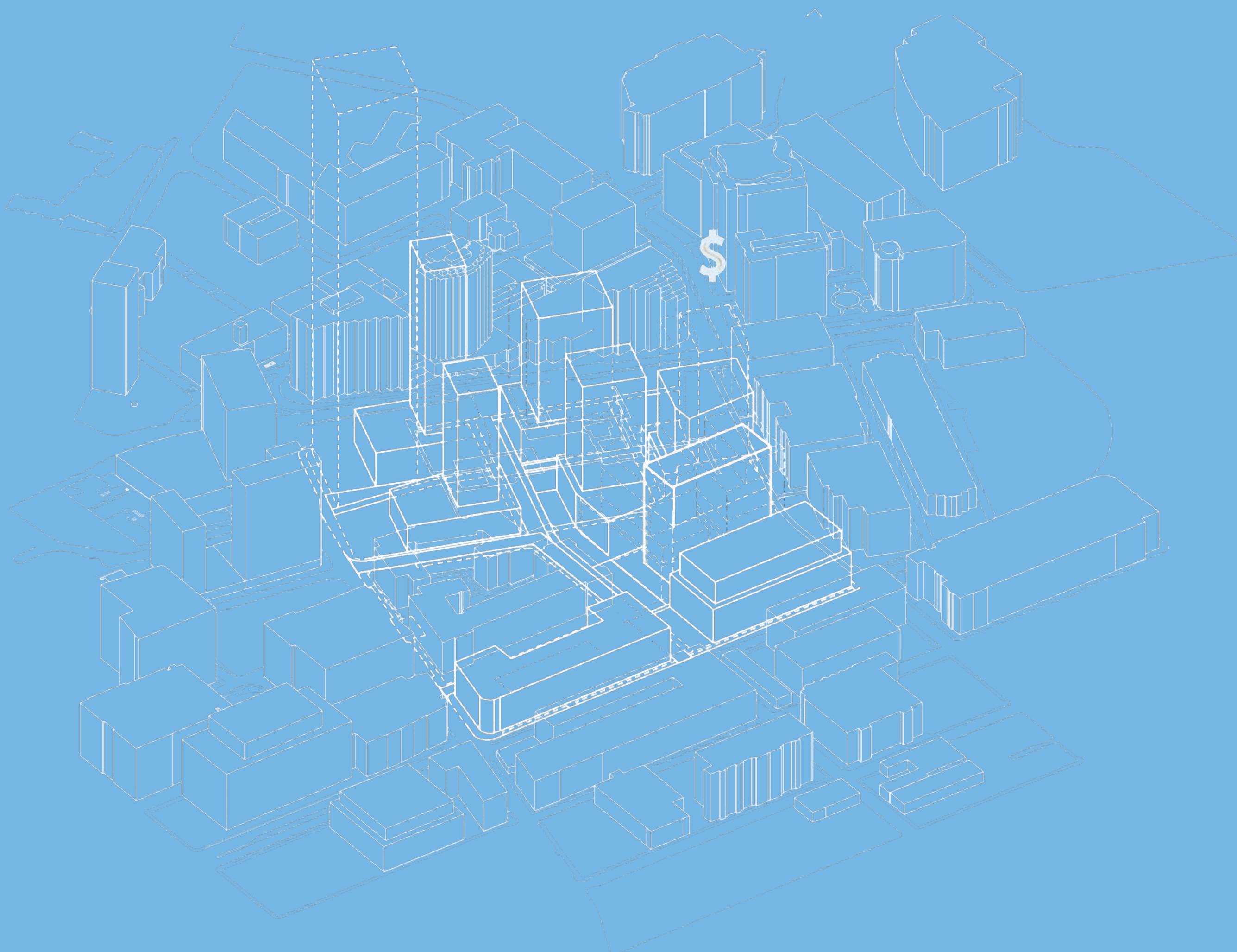

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Abstract

This thesis explores the factors that affect the potential of computational urban design tools as instruments to support the implementation of better urban design practices through more informed and collaborative urban development processes. Contemporary computational tools impact the inception of design ideas; evaluate design outputs objectively at different stages; and assist the further development of the design solutions. These tools streamline the creation of comprehensive and detailed urban design scenarios based on extensive quantitative and qualitative methods which relate to the extensive factors urban design needs to address. The goal is to result in more sustainable, vibrant and equitable developments through urban form, use allocation and other design specifications. However, external factors condition the implementation of these informed urban design practices. Particularly in the case of high-density, mixed-use urban infill projects, regulations and policies determine the possibilities for development and “opportunity space” within which the negotiation and trade-off between stakeholders in these often contentious urban projects takes place (Tiesdell and Adams, 2011). Both regulations and trade-off affect the final definition of an urban design project and the inclusion of better practices.

In this context, the thesis explores the pros and cons of computational modeling tools to adequately inform and support better urban design practices within the complexity high-density, mixed-use development processes subject to restrictive regulations and participatory planning processes. An analysis of theory, use cases and the in-depth exploration of the various approaches to urban design in the redevelopment of Kendall Square in Cambridge, Massachusetts leads to multisided results. First, computational modeling tools both empower and limit the capacity of design and planning practitioners through the complexity of their operations. Second, the advanced level of definition of digital tools early in the development process can streamline fundamental phases (e.g. approval, entitlement or design review), thus reducing uncertainty and risk. However, this can also restrict the opportunity space of stakeholders in the pursuit of their interests and impact negatively the implementation of practices that are not enforced by regulations. Third, while the use of digital tools can lead to more interactive and publicly accessible design and planning processes, the complexity of the tools and the information they build on affect their potential for effective communication. This can hinder better decision-making and consensus-building that supports the implementation of better practices. I conclude by providing a series of short recommendations for how to potentially address these issues.

Thesis Supervisor Professor Eran Ben-Joseph, Professor of Landscape Architecture and Urban Planning, Department Head

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Introduction + context

Opportunities of computational tools for high-density, mixed-use urban design

In the last decade, computational tools that plan and design cities through data-based and performance-driven approaches have gained high relevance in the design and planning field as a way to develop comprehensive and detailed urban design scenarios based on extensive quantitative and qualitative methods. These impact the inception of design ideas; evaluate design outputs objectively at different stages; and assist the further development of the design solutions. These relate through indicators, parameters, and standards to the many factors urban design needs to address result in more sustainable, vibrant and equitable developments through urban form, use allocation and other design specifications. Particularly in the case of high-density, mixed-use developments, adequate urban design practices are fundamental to achieve benefits such as quality urban space, reduced congestion and vehicle emissions, smaller ecological footprints, and long-term economic sustainability with mixed-used buildings housing multiple tenants.

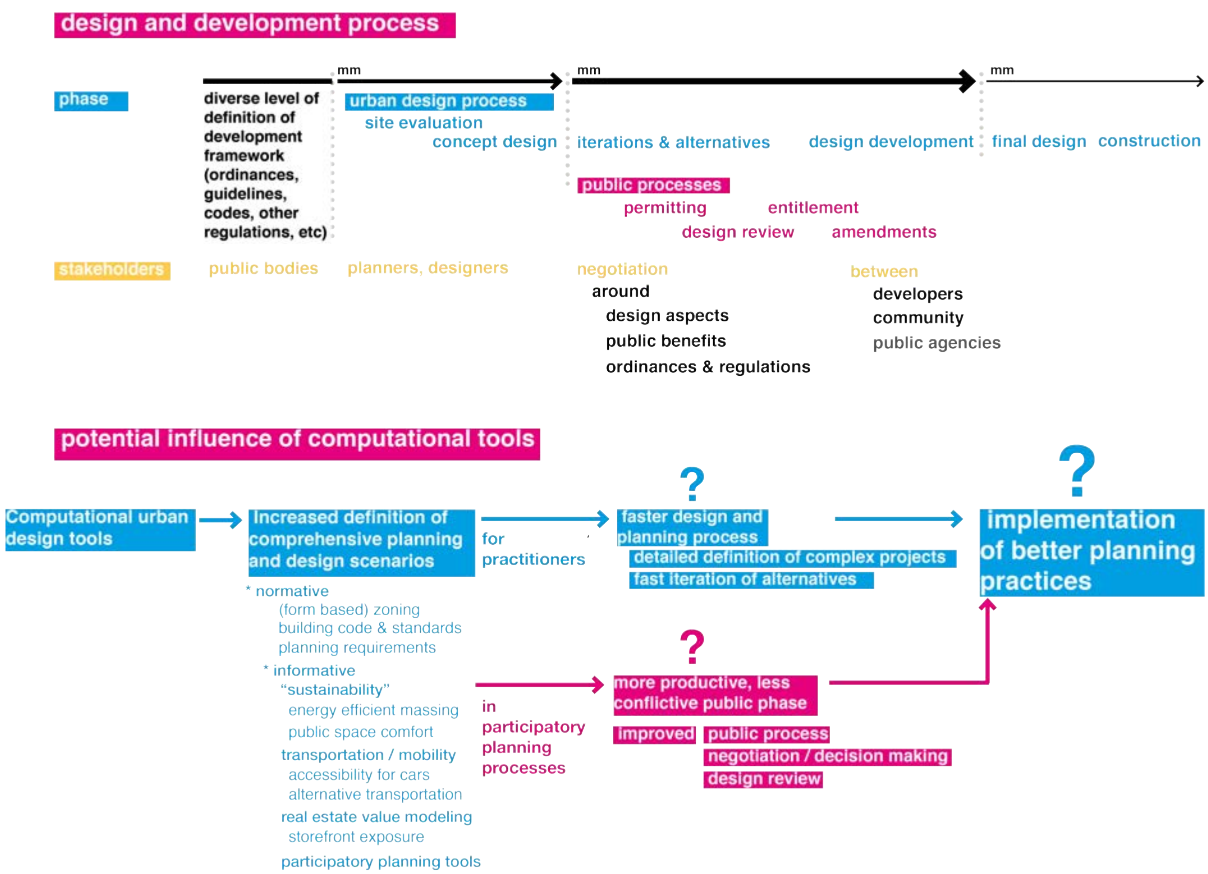
However, external factors condition the implementation of these urban design solutions. In contexts with participatory planning processes and multiple stakeholders, regulations and policies determine the possibilities for development and the "opportunity space" within which the negotiation between constituents towards the implementation of a project takes place (Tiesdell and Adams, 2011). In the case of high-density, mixed-use developments or any other large development project, the high development pressure that is necessary to carry out these complex and costly projects is more than not faced with community opposition and demands. As a result, the development of urban projects tends to become a trade-off process between stakeholders in the definition of the urban form or other design features that can affect the inclusion of better urban design. At the same time, while regulations may support the implementation of better urban design practices, their definition in legal terms tend to navigate an ambiguous space between zoning and building codes. Consequently, their level of enforcement is usually unclear.

As digital modeling design and planning tools become more present in the Digital Age, it is relevant to understand how advanced digital tools are being into the development process. What are the pros and cons of digital tools to adequately inform and support better urban planning and design practices within the complexity of the development process?

The richness of urban design proposals in Kendall Square in Cambridge, Massachusetts aid the understanding of how tools serve the consensus building process amongst different stakeholders towards the implementation of better urban design under a comprehensive regulation that incentivizes good urban design practices, an active participatory planning processes, and high market pressure. At the same time, research groups from MIT have approached Kendall Square as a testing ground for the tangible computing tools to enhance participatory planning and design processes through data-based and performance-driven approaches. However, they have had little influence on the real development processes despite their vast potential. As such. Kendall serves as an example for other large-scale urban developments that aim to foster more participatory planning processes and qualitative urban design outcomes.

While computational tools are only instruments for the inception and implementation of an urban design project, analyzing how they operate for the diverse constituents in development can help put a focus on better addressing the aspects that guide the decision-making of stakeholders. This can facilitate negotiations and trade-offs around large scale urban projects so that planners and designers can take advantage of technology to support the implementation of better practices beyond regulations.

Fig.1.1 Potential influence of digital design and planning tools in the development process

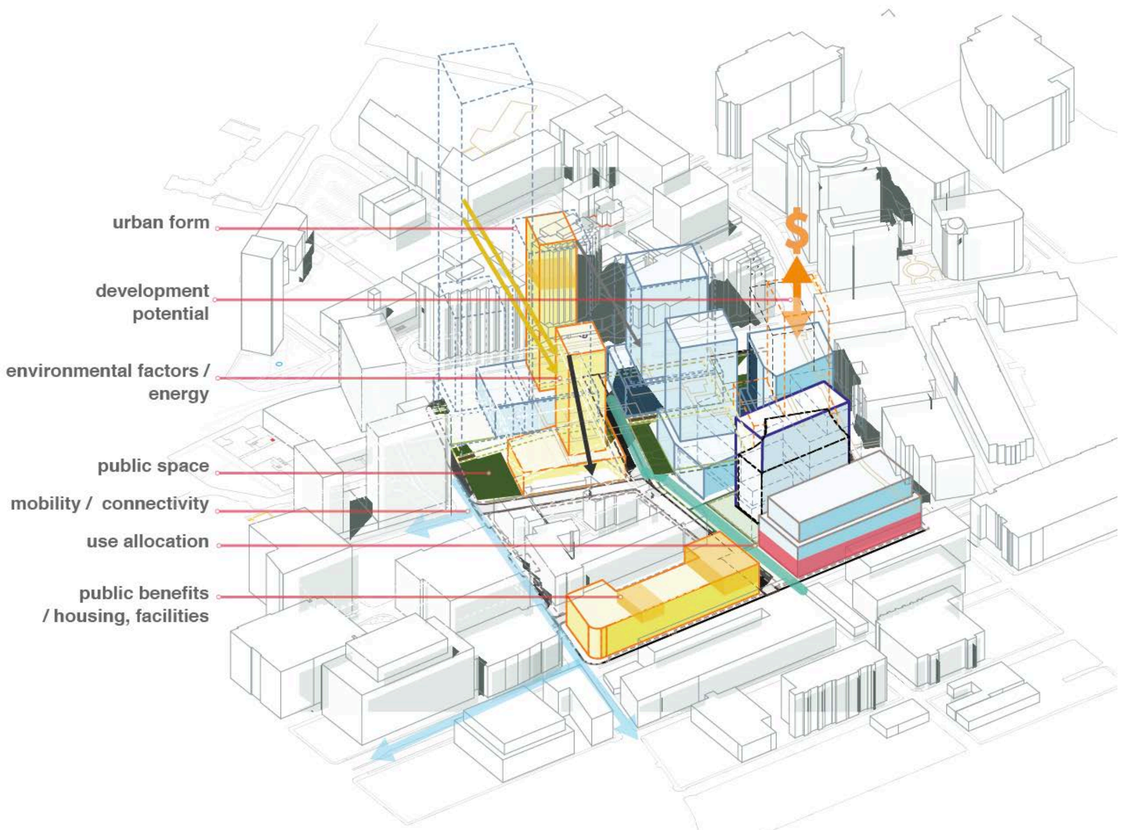


Towards better urban design and planning?

For a decade as a designer, learning and practicing, I have assisted the fast-paced evolution of digital modeling design and planning tools to allow the development of comprehensive and detailed proposals that through design aim to solve various urban challenges, from sustainability, livability, accessibility or equity. As a planning and design practitioner who aims to pursue a career in supporting the implementation of better urban and design practices, digital tools are a primary instrument for design and planning. There is no unilateral definition of what constitute "good" urban design or planning practices, as the understanding of "good" relates to a specific moment in time and may change over time. Many urban design and planning practices that we consider inadequate nowadays where defended as the panacea to solve urban problems in its time, such as most modernist ideals. However, for the purpose of this research, better urban design and planning practices are defined as the practices that aim to result in more sustainable, equitable and livable urban environments. This is both the result of a series of spatial planning and design solutions at the urban and building level, such as the adequate allocation of mixed-uses, sustainable building practices, quality public space and urban form, as well as of inclusive processes that bring together the different stakeholders involved in city-making, from public administrations and communities to developers and technicians. For this purpose, this research particularly considers the approach to the implementation of "better" urban design and planning practices in the case of Kendall Square, but the definition of these "better" urban design and planning practices can vary depending on the specific location and the development of adequate solutions to urban problems. Digital and computational tools open the door more collaborative development process that can bring together the different stakeholders involved in urban development projects for better decision-making and consensus building that results in the implementation of these holistic projects. Hence, understanding the limitations of these tools beyond all their technological possibilities as a way to empower the work of the design and planning practitioners became the object of this thesis.

In particular, I consider these tools can be particularly relevant for supporting better urban design practices in complex large-scale urban projects where the high development pressure that enables their often costly development contrasts with a need to incorporate urban design practices that result in more sustainable, livable and vibrant neighborhoods both for the future inhabitants of these projects as well as for surrounding communities. These practices often come at a cost and are many times not fully supported by development regulations. As a result, many contemporary high-density, mixed-use developments such as the recently inaugurated Hudson Yards in New York end up becoming lack-luster glorifications of high-end development with little contribution to the cities and communities they are located in, and where planning and urban design decisions seem to have been purely guided by real estate benefit.

Fig.1.2 Modeling Complex Urban Design (by the author, 2019)



Methodology and limitations of research

This thesis bases its findings on design proposals, legal documents, academic sources, and interviews. By contrasting theory, use cases and understanding the “story behind them” through the involved stakeholders, I could build up an analysis to understand how particular technological and human factors influence the potential of digital tools. How does the possibility of developing advanced scenarios for better urban planning contrast to the aspects that guide decision-making under particular regulatory and market conditions?

Despite the possibilities of computational urban design tools to provide solutions for many planning contexts, I decided to focus particularly on the high-density, mixed-use urban development of Kendall due to time restrictions and in order to obtain clearer results. As opposed to the infinite possibilities computational tools enable, I considered it relevant to ground it to a case that represents relevant issues in contemporary urban development, such as the pursuit of more livable, sustainable and equitable urban infill projects under high development pressure and within participatory planning processes. Kendall enables exploring this in detail as it has been parallel to the development of computational tools. Many of these, in different forms, have been instrumental for the inception of the area´s projects or have been used to set the stage for participatory planning and urban design processes. Hence, it is a very particular setting that has been researched at a particular moment of its long term history through analysis of documents and semi-structured interviews, but without real participation in the planning and design process. Hence, the outcome of this research can apply to projects with similar characteristics (size, market conditions, regulations, planning process), but it may not be valid for many other contexts with different features where computational urban design tools can also be used. However, the conclusions of this research can also help provide guidance on other types of situations or indicate that the use of computational tools may not be useful for those.

At the same time, the results of some the research projects with tangible computing tools carried out in the use case of Kendall Square did not end up providing precise outputs of urban design. These could have helped establish a more detailed analysis of how experimental approaches to collaborative performance-based urban design relate to the proposals being finally carried out or how they could have put into question the existing regulation. However, this lack of detailed results also indicated how limited advanced computational tools can be to inform real planning and development processes beyond their high-level technical capacity.

A short intro: the “opportunity space” theory (Tiesdell and Adams, 2011)

As outlined, in most complex urban development, the implementation of better planning and design practices is conditioned regulations and policies, but also by the negotiation and trade-off between stakeholders within the what Tiesdell and Adams have denominated “opportunity space” (2011). This is the space for manoeuvre of stakeholders towards pursuing their respective interests, which can be either economic, social or political. Tiesdell and Adams consider that the opportunity space of a stakeholder is constrained by three forces or contexts: the site, the regulatory, and the market context. The more problematic, difficult or constrained the site, the more demanding the regulations, or the more demanding or competitive the market are, the smaller the stakeholder's opportunity space and the opportunity to pursue their interests. This reduction of the opportunity space thereby conditions their potential concessions to elements that may affect the pursue of their interests. These concessions are fundamental towards achieving the implementation of better planning practices when these are not enforced by regulations, as can be the case of more sustainable construction, inclusion of more affordable housing and other public benefits, or different urban design features. While Tiesdell and Adams associate the "opportunity space" theory only to developers or designers, who either through balancing financial aspects or design decisions can achieve the implementation of these planning practices, throughout this research I realized that this opportunity space also extends to other stakeholders in urban development such as planning agencies or communities.

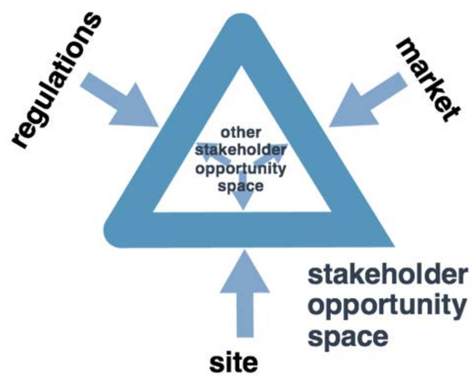


Fig 1.2 Opportunity space diagram (after Tiesdell & Adams, 2011)

Thus, one key assumption of this research is that technology in the form computational urban design tools can be employed to outline this "opportunity space", thereby bringing transparency to trade-off of interest and negotiation in the collaborative coordinated effort of implementing better planning practices.

A critical approach to technology – framing technology within culture

It is also necessary to highlight a more critical approach to technology instead of idealizing it. For this, "Technopoly: The surrender of culture to technology" (2011) by Neil Postman and "Frame reflection: Toward the resolution of intractable policy controversies" (1995) by Donald Schon and Martin Rein provide a theoretical basis to situate technology and computational within the context of culture, policy and conflict resolution. Postman argues that technologies reflect and create the ways people perceive reality and that over time the dominance of tech over culture has increased. From tool-using cultures and technocracy, nowadays we find ourselves within the technopoly, a cultural situation where technology has become the sole determiner of a culture's purpose and meaning, and in fact of its way of knowing and thinking. Technology has even become a way “not thinking” as we consider all its outputs to be unilateral truths and do not approach technology with criticality.

Schon and Reid´s frame-critical approach to policy-making and solving underlines the idea that the use of technology for solving urban development conflicts creates a frame that does more than describing a situation. Frames have normative implications and, as such, condition processes and outputs in front of real situations that are complex, vague, ambiguous and indeterminate. The use of technology risks becoming a mechanistic oversimplification of a model based on achieving objectives, for example, by aiming to develop specific ideal scenarios based on standards and indicators in the case of computational tools. At the same time, although technological platforms permit to emphasize pluralism and the presence of conflicting and competing interests, for example, by explicitly visualizing them in the case of computational urban design tools, computational process are limited in the representation and incorporation of the complexity of processes, actors, and interests that come together in complex urban planning and design. As such, technology risks becoming a partial frame that only incorporates those parties that are at the policy table and their interests while also influencing the interpretation and interaction individuals have with one another. Thus, computational tools and the frames they create must be viewed critically when technology is considered a tool for the development of solutions to problem complexes with multiple stakeholders and interests.

In this context, this research has aimed to approach technology in the form of computational tools for urban design and planning through a critical lens, underlining how its use conditions a certain understanding of urban design and planning, limits the exploration of aspects that are not incorporated into these tools, and risks reducing the real complexity of urban design and planning processes.

2

Coding the city

Towards data-driven digital urban design and planning tools

The technological advances of the last decades have allowed digital tools for design and planning to become more sophisticated in their computational processes and increase their capacity to assimilate, transform and apply information. The following section describes through a series of examples how digital tools have advanced over time towards better the streamlined development of comprehensive, detailed, and complex urban planning and design practices.

Initial technical limitations and operational freedom

CAD (Computer Assisted Drawing) methods for design and planning have been part of the design and planning processes since the expansion of personal computers and the AutoCAD software developer by AutoCAD in the early 1990s, slowly substituting the traditional hand-drawing approach and leading from cognitive to increasingly computational process. Practically a digital blank canvas, each scale and its corresponding level of details are introduced independently into 2D vector-based drawings, without relationships between drawings or documents nor more information than the drawing itself. The expansion of 3D modeling, which introduced a third dimension into the planar space of CAD, would follow after the initial technical limitations of personal computers were overcome. In the early 2000s, free and easy-to-use software like Rhino and SketchUp was widely adopted by design and planning practitioners for the development of projects from the very initial stages of ideation to the detailed definition of construction documents. Despite their technical limitations, AutoCAD, Rhino or similar tools are the primary tool to digital design and planning for most people due to the advantages of their simplicity and their operational freedom, and remain the preferred tool in projects that do not require excessive complexity.

Towards parametric and performance-driven tools

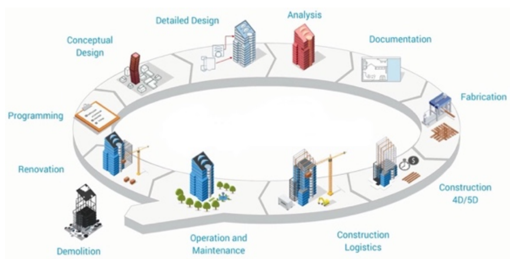
3D modeling tools would soon evolve to incorporate computational algorithms for modeling, leading to a new capacity of linking information to models in the form of parameters and indicators. Grasshopper, the widespread open-source visual programming language developed under the frame of Rhino in the late 2000s, was initially employed for parametric design through generative algorithms, although its open-access programming language would allow developing other tools or plug-ins for modeling. The new parametric altered the approach to architectural and urban modeling towards algorithmic generation procedures. Just a handful amongst an extensive catalog, tools like LadyBug or Urban Modeling Interface (UMI) by MIT´s Sustainable Design Lab serve sustainability and energy efficiency modeling at the building or urban scale using climatic, geometric and material data (Reinhart, 2013). Other tools like Urban Network Analysis (UNA) from Harvard GSD City Form Lab apply the concept of space syntax to analyze street systems and the qualities of urban form (Sevtsuk, 2012). Space syntax describes how the configuration of space relates directly with how people perceive, move through and use spatial systems (Karimi, 2012). Performance-driven and algorithmic tools gained relevance as urban planning and design became increasingly regulated through data-driven performance measurement aspects such as the green building certification LEED (Leadership in Energy and Environmental Design Standards) of the US Green Building Council or other requirements for sustainable practices in design since the late 1990s. Data-driven simulations had, therefore, become a tool to comply with mandatory aspects of spatial design.

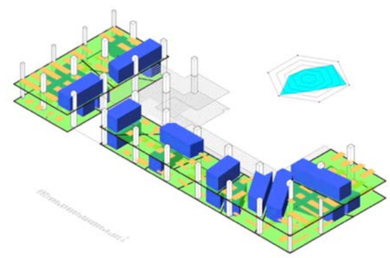
Fig 2.2 Parametric design tools and the urban scale (Sevtsuk, 2012; Reinhart, 2013)

BIM - enhancing workflows and limitations for urban design

In parallel, Building Information Modeling (BIM) developed a more advanced approach to 3D modeling through the creation of virtual information models (Autodesk, 2002). Instead of a traditional construction document package of drawings and specifications, through BIM discipline-specific knowledge and tracking of changes can be added in each stage of the design and development process, reducing the loss of information and creating a coordinated effort in managing the project (Ben-Joseph, 2011, 288). BIM enhances shared workflows and information sharing between actors in the construction process (e.g., developers, cost engineers, architects, suppliers, contractors). BIM is primarily a tool for value engineering and project management through aspects like lifecycle, cost, construction management, facility operation and application in green building. In its latest advances, it has incorporated features of generative for more performance-driven practices in building design and management. Generative design involves the integration of a rule-based geometric system, a series of measurable goals, and a system for automatically generating, evaluating, and evolving a very large number of design options. However, despite its technical capacities for project definition and green construction management, also relevant in the path towards LEED or similar certification, BIM was mainly limited to the building scale and not applicable at broader urban contexts (Wallis, 2012). Again, this section only describes one particular tool amongst many with similar features and use.

Fig 2.3 The BIM Cycle (Wallis, 2012) **Fig 2.4 Generative design (Autodesk, 2019)**





Zooming out - GIS and large scale planning

In 1981, ESRI released the first commercial Geographic Information Systems (GIS) software under the name GIS Solutions for Urban and Regional Planning (ESRI, 2006) . By merging diverse sources of data through their transformation into the GIS format, different operations result in mapping visualizations that help explore patterns, relationships, and situations between input data and geography at the large scale. The capability of overlaying layers upon layers of geo-referenced data and the ability to analyze these layers quantitatively has turned GIS into a powerful tool for strategic thinking (Haley, 2007). GIS is therefore a significant support system for large scale regional and urban planning, allowing to explore casual relations towards more comprehensive and performance-based city-wide planning approaches (Chackraborty, McMillan, 2018). Performance-based planning, which dates back to approaches in land use planning and economic forecasting in the early 1950s, defines the broader context of land use regulation focusing on zoning and planning outcomes. Results-based measurement is used at both the strategic and operational levels to attain desired outcomes. The concept of GeoDesign developed by Steinitz even bring this approach to the design of geography and natural systems and its integration with the built environment considering cities as ecosystems, leading ESRI to develop its product ESRI Geodesign (Dangermond, 2013). GIS is therefore widely employed at the regional and urban scale to inform and develop a regional or city-wide development vision within which the formulation of local planning policy takes place in terms of goals, strategies, and tools and the development of the local regulation of urban development (Duarte & Gil, 2008). This regulation will set many of the parameters which condition individual urban development projects of different scales, understood as pieces of an aggregate system.

Fig 2.5 GIS Tools (ESRI, 2006)

Defining computational urban design tools

For the first decades of data-driven design and planning tools, a duality between the tools for urban scale planning and building definition left a vacuum at the urban design scale. In this context, the theoretic approach of “City Induction” proposes an urban design framework at the scale of site planning that intended to develop urban design methodologies and analytical tools that the authors considered appropriate for a strategic and performative urban design approach (Duarte and Gil, 2008). The three modules of formulation, generation and evaluation framed three categories that would, combined, lead to a urban design development vision and a successful design outcome: design program, which encompassed requirements, values, urban patterns, and subjects; design solutions through form, space, relations, objects, and data; and, lastly, design analysis. Duarte and Gil also approached the then existing tool panorama, affirming that:

> *CAD Tools ≠ Urban Design tools - The components, parameters, and scale of urban design are very different. The intangible nature of public space and urban layout must be explicitly incorporated into urban design tools to facilitate the interaction between designed and non-built space*
>
> *Analysis Tools ≠ Urban Design tools - GIS platforms can perform display and analysis of large scale urban developments and be essential aids to the management of the data required for the urban design process, but they are not flexible or straightforward enough to integrate directly into the design process.*
>
> *Design Models ≠ Analytical models - Besides functionality and interface differences between design and analysis tools, an important distinction is in the elements that they manipulate.*

Analysis ≠ Evaluation - Evaluation requires an interpretation of the analytical results as it tests them against regulations, development targets, and quality and sustainability benchmarks. (Duarte and Gil, 2008, p.260-261)

Hence, the tools of the late 2000s needed to evolve to address the gap of the urban design scale.

Relating scales, models and information

Since the "City Induction" approach, the advances of technology have led to the development of urban design tools that deal with the outlined shortcomings for defining the urban scale by combining the respective advantages of 3D modeling, GIS and BIM. Equally, realizing the relevance of multi-stakeholder engagement for the definition of urban scale projects, extensive research has targeted the improvement of the existing and limiting hardware interfaces that digital tools operated on, such as the development of Graphical User Interfaces and Tangible User Interfaces (TUI) (Ratti, Ishii & Frenchman, 2004). These were paralleled by the development of the so called Planning Information Modeling (PIM). PIM imports and aggregates into GIS the geometries and tabular data of the multiple 3D and CAD files required to represent the built environment accurately. This way, the efficiencies and power of BIM are connected in geographic space to other relevant spatial data. PIM aims to not only inform the initial stages of design, planning and information management but also to create tools that permeate the whole development processes by better informing different actors beyond planners and practitioners.

*By spatially organizing and linking the standards, policies, and values that guide the development and ultimate form of the built environment to the analysis required to achieve shared awareness, GIS helps industry stakeholders better understand the future. (*ESRI*, 2006, p.5)*

On another hand, new methodologies and computing power were developed to address the creation of detailed urban models that would allow an informed contextual approach to urban projects. In 2011, ESRI acquired CityEngine, a tool developed by Procedural Inc. specialized in the generation of 3D urban environments through a procedural modeling approach that treats the city as a giant database. Procedural modeling is an umbrella term for several techniques in computer graphics to create 3D models and textures from sets of system rules and algorithms. Such modeling streamlines the generation of complex 3D models via information as opposed to traditional time-consuming modeling processes.

Build entire 3D cities - Create a massive city all at once instead of modeling each building individually. (CityEngine, 2019, website, last accessed May 2019)

Hence, CityEngine merges geospatial analysis and spatial modeling to apply geospatial principles to the spatial shaping of cities. Embedding information such as zoning regulations and their associated variables like massing into models leads to more analytic models that express the spatial outcome of regulations and their broader implication in the built environment through simulations like shadowing. This particular capacity for streamlining the design of the large scale in short time has led to its use for tabula rasa approaches to urban design such as masterplans in the Middle East and China or Campus Planning (Dailey, 2012). The lack of success of Urban Canvas, Autodesk´s extension of Revit into the urban scale halted since 2015 indicates the limitations of these products to successfully inform more complex projects and enhance the design and planning process.

Fig 2.6 Relation of selected GIS + 3D tools (ESRI, 2006; Autodesk)

Other tools such as Modelur (Modelur Urban Design Software 2019) or Envelope City directly develop their modeling through the massing variables embedding in zoning documents in order to obtain the buildable envelope allowed by regulations. The goal is to simplify the process of sourcing information from zoning documents and visualize the spatial expression of legislation, particularly in New York City, where the beta version has been developed. However, Envelope´s catchphrase “Opportunity Visualized. Legal-quality zoning analysis, Architecture-quality visualization. A fraction of the time and price” targets developers – or anyone interested in having fast access to assessing opportunities for development (EnvelopeCity, 2019).

Fig 2.7 Modelur (ModelurEU, 2019)

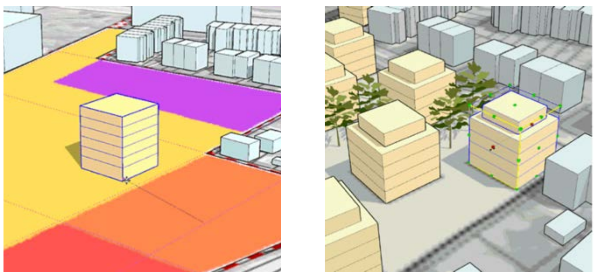
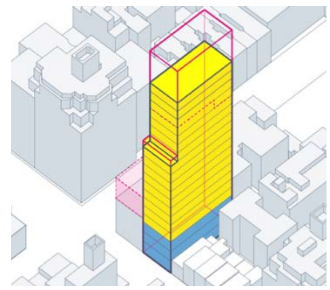


Fig 2.8 Envelope (EnvelopeCity, 2019)



Delving into the age of (new) data & urban informatics

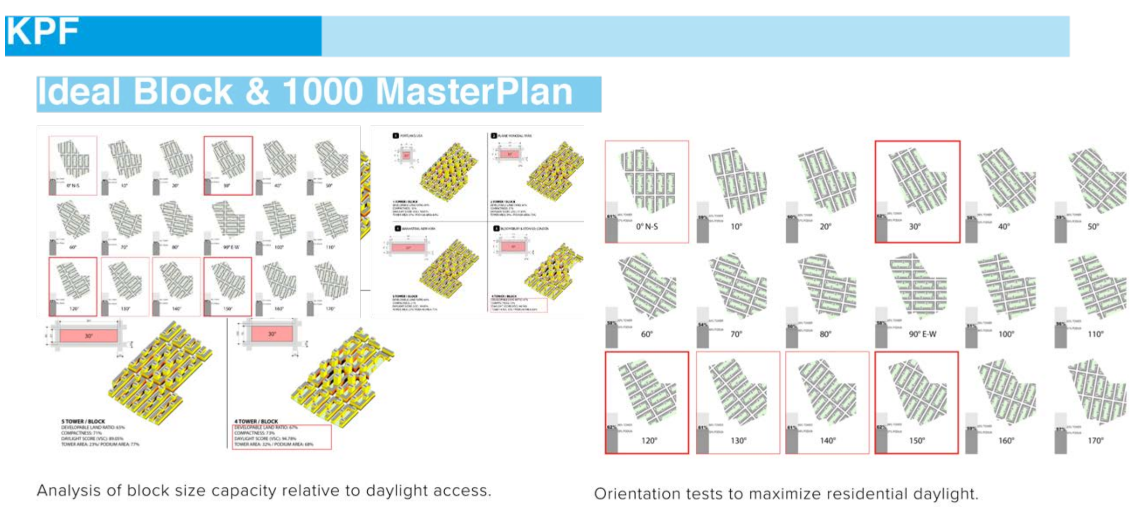
At the same time, in the Age the Internet of Things and Big, Open and Crowdsourced Data, there is a growing understanding that the increased complexity of urban challenges, from mobility to resiliency, requires new types of non-spatial data to be incorporated into spatial planning and design. New sources of information, from sensors to user-generated data from apps, allow to create and collect large amounts of data concerning diverse aspects of urban life that are many times publicly available through OpenData portals, making the tools more multidisciplinary and multiscalar. The development of the field of urban informatics has gained relevance in the process of urban design through the capacity to better understand diverse urban patterns at a new level of detail, as underlined by Ken Goulding, Director of Sasaki Strategies (Interview 6, 02/21/2019). As opposed to the purely spatial variables that most computational tools build on, this new data provides evidence for non-tangible elements like urban dynamics and flows that had long been interpreted by practitioners to develop qualitative approaches of urban design. Tools to be explained further on, like the CityScope (Alonso, Luis et al., 2018) or Urban Footprint (Calthorpe Analytics, 2017), incise on the relevance of this type of data for better understanding of urban realities that contributes to better public engagement and urban planning and policy analysis. (Thakuriah, 2015).

Towards a thousand masterplans - KPF´s Urban Interface

The evolution of modeling software combined with the free availability of data that can be embedded in it has resulted in the proliferation of data and performance-driven approaches to urban design by design and planning practices such Kohn Pedersen Fox (KPF), which through its 700 employees in nine global offices has designed dozens of urban scale projects around the world. The Urban Interface Group (UI) at KPF develops tools for urban design that address the challenge of applying computational design at the urban scale “due to increased computational expense, difficulty in limiting inputs, and more stakeholders involved in the process. This designer-led time-intensive process can hardly integrate the perspectives of the multitude of involved stakeholders with differing, and often misaligned objectives and expertise. Expert consultants, developers, planning agencies, councils, community boards, and the general public all bring valid perspectives that must be synthesized into a coherent vision” (Wilson, Danforth, Davila & Harvey 2019).

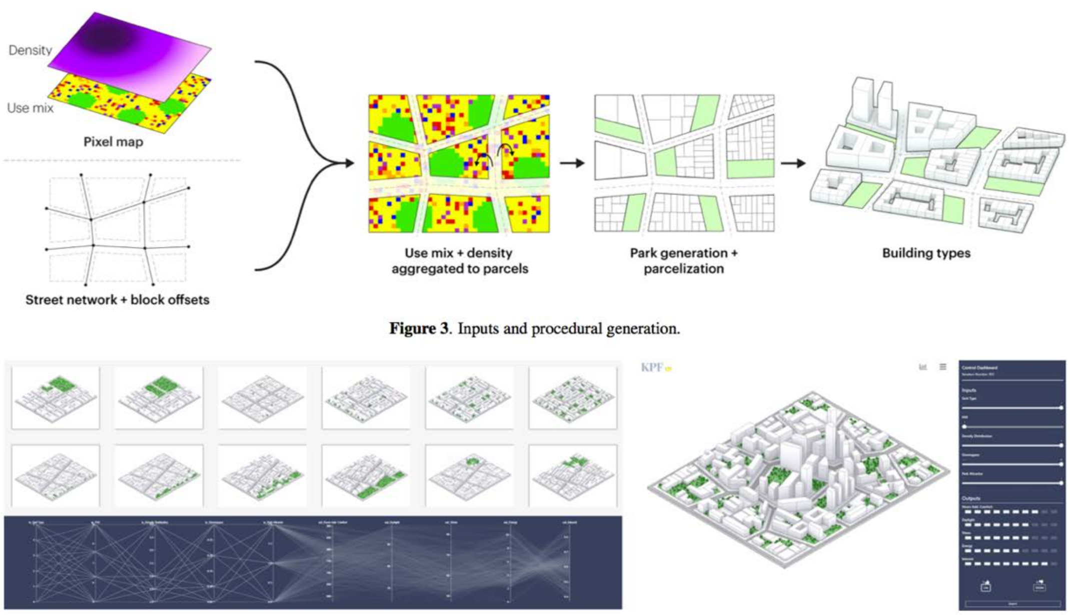
As an attempt to respond to this challenge, the UI group developed the term Computational Urban Design (CUrbD) in order to develop a way to generate an ideal block and a thousand master plans through a Decoding Spaces Toolkit (DCT) that could integrate the different perspectives of stakeholders with sophisticated computational approaches to urban design (Wilson et al., 2019). The DCT features two interfaces that anticipate different levels of user sophistication and facilitate the understanding input and output values and their impact on design. However, the resulting modeling workflow does not offer a way to incorporate stakeholder opinions.

Fig 2.9 – KPF Urban Interface Ideal Block & Thousand Master Plans (KPF UI, 2019)



Finally, moving one step beyond performance-based guidelines, the machine learning module "Unsupervised Learning" auto-generates trends based on the results, opening the door to the automatization of urban design through machine learning. While aiming only to be a support decision tool to decision making in the face of the many alternatives it provides, the thousand potentially correct alternatives do not favor the design and planning processes. The Urban Interface group admits itself that "while computational urban design shows much promise for providing an iterative, quantitative approach to master planning, its place within the master planning process remains in question" (Wilson, et al., 2019).

Fig 2.10 UI´s Decoding Spaces Toolkit Modeling Process and Visualization (Wilson et al., 2019)

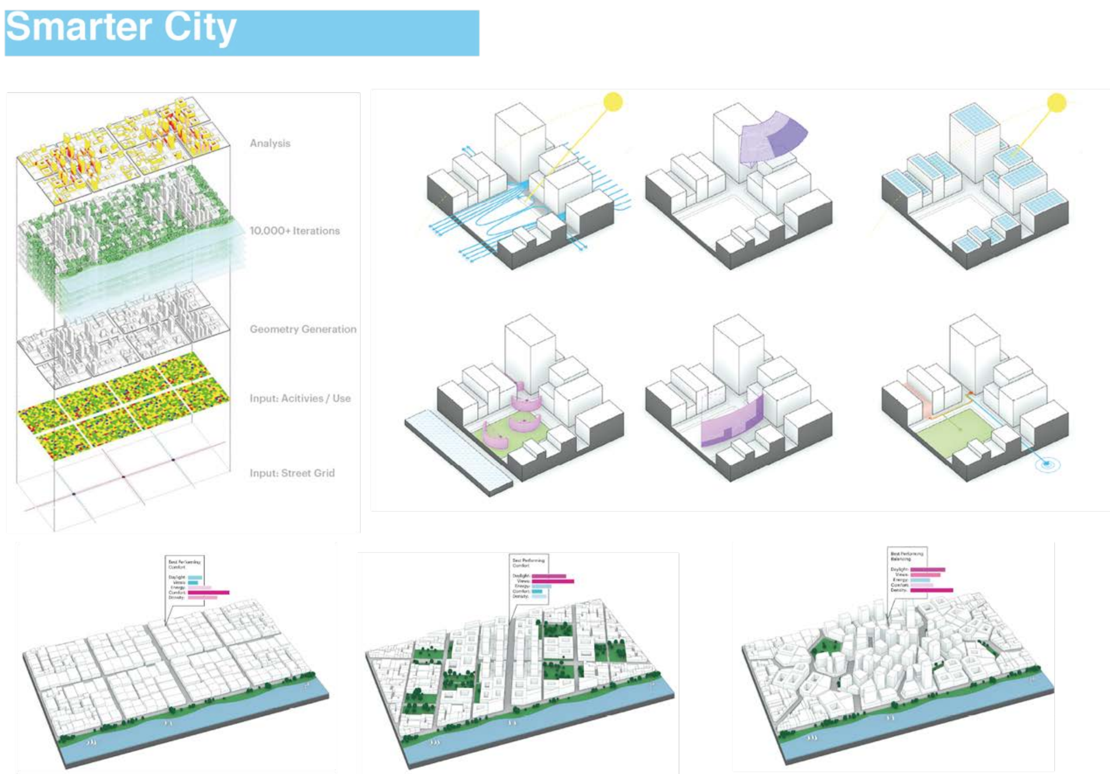


In its Smarter City project, KPF returns to a heavily data-driven scenario approach and affirms to be on the path towards the "smarter city" by asking whether the "smart city" can be more than technology grafted onto a traditional design.

> *By privileging performance over form, and merging the concerns of human experience (comfort, daylight, visual interest) with functional efficiency (sustainability, building efficiency, access to transit and green spaces), we are able to embed computational intelligence directly into the built form of the city. This iterative, analytical, simulation-based workflow is the future of architectural and urban design, creating cities that are resilient, functional, and livable. (KPF UI. 2018. Smarter City, retrieved from https://ui.kpf.com/smarter-city)*

UI defends that the urban DNA of "successful" cities can be coded into a tool that brings them together, from New York City's orthogonal street grid that allows for a flexible and efficient mix of high-density uses and Barcelona's rich variety of public spaces that support a wide range of activities to Rome's pleasurable medieval urban fabric. The overlapping of these coded layers of urban qualities results in design strategies for comfort, enjoyment, and livability as well as functional efficiency, that technically ensure that the “first city built from the internet up feels like an authentic global capital." (KPF, 2018, web)

Fig 2.11 – Smarter City Project, clockwise from upper left: Diagrammatic representation of Computational Urban Design; Diagrams of tools for Outdoor Comfort, Daylight, Energy Efficiency, Visual Interest, Unobstructed Views, and Access to Parks & Transit and Urban Design Outputs (UI, 2019)



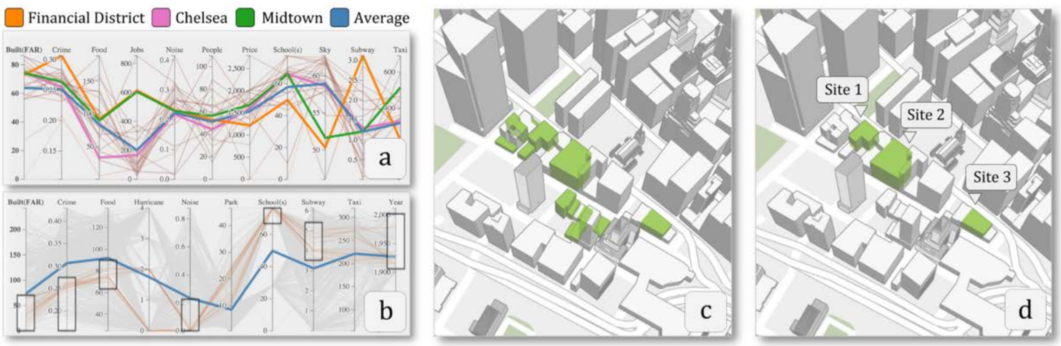
The Urban Interface group does itself question the validity of this approach, which only constitutes one of three aspects of design that are “everything they need to build a comprehensive, iterative model to generate thousands, or even hundreds of thousands of design candidates” (Wilson, et al, 2019). Along with the mentioned urban morphologies of interest, the other two aspects are the factors that define formal variation such as climate, culture, and context, and the benchmarks against which to measure success or failure. Once the inputs have been determined, the model follows a set of procedural rules to automatically generate building geometry based on uses, building height limits, relation to public space or the size of the blocks and parks. Although the resulting buildings are currently divided into only three typologies (high-density towers on podium, middle-density buildings, and low-density infill buildings such as townhouses and small offices), rules can define any building type. It is unclear whether these rules refer to a particular coding process or whether it follows the procedural modeling process exposed before. The combination of variables like daylight, comfort, sky exposure, solar radiation, wind, energy efficiency, visibility of buildings from/to landmarks, access to parks and transit, mobility, and even subjective characteristics like "visual interest" ultimately results in the "thousand masterplans".

A “thousand masterplans” that only demonstrate a computing capacity to create a design output based on the calibration of a set of variables that are considered relevant in urban design. The integration of the different perspectives mentioned before is therefore limited to playing with set variables and exploring different outputs. This iteration on a digital tabula rasa pays little attention to the restrictions of development regulations or the urban context that may affect any of the variables the iteration plan so ideally contemplates. While KPF affirms that the “Smarter City” approach helps to determine the optimal course of action for projects to navigate the myriad, seemingly contradictory constraints that urban design projects face outside of the digital world, the infinite possibilities actually imply a loss of capacity to determine one adequate vision that then, supported through data-based evidence, can be pursued beyond digital ideals.

Qualitative design - defining urban character and identity through computational tools

Beyond purely data-based spatial planning, UI has attempted to explore the “character” of a neighborhood, the impacts of new development and the experience of the city in partnership with the NYU Center for Urban Science and Progress through the Urbane project (Ferreira, et al., 2015). Urbane´s key assumption is that “while the experience of a city is inherently subjective, the characteristics that shape the quality of it are not.” A combination of physical data layers, like the geometry of land, streets, parks or water bodies and qualitative data layers such as locations of crime occurrences, taxi activity, subway stations, noise complaints, and restaurants define this urban character according to the authors. Other data in different format explores heterogeneous aspects that affect urban quality. For example, line data measures sky exposure to understand the impact of massing development at the street life level, while polygon data and grid data apply area values such jobs density, building density, average price of properties or elementary school zones. While the approximation to the concept of quality of the urban space through the combination of spatial and non-spatial values in modeling has also been employed by other research groups like the CityScope project to be detailed further on, Urbane´s obstructs a more tangible translation between the qualitative evaluation and the defined spatial features that define that quality. Its ambition to combine too many and too diverse values that can affect urban livability results in a loss of strength.

Fig 2.12 Application of Urbane in Downtown Manhattan Site (Ferreira et al. 2015)



Note /

In the opposite to the unlimited possibilities of KPF or other tools, very singular regulatory conditions have led to the development of tailored platforms to inform urban design. Both Flux Metro Austin) as well as tools developed by Sasaki for the Texas Capitol Complex Masterplan deal mainly with maximizing development envelopes under Austin´s singular for unobstructed views of the Capitol from specific locations (Didech, 2015; Sasaki Associates, 2017). While sounding anecdotic, it provides an opposite to the potential thousand masterplans developed on a tabula rasa – here, the coding language of computational tools allows to create a tailored solution for urban design under restrictive conditions.

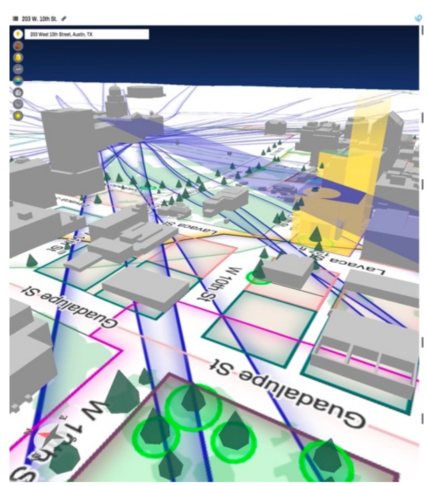
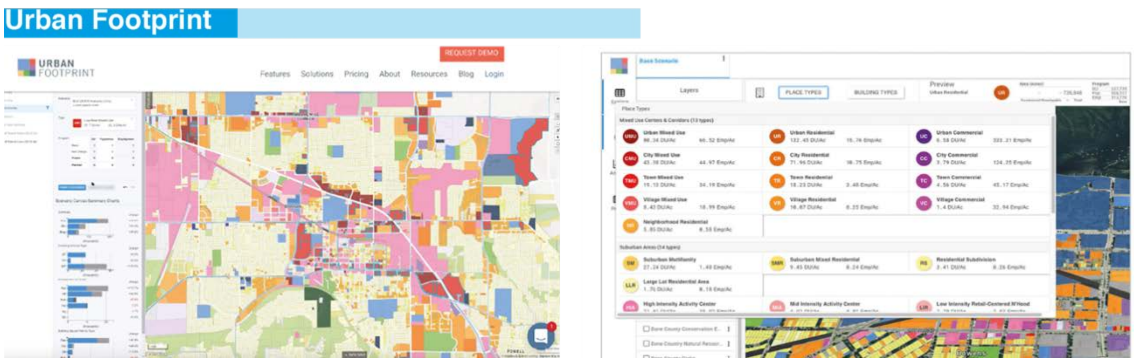


Fig 2.13 Flux Metro (Didech, 2015)

Urban Footprint and UrbanSIM and the future of web-based tools

Beyond the computational advances and the many digital tools and software highlighted so far, further advances in cloud computing have led to the development of web-based tools. Web-based tools promise advanced scenario simulation, customization through data and enhanced workflows by building on large amounts of information hosted on the cloud, from base maps to preset libraries and diverse sorts of data. Web platforms allow to overcome the limitations of software based on individual computers and the universal accessibility to and the exchange of information.

Fig 2.14 Urban Footprint Interface (Urban Footprint.com, last visited May 2019)



Urban Footprint, developed by New Urbanist Peter Calthorpe through Calthorpe Analytics in 2017, is the most prominent example for an ambitious web-based planning and design tool. Through a combination of data analytics from various sources applied to a GIS base framework with additional modeling capacities, Urban Footprint aims to become the ultimate tool for practitioners to associate any possible data to a spatial feature. In particular, Urban Footprint aims to simplify handling digitized data from development regulations like zoning, land use or some specific ordinances. Unlike Modelur or Envelope, Urban Footprint promotes itself as a tool to "restrict development" by facilitating the measuring "community impacts" through diverse metrics– clearly implying that communities tend to have a NIMBY (Not-In-My-Backyard) attitude (Calthorpe Analytics, 2017).

Urban Footprint´s main components are a Base Canvas, a library of Buiding and Place Types, and an Analytics Module with extensive spatial analysis features. The Base Canvas includes residential, employment, parcel or building area features, as well as built form type and land development category. Reference layers for environmental features, infrastructure, education, transportation, land use, census, social equity or public facilities overlap this base canvas. Building and Place Types complete the palette of development options and incorporate functional aspects such as building energy and water consumption, building-related greenhouse gas emissions, infrastructure operations and maintenance costs or household costs. Lastly, the Analytics Modules include emissions land consumption, walk and transit accessibility or transportation.

Urban Footprint approaches the economic factors of development through data from local, regional, state, and local sources that are used to derive cost and revenue factors. These vary by housing unit type, land development category, and land condition, giving local authorities a capacity to immediately assess the financial benefits to development. For other constituents of design and planning processes, like design and architecture firms, it caters a gain on efficiency and competitiveness by optimizing the design process through exhaustive analysis and comparative scenario planning. Urban Footprint also caters to developers as a tool for maximizing property investment with advanced location evaluation at the site level and alleging that potential obstacles can be known in advance through data and compliance can be ensured. By specifically targeting the interests of the different stakeholders in urban development, Urban Footprint provides not only a data-informed scenario, but also a comprehensive common ground for the stakeholders in urban scale projects.

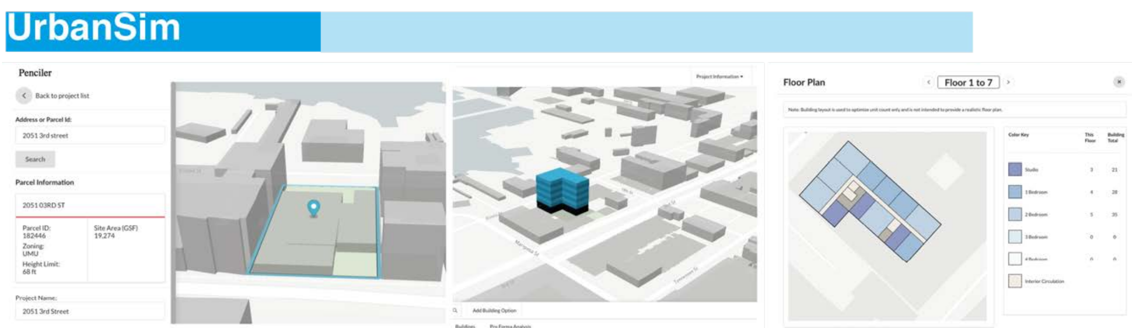
> *Better data will help you craft a proposal that benefits your project, supports the local community, and ultimately streamlines the path to development. (Calthorpe Analytics. April 2019. Retrieved from http/:/urbanfoorprint.com)*

Given its recent existence, the real impact of Urban Footprint remains unclear. The website outlines a series of use cases where it has been employed by private practitioners and local authorities, from the City of Madison´s 2040 Comprehensive Plan as it faces extreme growth, the City of San Diego Community Plan or the work of DZP, a practice founded by another NeoUrbanist, Andres Duany (website statement, Calthorpe Analytics, April 2019).

On the other side, **UrbanSim´s** main feature is its flexibility to allow for more open design and planning processes across different scales (Waddell, 2019). UrbanSim´s creation by Paul Waddell of UC Berkeley dates back to 1998 as an open source urban simulation system. By taking advantage of Open Data sources, its components UrbanCanvas Modeler and Penciler allow to merge quantitative data like employment, household, and socioeconomic with spatial characteristics such as street networks from OpenStreetMap or data uploaded by the user. Although it still requires technical knowledge, it simplifies the incorporation of up-to-date local data that can better analyze site-specific conditions and allow for the development of place-based solutions as opposed to the preset libraries of Urban Footprint.

Although UrbanSim markets itself partly as a “real estate market simulation tool”, its real estate development model links urban design and financial factors such as neighborhood land use mix and property values, recent development in the neighborhood or market conditions and vacancy rates, its 150 × 150 meters resolution hinders reaching a productive level of detail. As such, UrbanSim mostly serves the testing and development of new city-wide planning despite going in detail to parcel based zoning constraints such as floor-area-ratios, setbacks, building types, unit density, lot coverage, and maximum heights. As a particular innovation, zoning constraints can be specified to change for a location over the forecast time horizon, introducing a temporality factor most other tools ignore and which is fundamental given the long terms of urban scale development projects. This feature allows altering the development feasibility calculus for specific periods and locations in order to up-zone blocks surrounding a new transit station in the future, as a

Fig 2.15 UrbanSim interfaces (UrbanSim website, March 2019)



Unlike Urban Footprint´s limitations of granularity and detail, UrbanSim´s Penciler extension launched in 2017 reaches a better level of detail at the building scale. As opposed to a preset library, users can develop many different options for each site with different building programs and zoning constraints. This intends to help understand and visualize the effects of a local policy, such as a density bonus or inclusionary requirements, putting a focus on community engagement. Penciler allows to rapidly evaluate development feasibility for multi-family development using constrained optimization to generate a building footprint and floorplan that optimizes the unit count on a parcel, subject to the zoning and building code constraints applicable to the site. Penciler goes even further into financial aspects of development by analyzing the costs and sources of funds for each building option, including for affordable housing. Their comparison helps to understand the financial impact of different program decisions and rent profiles by even accessing 20-year cash flows. The incorporation of financial modeling of development in the planning and design process not only targets developers but every stakeholder in the process for which a long-term financial study can is fundamental, such as local governments. Penciler was employed in San Francisco by the Mayor´s Office of Housing and Community Development to analyze the feasibility for the city of turning city property into affordable housing, expecting to add 1,500 units of affordable housing to the city each year through this method (GovTech, 2017). This example shows an approach that goes beyond purely spatial variables to address the most pressing issues of urban planning by optimizing resource allocation in different sites through data-based analysis. Lastly, Urban Sim is pursuing high-detail representation of buildings, vehicles and pedestrians to much simpler forms as part of a broader effort to support community engagement through visualization.

Chapter summary

In conclusion, the comprehensive scenarios that computational tools enable to build through quantitative and qualitative indicators of diverse nature and the possibility of rapidly understanding their impacts at the urban design level allow planners and practitioners to take more informed decisions to steer better urban design practices in large development projects. The tools have evolved beyond spatial modeling and analysis to merge the building and urban scales by also incorporating other factors that influence better design and planning practices, such as the possibility of analyzing mobility or land values through various sources of data. The advances of web-based tools that enable the incorporation of local data enable a site-specific approach to urban design as a way of solving local planning issues. By utilizing systems thinking where the connections between issues are explored across scales, integrating quantitative and qualitative information, and explicitly considering visionary or normative elements, current tools can support better development processes at the urban scale (Godspeed 2017). They also provide the coordinated view that is necessary for stakeholders to determine which strategy presents the best short-and long-term solutions to pursue more sustainable development practices (Wallis, 2012). Immediate scenario development and impact assessment also facilitate the negotiation on the features of urban scale projects between constituents and help achieve mutually beneficial outcomes. However, the potential of the tools for increasing the collaboration and understanding of stakeholders that can lead to the implementation of these comprehensive proposals remains unclear. This issue will be explored in the analysis of the proposals and development in Kendall Square in the following chapter.

Fig 2.16 Evolution of computational tools – the path to inform better urban design

3

Long term, large scale

Forces behind the design, planning and development of Kendall Square

I /

An introduction to Kendall Square

Visions for an urban innovation district

Why Kendall?

The Kendall Square neighborhood in Cambridge, Massachusetts, has been undergoing a phased redevelopment in the form of Planned Unit Developments (PUD) since the inception of the 1969 Kendall Square Urban Regeneration Plan (KSURP). In the transformation from a decaying post-industrial site to a booming biotech hub since the mid-2000s, different urban design visions for a sustainable and livable high-density, mix-use district have been conceived within a development regulation that through various mechanisms pursues better urban design, from enforcing regulations to design guidelines and indicators. Computational tools have been instrumental for the development of these visions that reflect the different forces, strategies, and interests behind them and the shaping of urban design through them. The evolution of these visions towards implementation reflects the trade-offs and negotiation processes around the urban form that characterizes the development process of high-density, mixed-use urban projects framed by participatory planning process and high development pressures. In parallel, diverse research groups at MIT have used Kendall Square has a testing ground the tangible computing tools, which aim to advance data-based collaborative processes of urban design putting emphasis in the process and not the result. What can we learn from the complexity of Kendall to understand the potential and limitations of computational tools to steer better urban design practices?

A spatial approach to Kendall

A diverse yet unstructured urban tissue underlines the historic character of Kendall as a crossroads of uses and patterns over time that led to the undefined morphology of today. While the MIT main campus holds relatively low-rise buildings and continuous facades as an urban perimeter, stretching along Main St. and Memorial Drive, the Golder Triangle between Main St and Broadway rises like a solid block. The Golden Triangle is the result of the intersection of several different urban grids, a most symbolic Gateway into Cambridge from which two of its main streets depart. Towards the north, high and medium rise new condominiums and low industrial structures mix with vacant lots of diverse sizes that transition towards the low-rise residential typology of Cambridge.

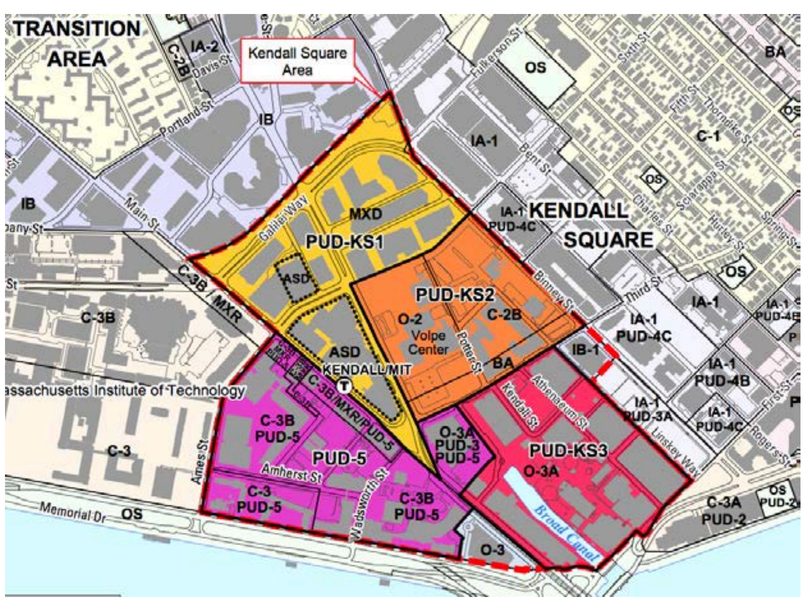
Fig 3.1 Kendall 1960 vs 2018 (Cambridge Redevelopment Authority, Google)

PUDS – framing long term growth

The Kendall Square Urban Renewal Plan (KSURP) guides the large-scale, long-term redevelopment of Kendall and subdivides the area into diverse Planned Unit Developments (PUDS). The administrative subdivision into PUDs is fundamental to frame the evolving conditions for development in the area and how urban design aimed to provide a response to particular urban issues. Currently, the PUDs find themselves at different levels of completion:

- 1999-2005: PUD-3 Cambridge Research Park - under construction
- 2000: PUD-1 Cambridge Center & MXD – completed / under construction
- 2013: PUD-5 MIT Campus East Gate (SOMA & NOMA) – under construction
- 2015: PUD-2 Volpe Site – under proposals

Fig 3.2 Zoning Map PUDs (Cambridge CDD, 2015)



These PUD´s have undergone minor alterations of their boundaries over time, while others, such as the PUD-5 MIT East Gate, have been defined through new zoning petitions and plan amendments. Lastly, PUDs are subject to special development regulations which emphasize the quality of urban design and will be detailed later on.

Plan amendments & the definition of urban design through numbers

The KSURP has undergone a series of amendments over time to balance a better distribution of uses and a response to market conditions and demand. Over the years, Kendall has evolved from a primarily tertiary district to accommodate more residential area in its quest to become a lively mixed-used district over two decades. Despite the focus on increasing the housing surface in the Volpe site, the residential surface is very reduced in contrast to the predominance of office, lab and tertiary uses. As a result of the development of the last years, a 2017 market profile for Kendall Square counts 52,000 employees versus roughly 7,000 inhabitants in a 0.5-mile radius (HR&A Kendall Square memo) – a nearly 8-1 ratio that is very distant from the "work-play-live" vision. This imbalance of uses also reflects itself in Sasaki´s land use analysis timeline (fig 3.3) for the Cambridge Redevelopment Authority.

The distribution of development potential and land uses for each of the PUDs of Kendall sets the frame for the definition of the development within it – and how urban form and urban design translate these numbers into buildings and spaces. An envelope of what is possible within which the CRA aims to address this imbalance of uses and achieve the goal of balanced economic vibrancy, housing, and open space to create sustainable communities through new and revitalized development (CRA, 2019, "Kendall Overview"). As a result, achieving these goals through urban design implies a trade-off in the allocation of development and uses within the defined values. The parameters associated to zoning and land use, such as lot occupancy, floor area ratios (FAR), offset, maximum height or offset define density and massing, finalize the definition of the buildable envelope. Within this envelope, developers pursue the maximization of development (and on top of that, of particularly profitable uses in the current market conditions, such as labs) and communities aim for more publicly beneficiary outcomes through the inclusion, for example, of more housing. Through their respective role in the development process, such as design review, these stakeholders exercise their power towards the implementation of projects. However, this quantitative definition has, per se, no qualitative character. Indeed, approaches through pure Euclidean Zoning fail in creating dynamic, livable communities. Thus the relevance of urban design in Kendall for achieving its vision – and of computational tools to bring them to life.

Fig 3.2 Land use in Kendall and KSURP amendments over time (elaborated via Sasaki / Cambridge CDD)

I) 1980 - 2002

1980 | 1990 | 2000

development & land use

KSURP (Kendall Square Urban Renewal Plan) in numbers

1978	1981	1993	1997	2001
Original KSURP	**Plan Amendment No. 2**	**Plan Amendment No. 3**	**Plan Amendment No. 4**	**Plan Amendment No. 5**
2,773,000 GSF	**- 0 -**	**- 0 -**	**- 0 -**	**+ 200,000 GSF**
2,773,000 GSF	2,773,000 GSF	2,773,000 GSF	2,773,000 GSF	2,973,000 GSF
		830,000 sq ft office to 1,305,000 sq ft biotechnology manufacturing 80 to 96 feet max. height (laboratory facilities)	+190,000 sq ft hotel -100,000 sq ft residential - 20,000 sq ft retail -70,000 sq ft office	+ 200,000 sq ft high-rise multi-family residential

Cambridge Planning Guidelines

II) 2004 - 2014

2005 | 2010

2004	2010
Plan Amendment No.6	**Plan Amendment No.8**
+ 29,100 GSF	**+ 225,000 GSF**
3,002,100 GSF	3,227,100 GSF
+ 29,100 sq ft biotechnology manufacturing and offices	+ 300,000 sq ft office and biotechnology manufacturing - 75,000 sqft high-rise multi-family

III) 2015- 2020

2015 | Envision Cambridge | 2020

2015 | 2020

Plan Amendment No.10

+ 1,034,600 GSF

4,261,700 GSF

Zoning modifications
+ retail
+ office
+ residential

Anticipated Net New Gross Floor Area (GFA) - Cumulative

District	Residential	Office / Lab*	Retail	Other	Total	
PUD-5 MIT	285,000	871,000	87,000	207,000	1,450,000	- balanced res / office
PUD-KS Volpe	1,116,000	1,716,000	140,000	None*	2,972,000	+ balanced res / office
MXD (CRA)	400,000	660,000	30,000	None*	1,090,000	

Anticipated Total Gross Floor Area (GFA) - Cumulative

District	Land Area	Existing GFA	Net New GFA	Total GFA	Total FAR	
PUD-5 MIT	1,150,000	2,571,000	1,450,000	4,021,000	3.5	
PUD-KS Volpe	620,000	375,000	2,972,000	3,347,000	5.4	+ dev / - area = + density
MXD (CRA)	890,000	3,288,000	1,090,000	4,378,000	4.9	

** 2015 KSURP Zoning Amendment*

Increment of Middle Income Housing in Volpe

District	Current Zoning	Initial Proposal	Revised Proposal	
Total Housing	967,000	1,116,000	1,116,000	more housing - diff vision ?
Affordable Req	11.5%	15%	20%	
Total Units	880	1,014	1,014	
Total Aff. Units	100	150	200	

II /

The evolution of Kendall Square

Long term redevelopment and transformation over time

From blooming industry towards decline and recovery – the birth of the KSURP

During the 19th century, Kendall Square grew into a relevant industrial area due to the availability of land for industrial uses close to Boston and the deployment of railway infrastructure to serve the industry. MIT relocated to its current site on the Charles northern bank in 1916, later sprawling from its core on Massachusetts Avenue towards the Kendall Square area in the east. Kendall was zoned industrial after zoning was introduced in Cambridge in 1924. Following World War II, many industrial businesses shut down or moved to cheaper sites (Blanding, 2015).

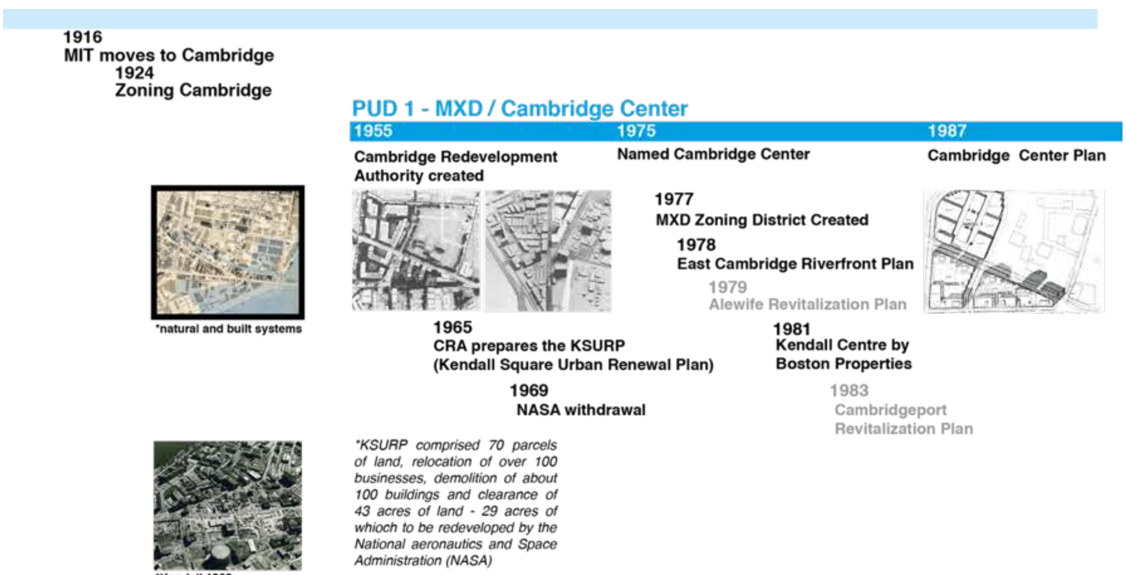
In 1955, the Cambridge Redevelopment Authority (CRA) was created to foster the recovery of the area through low land value and flexible development opportunities. Short after, the CRA planned Technology Square, one of the first university linked business Parks with the local government and the President of MIT. This initiative brought relevant technology corporations to set a branch across the streets of MIT. In 1964, following the Federal government´s request to initiate an urban renewal plan for Kendall Square, the CRA developed the Kendall Square Urban Development Plan (KSURP). Its largest sites meant to accommodate one of NASA's Electronic Research Center following Bostonian President John F. Kennedy´s will. In order to transform the 42-acres of urban blight into vacant land suitable for development, the CRA acquired 70 parcels of land, relocated 100 businesses, demolished 50 buildings, filled the Broad Canal, and constructed public infrastructure improvements and roadways (Blanding, 2015). At the same time, CRA began concept planning for the 13-acre "Golden Triangle" to be privately developed. The plans show a modernist approach of repetitive buildings and green areas in between, with a certain sense of unity and urban landscape.

In 1970, NASA abandoned its operations in the project and transferred its interests to the U.S. Department of Transportation to create the Volpe Transportation Research Center on only 6.3 of the 13 acres. Only half of the parcel was built, resulting in a massive building surrounded by vast parking. It reflects the urban design ideals of its time of a car-centered city of corporate headquarters devoid of street life and residents. At the same time, the CRA actively pursued the development of job-intensive uses on surplus NASA land and the mixed-use development on the

Golden Triangle, renamed Cambridge Center in 1975. The MXD Zoning District was created in 1977, but a series of financial and planning hurdles delay approval until 1979. During that year CRA finally executes a development agreement with Boston Properties, anticipating 1,500,000 square feet of privately financed development on the Triangle to be completed in 1981 (Spalding, 2018).

The Cambridge Center on the Golden Triangle, as well as other large corporate buildings, were completed through a vision very divergent to the original idea: repetitive towers housing hotels and offices inside a mega block with public spaces in its interior. Three million square feet of office/research & development served by hotels and retail uses with little attention to ground floor retail and a pedestrian-oriented street life The 1987 Cambridge Center Plan shows the expansion into today´s MXD Use District, with dense but low massing, a large parking structure, and very little public space. It is not until 1990 that construction is completed on Ten Cambridge Center, a building to be fully occupied by Biogen later that year – the first large biotech corporation to move to Kendall (Spalding, 2018).

Fig 3.3 Kendall´s beginnings and the KSURP (Simha, 1964)



PUD-3 Kendall Square Research Park – advancing urban design

In 1998, the Kendall Square Research Park was established to complete PUD-KS 3 to the north of the Broad Canal, a primary asset for quality urban space confronted to high limitations for development linked to the remediation of its long term use as a gas plant. The Lyme group under the lead of David Clem under the advisory of urban design and planning firm Urban Strategies led by Michael Trocmé developed a masterplan for the site. This masterplan contemplated six massing options in a site with high limitations due to the soil conditions, of which the most favorable was forwarded for the PUD petition. Once this was approved, developer and design teams organized an international design competition for the completion of the building. The masterplan displayed a unique relationship between a developer seeking design excellence and a design team, even if the area had a "bad reputation" [1] amongst developers. Lyme recognized the value of good design for the then emerging life sciences and returned from retirement to push for the development of the innovative Genzyme Center, one of the first buildings to achieve LEED Gold status long before it was enforced. This would be partially due to the lucky coincidence of being right next to a steam plant, putting less pressure on achieving sustainability through design, as the Urban Strategies team recognizes [2].

The voluntary commitment to green building and LEED principals, as opposed to today´s LEED requirement for any large building in Kendall, is singular since the financial benefits of energy efficiency go to the tenants rather than the developers, who incur higher costs of development. Today, advances in the industry and the possibility of faster and more accurate energy-efficient modeling as seen in previous chapters has enhanced the design and construction process and reduced costs and are actively used both by design teams and developers due to prescriptive requirements [1,3]. Urban Strategies´ masterplan put a particular emphasis on qualitative urban design. The then existing limited computational tools of 3D modeling, still in the process of industry-wide adoption, were fundamental to test iterations of urban configurations and allocation of uses and give a sense of the influence of design in environmental factors, as Michael Trocmé underlines. In parallel, the Kendall Square Research Park was used as testing ground for advanced urban design modeling by MIT´s Media Lab through the Luminous Table, which will be explained in detail later on.

At the building level, the then relatively novel computational approach became fundamental to achieve the implementation of better design practices. As Michael Trocmé underlines, it allowed to effectively communicating the value of the design proposal against the existing conservative design standards to obtain approval through the design review process. Years later, the recognition of the project showcases how specific design regulations and public processes can hinder innovation in the built environment (Budd, 2011).

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[1] Int 9 David Clem, Founder Lyme Properties. 02/22/2019
[2] Int3 Michael Trocmé, Principal Urban Strategies. 02/14/2019

Fig 3.4 The Cambridge Square Research Park project (Urban Strategies, 1998)

2001 - CityWide Rezoning

The City of Cambridge adopted a building moratorium in 2000 In the face of increasing market pressure through the establishment of the first biotech companies in the area and foreseeing the development to come, undertaking a comprehensive study of land use that led to the 2001 Citywide Rezoning. It emphasized the importance of pedestrian-oriented development and creating open spaces at the street level (Cambridge CDD, 2007). Under this umbrella, the 2001 Eastern Cambridge Rezoning & Planning Study started proposing the reconversion of the Volpe into a mostly residential area of low housing blocks with various configurations around green areas and framing a more extensive park. Of this, only the residential development at 303 Third Street has been completed. However, soon the unanticipated exponential growth of the biotech industry would transform Kendall into one of the most valuable real estate areas of the country, creating a development pressure that would alter the conditions and outcomes of urban design projects in the area.

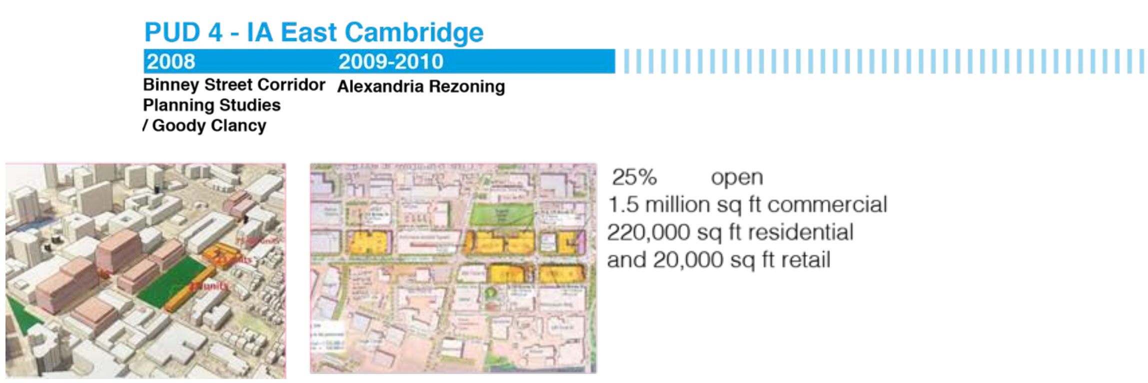
The biotech boom & the renaissance of Kendall

Today, sixty-two public companies with a combined market value of about $170 billion call Kendall Square home, amongst them pharmaceutical giants such as Takeda Pharmaceutical Co., Sano SA, and Novartis AG. The growth of the biotech industry and the sense of being at a historical crossroads has meant that Kendall Square now competes with midtown Manhattan as the priciest commercial real estate market in the country At 3.6 percent, Cambridge has the lowest vacancy rate of the significant downtown markets in CBRE’s report, compared with a national average of 10.5 percent (Alcorn, Stacey, 2016). Joel Marcus, chairman, and co-founder of Alexandria Real Estate Equities Inc. based in California, became one of the driving forces of the transformation of Kendall Square in the early 2000s. Understanding the dynamics of agglomeration economies in the field, and realizing that a similar cluster to those already existing in California was missing in the East Coast, Marcus considered that Kendall could become one if it managed to attract more global pharmaceutical players. After an initial acquisition in 2002, Alexandria bought the seven-building parcel of Technology Square from MIT for $600 million in 2006. Alexandria converted two of the buildings from office to lab space, doubling the rent and fully leasing them immediately. It seems that not even MIT anticipated the Kendall boom.

That success led Alexandria to create a biotechnology campus from the ground up to attract further tenants by assembling about a dozen parcels along Binney Street from 2006 to 2008. In 2010 a PUD Special Permit allowed 1.5 million sq ft of commercial use, 220,000 square feet of residential use, and 20,000 square feet of retail use in those spread out parcels. Still undergoing development and approval, the Binney Street Planning Study of 2008 again by Good Clancy contemplated various massing options that aimed to portray a reduced impact in the neighboring residential area. This approach followed a communication strategy to reduce community opposition and achieve faster approval [3].

Despite souring real estate market conditions, Alexandria kept buying and building into the recession. From the 35 buildings it owns today in Cambridge, Alexandria brought in $318 million in rental income last year (Alcorn, Stacey, 2016). While Alexandria may be the underdog developer, most of the area's property is shared amongst Boston Properties, BioMed Realty Trust and MITIMCO – the latter becoming a major player through MIT´s East Gate Expansion and Volpe projects. As Kendall evolved into a real estate hotspot, the design and planning of the area became conditioned by a market pushing for development, a community defending its interests and a City Planning Agency trying to find a balance between both as well as achieving citywide planning goals. The shaping of Kendall Square became a conundrum of changing planning regulations and design visions commissioned by diverse groups in order to defend their interests.

Fig 3.5 – Proposals for Binney Street (Goody Clancy, 2008)



[3] Int 11 Thomas J. Andrews, co-President of Alexandria, 02/22/2019

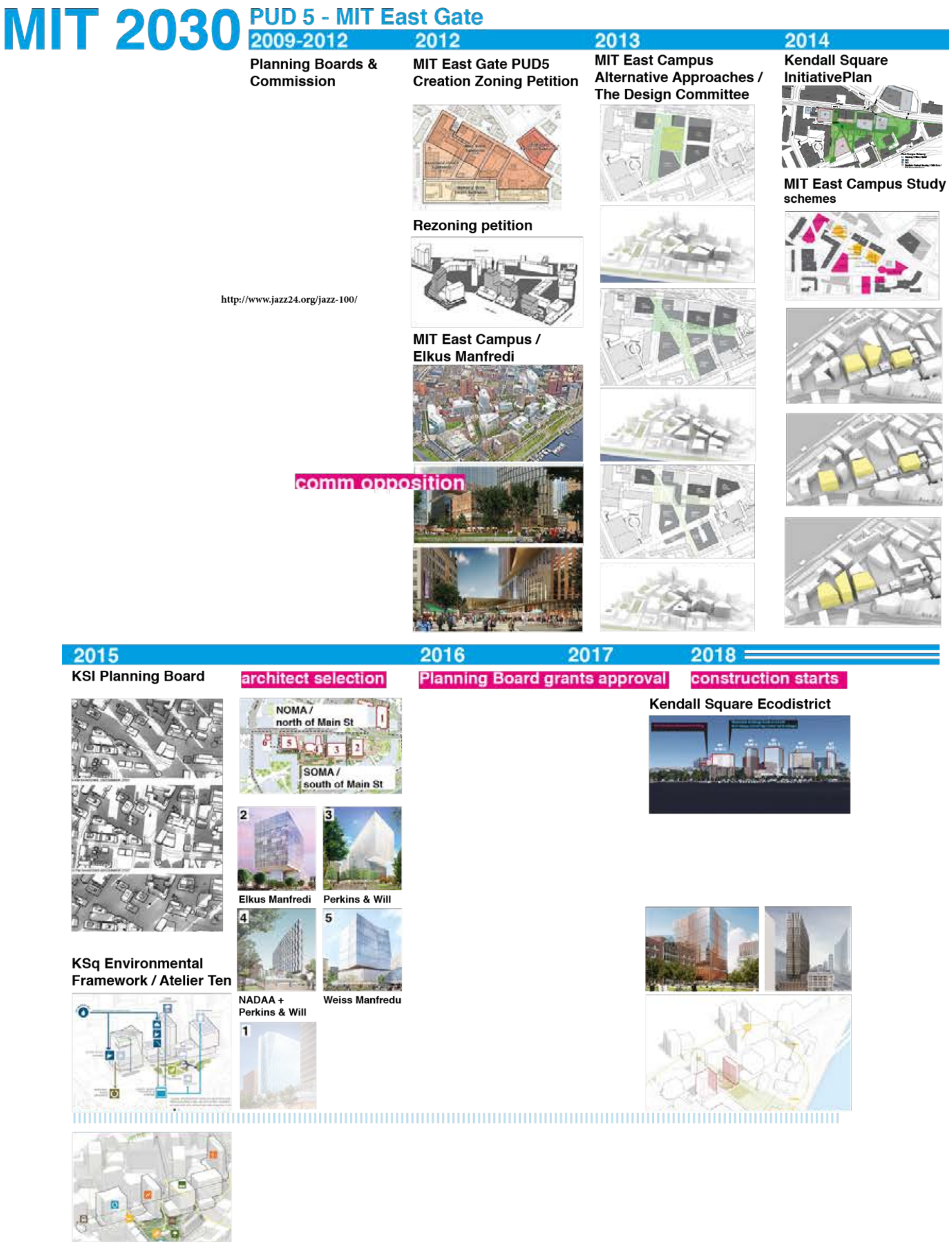
The MIT East Campus Project

In 2009, MIT started to plan the renewal and expansion of MIT´s campus to take advantage of its valuable land property in the Kendall Area under the MIT2030 framework. The Zoning Petition for the creation of PUD 5 MIT East Gate in 2013 included an initial Masterplan by Elkus Manfredi led by MITIMCO, MIT´s Investment Management company, which initially contemplated three massive buildings (Cambridge CDD, 2013). This proposal faced the opposition of the community as well as of the SA+P Design Committee, composed of faculty of MIT´s School of Architecture and Planning. They considered MIT needed to push towards a distinctive architectural proposal against the development-oriented approach of MITIMCO, MIT´s Investment Management company (Cambridge Day, 2013). The SA+P Design Committee developed in 2013 the “MIT East campus alternative approaches,” a series of simple formal variations for the infill of the area through lower blocks and particular attention to the resulting public space. In parallel, the MIT Campus Planning Group, led by Pamela Delphenich, director of MIT Campus Planning from 2005 to 2015, commissioned to Michael Van Valkenburgh architects the development the East Campus Urban Design Study "to help MIT creates a long-range development framework that shapes an initial vision of academic, residential, and commercial uses for its properties in the Kendall Square area." (Michael Van Valkenburgh Associates Inc., 2014). Very similar to the proposal of the SA+P Design Committee, this proposal for the MIT site reduces the height of the blocks and focuses on the resulting public space. The reasons for outsourcing the planning of the site despite having a faculty group working on it remain unclear, but Delphenich argues that the scope of the work the Committee grew enormously from the initial expectations: from looking at developing retail to improve Kendall Square and the life of the MIT community in 100.000 sq ft to expand to millions of sq ft to make the operation profitable within the many conditions to the development of the area.

On the other hand, while the result of the report has been deemed questionable, externalizing consulting services to people who do not belong to the community was considered relevant for present the image of unbiased work in favour of MIT as a way to establish a better relationship with the city and the community [4]. Although initial input was collected through eighty community meetings, the Planning Group would have desired a focus on the process and the engagement of stakeholders to set the departure point for a more participatory design and planning process. Meanwhile, the CityScope project, which pursues exactly the goal of more participatory design and planning, was being developed inside MIT´s Media Lab.

[4] Interview 4, 02/14/2019

Fig 3.6 – MIT 2030 – MIT East Gate Project Proposal Compilation (MIT Campus Planning, The SA+P Committee, Elkus Manfredi Architects, Kendall Square Initiative, Atelier Ten, Nadaa, Perkins+Will)



Reimagining Volpe

As development took over Kendall, the 14 acres of the Volpe became subject to several redevelopment studies. The primarily residential low-rise vision from the 2001 Eastern Cambridge Rezoning & Planning Study with its postmodernist configuration of small blocks around courtyards, of which only 303 Third Street was completed fragmenting the site, gave space to the much denser Reinventing Kendall Square Study, again, by Goody Clancy (2014). The proposal shows an extremely densified vision for all remaining parcels in Kendall Square with barely any public space. The proposal allocated uses by a distributing the surfaces of each of them as specified in the Plan Amendment and introduced spatial diversity with the height increase while reinforcing the idea of a street-wall through fostering retail uses in the lower level in the pedestrian environment. The shadowing analysis of the massing explicitly displays in narrow, overshadowed streets and a public realm of little quality.

The K2C2 Design Guidelines

As the MIT East Gate and Volpe projects started to be shaped, the city developed the "K2C2 Design Guidelines" as an effort to connect Central Square and Kendall Square and steer the booming development in both areas trough better urban design practices (Cambridge CDD, 2013). The principal approach of the K2C2 planning process was to increase the allowed density to encourage the development of more housing, incubator space, open space, continuous retail, improved pedestrian experience, and other desired outcomes. As seen in the Incentive Zoning Ordinances, many of these would be developed by developers in return for greater density, underlining the relation between the market forces and the quality of urban design in Kendall. The K2C2 Guidelines also proposed a rezoning of the area, unifying the Volpe Site and creating a new PUD for the expansion of MIT, as well as proposing height increases that were finally adopted. Other features range from an adequate distribution of mixed uses and of the required affordable housing units, a particular emphasis on housing and ground-floor retail, human scaled permeable block size that increase permeability to the pursue of an integrated network of high-quality streets and open spaces. Additional points include the vague definition of architectural diversity that represents the area´s “spirit of innovation and creativity” through detailed building massing prescriptions for heights, setbacks, and façade subdivisions.

Despite not being prescriptive regulations, the K2C2 Guidelines are used by the Planning Board in the review for approval of Special Permit and PUD applications which is so present in Kendall. As a result, there is a clear change in the proposals developed before and after 2013. These proposal of the K2C2 Guidelines for the Volpe site reflect these points, introducing a higher level of detail in building definition and a plethora of green patches. The hand-drawn method employed for this vision reflects its informative character as a guidance to inspire the proposals being carried out by the development team´s while also aiming to portray Volpe as a new urban center that would benefit the Cambridge community [5].

massing guidelines

middle income housing allocation

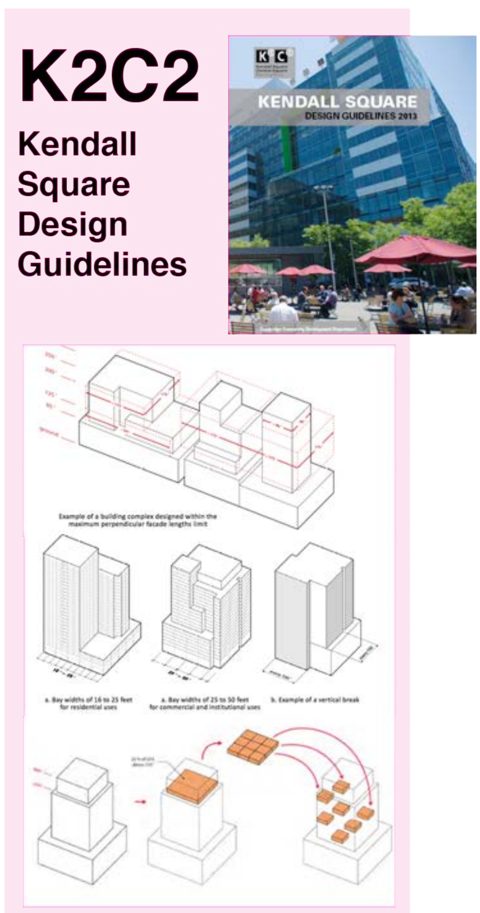


Fig. 3.8 K2C2 Guidelines (Cambridge CDD, 2013)

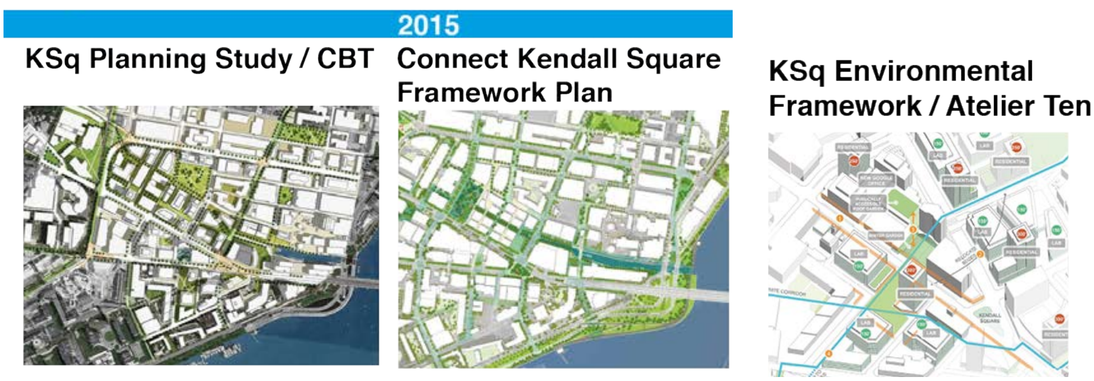
New district wide plans

[5] Int1 Ben Carlson, Director of Urban Design , Goody Clancy. 02/13/2019

Noting a land use imbalance with excessive commercial office and laboratory space in the existing proposals, in 2104 the East Cambridge Planning Team commissioned a study to CBT architects. The independent study called for 446,000 square feet of new residential space, more than double the amount of residential space than was recommended in the K2C2 Study. The emphasis is put in connected and sunlit public spaces and a very diverse urban morphology through broken up blocks without specifically indicating use distribution, in a very different approach than Goody Clancy´s studies.

The emphasis on the public realm of CBT´s study would be continued by the 2015 Connect Kendall Framework, which again proposes an entirely different configuration for the Volpe site, emphasizing connecting the Broad Canal and densifying around it (David Rubin Land Collective, 2015),. Limited to the vision of a footprint, Connect Kendall aimed to achieve the integration of the unstructured development of Kendall through a network of public spaces – but its influence in the further proposals for the different sites to be developed to achieve that unified vision in the future seems minimal.

Fig 3.9 –Areawide Plans (CBT Architects, 2015; Atelier Ten, 2014)



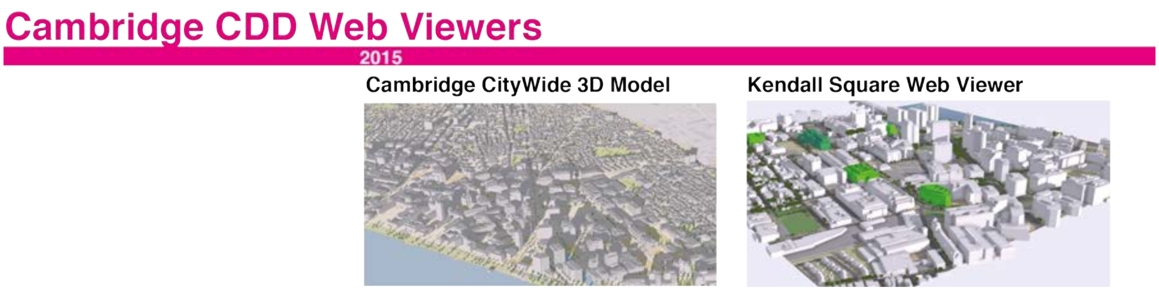
Back in 2014, the Kendall Square Environmental Framework by environmental consulting firm Atelier Ten developed a proposal for an energy district, allocating development and uses with unclear criteria beyond set heights and an approximation to retail allocation. While technically focused on energy aspects, the project itself lacks any reference to energy modeling in the built environment but instead focuses on selling the friendly ideal of lively, green streetscapes as the visible representation of sustainability. Another energy district plan was developed by the world-renowned engineering consulting group Arup the same year, but the documentation is not accessible. The spatial and functional conditions that define an energy district or the benchmarks for sustainability remain unclear despite existing computing capacity for in detail simulation. In the same year, yet another planning study for the Volpe site was developed, again, by Goody Clancy to explore the allocation of growth and uses and the impact of different urban morphologies in the resulting public space (Good Clancy, 2014, "Kendall Square Planning Study).

All these proposals advanced visions for a site that remained vacant until in 2015 the General Services Administration (GSA) invited bids for a "development partner" on a Volpe Center redesign project. MIT was selected as the winning bidder in November of that year to design and construct a new federal facility on approximately 4 of the 14 acres to replace the existing Volpe Center. In exchange, MIT would work with Cambridge to plan a vibrant mix of uses, including commercial innovation space, residential and retail facilities, and open space on the remaining 10 acres now under its property. Following this agreement, the 2015 Volpe Site Rezoning Proposal increased the maximum allowable height in the southern half of the Volpe site (Cambridge CDD, 2015). Diverse massing and site configurations maximizing built area show their impact on the shadowing of public space, which seems to be considered the primary qualitative indicator for the different alternatives. The odd proposal for a large tower reflects the insistence of a Planning Board member of the time to have such a building erected to act as a landmark against the Boston skyline. This episode underlines the problematic issue of the relevance of elected officials in the planning process and their impact on long lasting decisions beyond their political cycle.

The city´s digital approach – Cambridge and Kendall 3D Web viewers

In 2015, Cambridge CDD developed a CityWide 3D model as well as a 3D viewer focused solely on Kendall Square employing ArcGIS Pro and CityEngine (Cambridge CDD GIS, 2015). Hosted on the GIS section of the agency and thereby publicly accessible, both models were meant to provide the public with a holistic view of the urban transformation of the city and of the impacts of the anticipated development – not only in Kendall, but also in other large redevelopments in Alewife or Cambridge Crossing. At the same time, the CDD developed an OpenData portal to facilitate access to diverse data, including an up to date mapping of all development in the city and of buildings fulfilling green building requirements. While a Cambridge OpenData ordinance was established in 2015 and a Open Data Strategic Plan has been established for 2020-2022, both the CityWide 3D model and the Kendall Square Viewer were last updated in 2016 and the 2019 update is months behind schedule. This is due to a need to externalize the model to specialized consultants due to lack of a trained workforce in the local body. As a result, Cambridge CDD has lost agency in using these customized digital tools for the local planning processes. Out of synch with the fast-paced development happening in the city, the tools have become useless for analyzing the impact of development proposals and engaging the public in the public phases of the development process originally intended. Indeed, the GIS team at Cambridge´s CDD points out that the 15-year gap between technology development and adoption can take much longer in public agencies if no substantial efforts to incorporate a trained, costly, and scarce workforce are undertaken [6]. However, the GIS team (Interview, anon) also pointed out that the abandonment of having an up-to-date model of the city responded to an interest in not fully releasing information that could empower NIMBYism.

Fig 3.10 Cambridge and Kendall 3D Web viewers (Cambridge CDD, 2015)



2017 PUD–7 Volpe Zoning Amendment: increased definition of the urban form

With development pressure increasing on the Volpe Site and several proposals for the area, the 2017 PUD–7 Volpe Zoning Amendment (Cambridge CDD, 2017) introduced additional conditions for the development of the site. The new PUD-7 Guidelines and Factors established a defined urban character through a “streetwall” height that is distinct from taller “tower” elements of buildings following the recommendations of the K2C2 Guidelines (Cambridge CDD, 2013). The PUD Guidelines also advanced additional measures towards environmental comfort through urban form, promoting that open spaces, and the buildings that frame them should be designed to minimize undesirable environmental impacts. These measures include as parameters cast shadows and step-backs, location of taller buildings on the southern part of the site and configuration of park space to maximize solar access while balancing the need for logical pedestrian circulation and spatial organization of new buildings.

Other considerations do not relate to form but to functionality, such as the embodied energy and performance, the maximization of on-site power generation and the consideration of alternative building mechanical systems. The guidelines go further into design detail to suggest avoiding

[6] Int 2 Jeff Amero, GIS Manager Cambridge CDD. 02/13/2019

excessive use of glass, the incorporation of passive design strategies such as building orientation, external shading, operable windows, other approaches for natural ventilation/cooling, thermal mass or high-performance insulation. This definition of performance-driven design details at diverse levels of design detail leads to the recommendation that energy modeling should be incorporated early in the architectural design process to optimize building energy performance.

Envision Cambridge – setting Urban Form Indicators

In 2017, the Cambridge CDD for the first time established a series of Urban Form Goals within the Envision Cambridge project.

> *Envision Cambridge is a community-wide process to develop a comprehensive plan for a more livable, sustainable, and equitable Cambridge. It provides a framework for managing growth and change across six key focus areas—housing, economy, climate and the environment, mobility, urban form, and community interaction. With input from the community, Envision Cambridge created a shared vision for the future and articulated the city's core values that will guide future change. Moving forward, this process will develop goals, targets, and strategies for each focus area to help realize this shared vision. (Cambridge CDD,2017,p.8)*

Urban Form is put at the forefront for achieving these citywide visions through the following goals: Patterns of City Development, Growth in Evolving Areas, Transitions between Used and Districts, Open Space, Public Life, Enhance the Public Realm and Regulatory and Development Review Process. In the latter, the accent is put in improving the development process to ensure clearer and more predictable procedures". The report then defines a series of Urban Form Indicators and Targets related to the goals with their respective baseline, target values for 2018 and 2030, and the data sources they would build on.

Envision Cambridge sets numerical values to the relation between urban form and good urban design that leads to a better urban space while also putting an accent in the public perception of "appearance". The indicators were developed based on initial suggestions from urban planning consulting firm Utile and then modified based on discussion within Cambridge´s urban design staff. However, baseline conditions have not been collected as of yet [7]. The data sources to define

[7] Int 5 Cliff Cook, Senior Planning Information Manager Cambridge CDD, 02/14/2019

them rely on visual surveys, GIS data or Open Data – reducing the approach to a planar level that obviates that urban form is a rich relation between 3D volumes that are indeed included in the K2C2 guidelines. Additionally, these limitations are surprising given the existence of a 3D model that could help set more defined values and richer spatial relations. These underlines again the limitation of the City to exploit the full potential of digital modeling tools for steering better development and urban design practices.

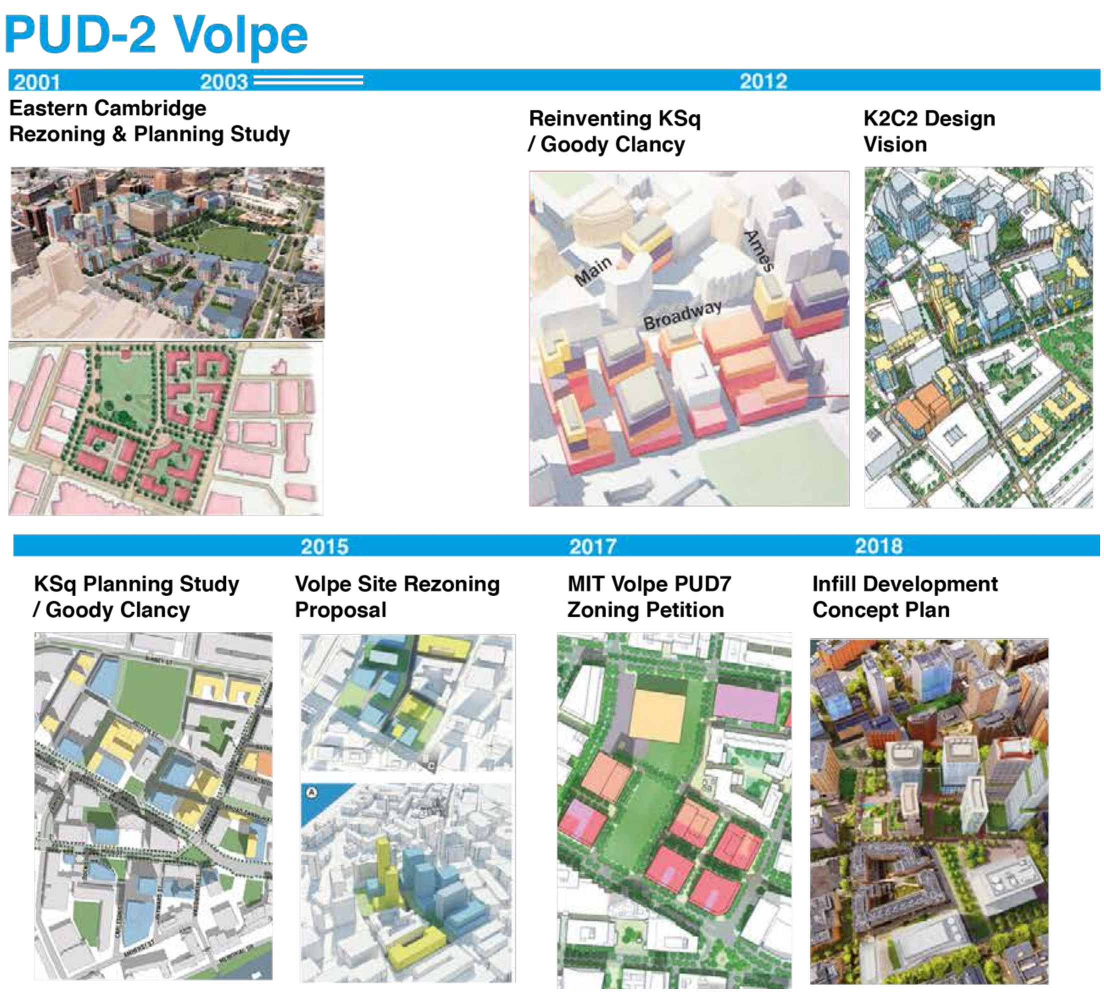
Fig 3.12 Envision Cambridge Urban Form Indicators and Targets (Cambridge CDD, 2017)

	Indicator	Related Goal	Baseline	Target	Data Source	Additional Resources, if any
1	Percentage of frontage along Mass Ave, Cambridge Street, and squares that have result in positive urban design outcomes					
	• Percent of blocks with at least three building entrance per 200'	Public Life, Public Realm, and Patterns of City Development	TBD	TBD	Visual survey	Staff support to conduct periodic visual surveys
	• Percent of total frontage on corridor that is restaurant or retail use	Public Life, Public Realm, and Patterns of City Development	TBD	TBD	Visual survey	Staff support to conduct periodic visual surveys
	• Percent of parcel frontage along corridors with building frontage within 5 feet of parcel boundary (measures completeness of street wall)	Public Life, Public Realm, and Patterns of City Development	2018: 66.5% of parcels along corridors with building frontage within 5 feet of parcel boundary (excluding open spaces and university campuses)	2030: • 80% in squares; • 50% in active pedestrian segments; • 30% in mixed residential segments	GIS	
2	Percentage of housing units that are within a certain distance to 3 or more different parks, including parks in adjacent municipalities Quarter-Mile Walking Distance • Playgrounds • Passive Open Space Half-Mile Walking Distance • Active Recreation • Trails and Nature • Specialty (Off-leash, Exercise Equipment)	Open Space Community Health and Wellbeing	2018 - 85.2%	2030 - 87%	City open space data GIS	
3	Percent of respondents that rate Cambridge's overall appearance as good or excellent	Public Life, Public Realm, Transitions	2014 - 83%	2030- 90%	Biannual City Manager Survey	None
4	Percent of tree canopy over sidewalk and streets	Public Realm and Patterns of City Development	TBD as part of Urban Forest Master Plan study	TBD	GIS	None
	• Percent of blocks with at least the given length of curb per 300 linear feet of block face: ○ 180' in major squares ○ 150' in active pedestrian zones ○ 120' in mixed residential segments	Public Life, Public Realm, and Patterns of City Development	2018: • 70% in major squares • 74% in active pedestrian zones • 95% in mixed residential segments	2030: • 85% in major squares • 85% in active pedestrian zones • 98% in mixed residential segments	GIS	
	• Percent length of building frontage that is transparent (at least 10 feet tall; no posters or curtains; no tinted glass or other window treatments)	Public Life, Public Realm, and Patterns of City Development	TBD	TBD	Visual survey	Staff support to conduct periodic visual surveys

Current vision for Volpe (march 2019)

The latest proposal for the Volpe Site, the Volpe Preliminary Principles from the 2017 MIT Volpe PUD7 Zoning Petition displays an approach to all these concepts: a gridded subdivision of repetitive blocks with massing variations on the southern half of the site in relation to the Golden Triangle, while the Volpe Center occupies the middle of the remaining area (Cambridge CDD, 2017). The latest releases visions for the site (VHB, 2017) show a landscape of repetitive towers on podiums, surrounded by slightly diverse public space. Different materials and facade configurations advance a level of detail that had not been contemplated before, while green roofs and terraces seem to addressing the PUD-7 Guidelines for environmental design and energy efficiency guidelines mentioned before.

Fig 3.12 Evolution of proposals for Volpe (Goody Clancy, Cambridge CDD, various dates)



Chapter summary

As expected from such a contested development area and the continuously evolving conditions, the visions for Kendall show no rationale in their approaches to urban design and there is no comprehensive vision for the area despite the city´s effort. Instead, they follow the particular interest of the group behind in shaping Kendall – from increased development for developers to more public space in the studies commissioned by the community.

However, there are recognizable traits across a variety of proposals. The concept of “good” urban design is more related to the quality of the public space between the buildings than to the buildings themselves. This, at the same time, is associated with an understanding of small footprints and blocks that result in a permeable urban form. Unlike the initial plans for the Kendall Research Park or the completed residential projects on Third Street, with their medium density, average height, and a larger footprint, in the new development, this can only mean one thing – to go up. Indeed, both at the MIT East Gate and Volpe projects, there is a recognizable pattern over the proposals: increasingly reduced footprint to enable more public space area related to increasingly higher buildings that allocate differently the maximum development potential that corresponds to them. While scenarios aim to analyze the potential impact of the variations, there are no guidelines in assessing which solution is the most adequate from an objective point of view. It is equally remarkable that the K2C2 urban design guidelines are not reflected in any of the proposals following 2013 – architectural singularity is prime at MIT East Gate as opposed to the regularity the K2C2 guidelines suggest. As per the urban form target and indicators of Envision Cambridge, they are still too recent and undefined to have any impact in the ongoing Volpe visions.

Other studies such as the Environmental Framework or Ecodistrict Plans that could provide more information on other approaches to urban design through factors other than building bulk and public space configuration and could relate the contemporary urban design of the area to fundamental aspects such as energy grids or sustainability remain equally superficial and fail in providing any insight. The lack of detail of these proposals is logical given that they correspond to preliminary phases of design and planning. However, particularly in Kendall, the early detailed definition of any project with a particular focus in the urban design quality of it is fundamental for streamlining the development process of the contentious projects and achieve their implementation, as the following section outlines.

III /

Framing Kendall´s development

Cambridge´s regulations and the pursuit of better urban design practices

All the proposals and visions for Kendall were conditioned by Cambridge´s regulation, which has evolved as a response to the development pressures to steer the transformation of the area towards the vision of a dynamic high-density mixed-use area. The singular regulations that apply in the area´s PUD´s lead to an accumulation of zoning ordinances, overlay zones with specific features, public benefit requirements, inclusionary zoning and design and construction specifications. On top of that, Kendall´s planning process contemplates active public participation, making the decision-making and trade-off between constituents is key for the implementation of urban projects.

Regulations and the predetermination of urban design

A complex constellation of documents and content of diverse sources and with various level of enforcement define the conditions for the development of an urban design project and have long burdened the development process through a vast amount of information that is sometimes clearly delimiting, other times vaguely indicative and, more than often, contradictory. Development regulations and guidelines take the form of policies, laws, regulations, codes, standards, design guidelines and strategies, briefs, development standards, spatial master plans, and others. In these documents, a series of parameters define the conditions for urban development across scales. For example, lot occupancy, floor area ratios (FAR), offset, maximum height or offset define density and massing values in zoning and land use documents. Other additional numerical values describe diverse spatial relations and requirements, like open space requirements, program allocation or public benefits through linkage policies or incentive zoning. Through this language, regulations carve a virtual envelope for potential development that highly conditions the inception of any project (Noyman, 2015). These values are the ones employed by Modelur and Envelope to automatize the translation of zoning and building codes into norm-conforming virtual building envelopes.

By defining the possibilities of urban development, regulations arbitrate the exercise of negotiation between politics, finance and the social benefit of urban development. Adequate regulations balance the interests of stakeholders to steer adequate urban development, understanding both the relevance of all constituents and of their interests to achieve successful results.

Regulating Kendall – city strategies, market pressure and community

Given the complexity of the large-scale, long-term development of the area, Kendall does not follow one distinctive planning approach but rather an accumulating set of zoning laws, design guidelines, policies, and regulations. Unlike sites where the urban form is predetermined, in Kendall it is the result of a detailed regulatory construct merged with active stakeholder implication – a complex process that exemplifies the adaptive and participatory planning many contemporary urban design projects follow. On top of that, many regulatory amendments for rezoning proposals have emerged from new and on-going projects nearly on a project-based discussion as described in the evolution of the visions of the area, putting the public urban design discussion to the forefront. (see bibliography: planning documents).

Fig 3.9 Cambridge CityWide Planning Guidelines (Cambridge CDD)

Regulatory bodies and the development process in Cambridge

In the local planning debate, the Cambridge Community Development Department (CDD) is the local authority to steer the "shared vision for the future of Cambridge developed together with the community" by defining the citywide strategies for housing, transportation, economic opportunity, urban form, and the environment (Cambridge CDD, 2017). At the same time, the CDD put special emphasis on urban design, "which is nothing short of every aspect of how a city is put together, including the design of streets, parks and open space, and how buildings look and feel." The city's current comprehensive plan is composed of a set of documents: the Zoning Map, the Zoning Ordinance and the City's growth policy document "Towards A Sustainable Future" (Cambridge CDD, 1993M updated 2007) and a series of major area-wide planning studies that are currently applicable across the city. Zoning in Cambridge is approached as a dynamic tool that "adapts as needs and development opportunities change", with the Zoning Ordinance being accordingly adaptable (Cambridge CDD, 2017).

The CDD is responsible for the ordinances and administers the Cambridge Planning Board, which, in turn, reviews plans and proposals under the Special Permit provisions of the Zoning Ordinance and makes recommendations to the City Council on proposed projects. As a condition of Special Permits, most projects in Kendall are subject to design review, which in Cambridge is carried out by a mixed professional and non- professional board of community members and planners. As such, achieving the approval of design review can result in a highly political, biased and subjective process, particularly in NIMBY (Not-In-My-Backyard) communities that tend to oppose development. In the case of Kendall, broad community opposition to development has evolved to become active on the definition of the unstoppable development to achieve the highest possible benefits from the development, understanding the benefits of collaboration instead of opposition [8].

Fig 3.11 – Special Permit Map (Cambridge GIS, 2019)

The singularity of Planned Unit Developments

The Cambridge Zoning Ordinance contemplates a particular regulatory complexity for the Kendall Square Area, where Overlay districts overlap to the Base Maps, numerous Zoning Amendments have been approved, and diverse Design Guidelines and Area Plans apply. The subdivision of Kendall into Planned Unit Developments (PUDs) intends to promote the opportunity for the construction of quality developments on large tracts of land by providing flexible guidelines which allow the integration a variety of land uses and densities in one development (Art.12). The PUDs house special zoning districts such as the Mixed-Use Residential (MXR) Overlay District in the MIT East Gate Main Street front (in Art. 13). Kendall is also home to singular development regulations in the development-conservative Cambridge: through Transfer of Development Rights (TDR) buildable floor area can be transferred from one lot to another to, amongst others, "(iii) facilitate the implementation of urban design" (Art.21). Additionally, other specifications include spatial and program requirements such as Art Innovation Space, Lot Density Limitation, Middle Income Housing Requirement, Affordable Housing Requirement, Active Ground Floors, District Public Open Space Requirement, Pedestrian ways, and Parking space (Art. 14).

[8] Int 9 David Clem, Founder Lyme Properties. 02/22/2019

Better urban design practices and development incentives

Hence, incentive zoning establishes a direct relationship between an increased development allowance and diverse features that result in public benefit through better urban design. For example, the maximum allowable height may be increased to one hundred and ten feet upon permission of the Planning Board if a development provides substantial public benefits through elements such as public space (walkways, malls, arcades), family- and mixed community-oriented design goals or amenities that add public value. (Art. 13, Appendix B)

Projects applying for a special permit, that is, again, the majority in Kendall, are also linked to better practices in urban design. They need to comply with criteria such as responding to existing or anticipated pattern of development, being pedestrian and bicycle-friendly, mitigating adverse environmental impacts upon its neighbor or reinforcing and enhancing complex urban aspects of Cambridge such as open space amenities. (Art.4 Use Regulations, Appendix B). Other aspects like shadow casting, visual, traffic and parking impact apply, too.

Parameters for equity – incentive zoning for inclusionary housing

The housing policy of Cambridge plays a fundamental role in shaping the projects in Kendall through the Incentive Zoning Ordinance, which requires a housing contribution to the Affordable Housing Trust for large (+30,000 sq ft) non-residential developments to mitigate their impact on the need for affordable housing in the city (Art.14). At the same time, 20% of the residential floor area of new residential developments or buildings converted to residential use (10+ new housing units or + 10,000 sq ft) have to be devoted to affordable units as per the Inclusionary Housing Program. In exchange, developers may be eligible for a density bonus of up to 30% of the floor area and unit count allowed by the base zoning district. In the Kendall projects, incentive zoning only applies to Volpe, where on top student led protests have demanded more graduate housing to MITIMCO, Volpe´s developer, considering that the amount of housing in the MIT East Gate Project is insufficient (Hudson, 2017).

Regulating building design for sustainability

The Green Building Requirement, which promotes environmentally sustainable and energy-efficient design and development practices in new construction and renovation projects, imposes the most rigorous technical specifications on the development in Kendall, where buildings over 50,000 square feet need to conform to the highly demanding LEED Silver standard (Art. 22). The requirement makes the integration of energy efficiency performance in the early stages of the planning and design process mandatory, as it requires a LEED-conforming conceptual design in order to apply for building and special permits.

Chapter summary

Cambridge´s regulations require and incentivize in the early stages of any project the detailed definition of urban design through very different qualitative and quantitative parameters, from site planning and related environmental performance to the allocation of uses and public benefits. At the same time, the regulation also establishes a strong relationship between various good urban design practices and the benefits developers can obtain through increased development. These incentives reflect themselves in the visions for Kendall that put an increased value in urban design and employ diverse methods to relate proposed developments to better design practices. However, they remain undetailed and un-scientific despite the potential to do so and, potentially, obtain even higher development bonus or streamline the public phases of review and approval. A high level of definition seems rather unwelcome. However, all the proposals in Kendall remain a two-sided process where one-side, developers and design teams, envisions while the other side, the public and the city, judge and overview. On the verges of Kendall, research groups would develop advanced computational tools to reverse this and use Kendall as testing for collaborative processes for better urban planning and design.

4

Towards collaborative urban design tools

The development of tangible computing tools and their use in Kendall

The complexity of the development of Kendall not only led to an amalgam of different proposals for its many sites, but also made it particularly attractive for research groups at MIT exploring new approaches to urban design through interactive scenario modeling as a way of advancing planning tools for direct engagement and public input through co-design.

I /An introduction to tangible computing tools – the Tangible User Interface

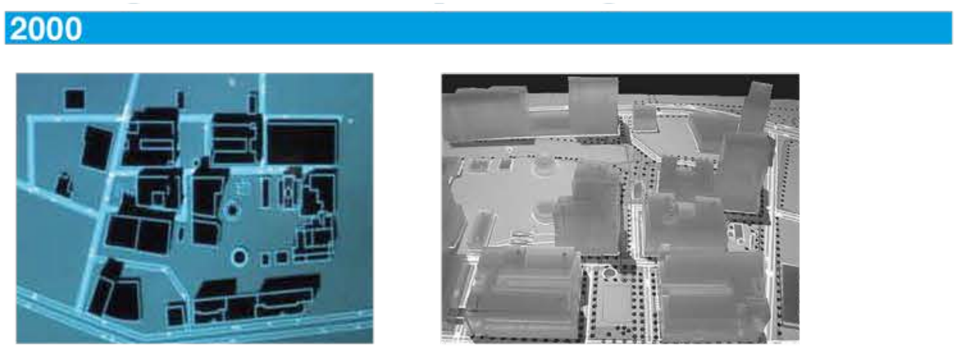
The Kendall Square Research Park was the first attempt of the Changing Places Group at MIT´s Media Lab to develop research on Graphical User Interfaces (GUIs) as a path towards more interactive processes of computer interaction that led to the development of Tangible User Interfaces (TUIs). The philosophy behind TUIs was to allow people to interact with computers via familiar tangible objects, therefore taking advantage of the richness of the tactile world combined with the power of numerical simulations – this leads to the denomination tangible computing through the capacity of the tools for integrating physical models and interactive technologies.

> *"Multi-layered manipulative platforms that integrate digital and physical representations will have a significant impact on urban design and planning processes in the future. The usefulness of these platforms will be in their ability to combine and update digital and tangible data in seamless ways to enhance the design process of the professional and the communication process with the public." (Ben-Joseph et al., 2001, p. 196)*

While two experimental systems named Illuminating Clay and SandScape, with diverse applications to GIS introduced new methods for users to understand the relationship between space and data, the TUI brought this approach to spatial planning and urban form forward through the Luminous Planning Table (Ratti, Wang, Ishii, Frenchman, 2004). The prototype was composed of hanging projectors and cameras that allow a computer to analyze the positions of different physical objects with attached features. Shadows, ground wind patterns, reflective glare, view corridors or even traffic analysis would be altered according to the alteration of the physical objects. Researchers and students could explore the implications of diverse massing options in a more effective way, reducing "the spatial and temporal separation between the forms of design representation increases the cognitive load on the urban designers who is required to draw relationships between dislocated pieces of information during design sessions" (Ben-Joseph, Ishii, et al., 2002).

However, while the TUI could help knowledgeable practitioners, it still had shortcomings in its operations and representation methods, limiting its use to practitioners with technical knowledge of the tool and the represented outcome (Ben Joseph, 2000). An excessive level of abstraction of the built environment would not allow defining urban design projects in detail beyond basic massing. Yet, the TUI helped inform the modification to the building height and street configuration of the Kendall Research Park Masterplan to allow sun to the public spaces changed the original design.

Fig 4.1 The Tangible User Interface in Kendall Research Park (Ben Joseph, 2000)



II / CityScope the advances of Tangible User interfaces

The TUI and the Luminous Table set the technological precedent that, over time, would lead to the development of the CityScope project inside the CityScience Group at MIT´s Media Lab. CityScope is a thematic approach to creating urban planning experiences with augmented tangible tools that range from simulations that quantify the impact of disruptive interventions in cities to collaborative planning tools. The CityScope team aims to employ technology in the form of a tangible and digital platform for data-driven physical modeling as an urban decision-support system augmented by artificial intelligence. As such, the team argues that through the use of this technology, design decisions can be guided by evidence-based quantifiable Urban Performance Indicators and data rather than the subjectivity that often characterizes co-design processes and that the decision quality could be improved by the organic combination of the strengths of human intelligence and of machine intelligence (Zhang, Yan, 2017). The Urban Performance Indicators correspond to various social, economic, and physical attributes or metrics and are categorized under the headings of density, diversity, proximity, mobility, building energy and innovation potential, each of them defined by a series of spatial or functional parameters. CityScope falls under the umbrella of distributed participatory design through its intention to enable access to complex planning and design processes to the general public. The term “Citizen Design Science" also defines this approach as a new strategy for cities to integrate citizens' ideas and wishes in the urban planning process through data collection, practical design, and translation into the work of professionals (Mueller, Lu et al., 2018).

> *CityScope is a concept for shared, interactive computation for early-phase planning, allowing non-expert stakeholders to engage with high-level parameters that frame urban development and infrastructure scenarios. Stakeholders interact with models, allowing them to quickly and intuitively understand constraints, challenges, and possible solutions for various development scenarios. (Alonso et al., 2018, p.1)*

CityScope tools have used Kendall as a testing ground for the implementation and analysis of the technology, providing the opportunity to explore the limitations of these advanced computational tools for collaborative planning and design processes and decision-making.

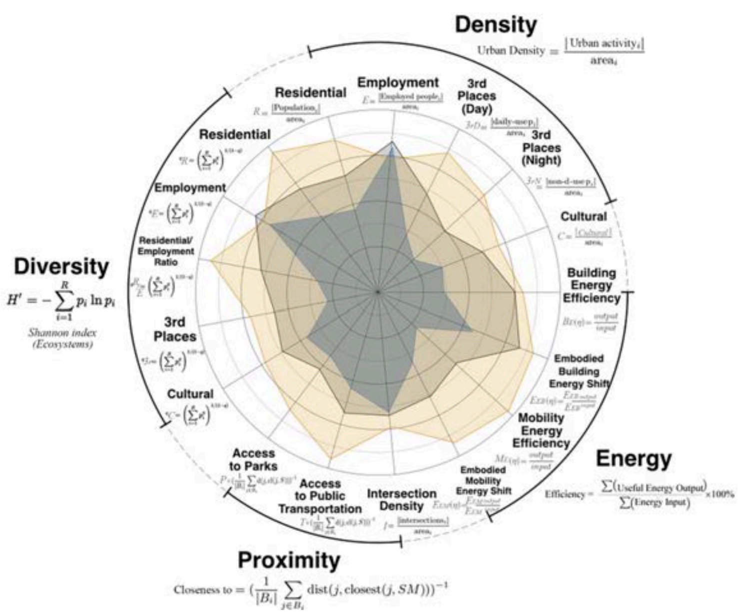
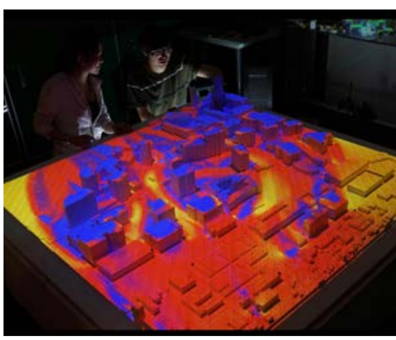


Fig 4.2 Urban Performance Indicators (Alonso et al., 2018, CityScope: A Data-Driven Interactive Simulation Tool for Urban Design. Use Case Volpe)

III / The elements of CityScope - CityMatrix, CityIO and CityModel Table

The creators describe the system through its three main components: CityMatrix, CityIO and CityModel Table. The current division in components is the result of a long term research on computing tangible models through the **Mark I Urban Data Observatory (Fig 4.3)** projects by Mo Hadhrawi, Carson Smuts and Ira Winder, Mark II CityScope Out by Josh Fabian and Ira Winder, and Mark III CityScope Reconfigure project by Josh Fabian, Grady Sain and Ira Winder.

In the current version of the CityScope project (May, 2019), the motherboard of the system is the CityMatrix, a gridded platform on which the urban design models are developed through coded blocks from the so-called Bank Module. The CityMatrix and the Bank Module are an evolution of a research project by scientist Ira Winder denominated **“System for Real-time Digital Reconstruction and 3D Projection-Mapping of Arbitrarily Many Tagged Physical Objects”** (Winder, 2015) **(Fig. 4.4)** that was further explored in the project **“Bits and Bricks Tangible Interactive Matrix for Real-time Computation and 3D Projection Mapping” (Fig. 4.5)** (Winder & Larson, 2017). This system could a) detect tagged physical objects in real time as they were moved by the user, b) perform real-time reconstruction of the configurations of these objects through form, position, ID and any metadata, c) perform real-time analysis of the objects´ configuration, and d) perform the real-time visualization of this analysis via display screens and projection mapping of visual content onto objects (Winder, 2015).



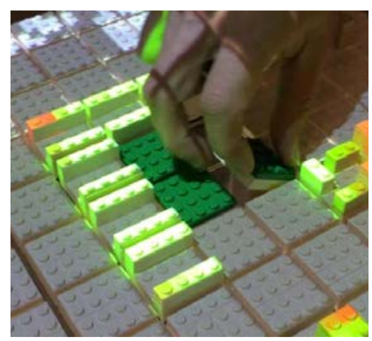
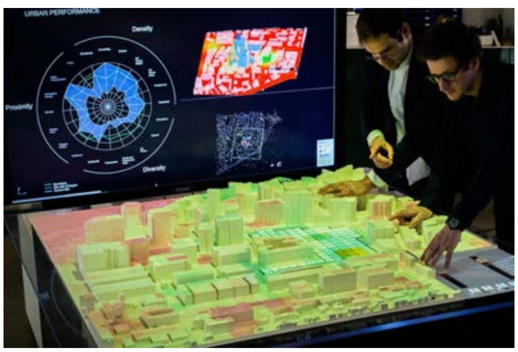


Fig 4.3 Mark 1 Urban Data Observatory in Kendall
Fig 4.4 System for Real-time Digital Reconstruction and 3D Projection-Mapping of Arbitrarily Many Tagged Physical Objects” (Winder, 2015)
Fig. 4.5 Bits and Bricks, Winder & Larson, 2017)

In the current version, the Computational Unit in CityMatrix structures an algorithm that complies zoning, code and regulations and embeds the information into the tiles or blocks that configure the Bank Module. A series of sub-algorithms analyze broader implications of the proposed design through the selected Urban Performance Indicators such as climatic and energy parameters, mobility, walkability, population density, and land use distribution. Design variations are then developed with the tiles or blocks on the City Model Table. The indicators of each of the building blocks employed result in aggregate data that is measured to reflect in real-time the impact on the built environment of the proposal. This allows to iterate options of design and find the most optimized version according to the chosen indicators (CityScience Group, 2019).

cityIO, where IO stands for input and output, is the operating system of CityScope, a cloud- and database-driven platform that allows for database augmentation and high-end complex visualization. While originally limited to the modeling in the CityMatrix as in the Bits and Bricks project (Winder & Larson, 2017) , it has evolved to become a “Cloud-Based Urban Data Platform”, a software that according to the CityScience group allows for remote participation in the process of simulating models (CityScience Group, 2019). This aims to promote an equal and decentralized discussion for multiparty stakeholders in the form of augmented and immersive reality. Thus, cityIO claims to offer municipalities, and planning authorities the ability to communicate complex planning processes better and to aggregate the public's opinion in real time.



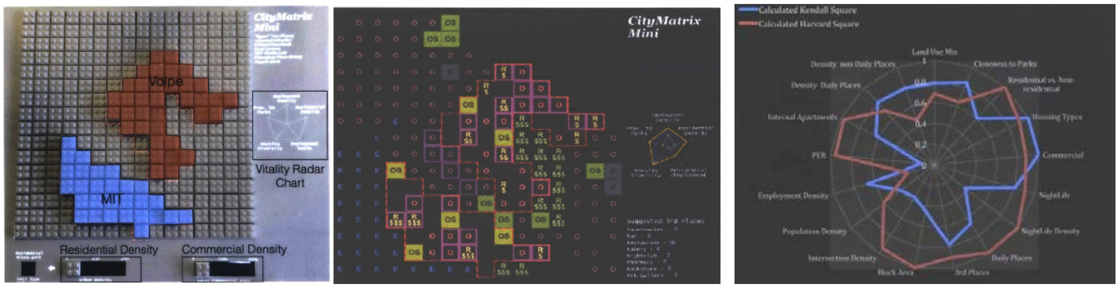
The CityModel Table itself provides the base to locate the CityMatrix in its urban context and provide the urban context for the development of the models. An adjacent screen displays the performance of the different models developed through CityMatrix.

Fig 4.6 CityScope Volpe Project with city Matrix and CityModel Table (Alonso et al., 2018)

IV / Coding urban form and life – an urban vitality evaluation tool

As outlined, the innovation in the CityScope project is its attempt to approach urban design and planning not through spatial parameters, but by establishing a correlation between urban form and urban performance. This approach, theoretically grounded in Jane Jacobs´ urban vitality indicators, results in quality of life and vibrancy through spatial planning (Gowharji, Waleed, 2016). In the case of Kendall, CityScope analyzes the potential livability of Kendall Square by contemplating land use variables such as land use mix, proximity to parks, residential-to-non-residential-ratio, housing types, or variables used as proxies to human activity (commercial, nightlife, third places). It also contemplates block size, intersections, population and employment density and relations between these variables to evaluate the urban design proposals. This approach creates a very particular frame for analysis through the use given to the technology.

Fig 4.3 Urban Vitality Tool Kendall (Gowharji, Waleed, 2016)



V / CityScope Volpe

CityScope Volpe aimed to spatially model “a world class Innovation Community” asking whether the Volpe site could accommodate the interventions required to enable a complete, high-functioning Kendall Square community or whether mathematical models could predict the innovation potential of the district. Other elements to be analyzed included health and wellness, energy consumption, accessibility or autonomous mobility in a completely different approach to the variables that determined the urban design processes for the area as exposed in the development of the site (CityScience Group, 2018).

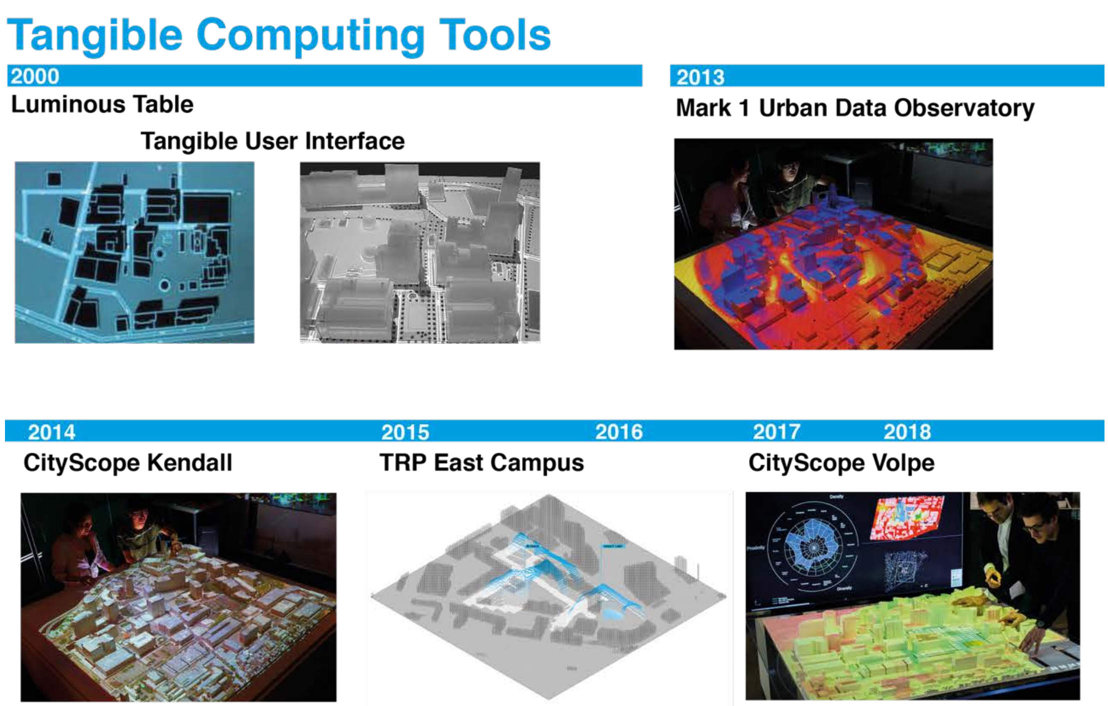
As a response to the evolving normative framework of the area and of the proposals for each of these conditions, CityScope also targeted to replace static land use regulations with algorithmic zoning that could enable the district to evolve as needed over time. In a context of large scale, long term development with changing conditions, this question seems fundamental and would be explored further in the Tangible Regulation Platform. The project also aimed to empower the community to iteratively explore alternative visions for the future of Kendall Square as a way to open a direct channel of conversation on the characteristics of the Volpe design proposals between community and developers.

Fig 4.4 CityScope Volpe City (Alonso et al., 2018, CityScope: A Data-Driven Interactive Simulation Tool for Urban Design. Use Case Volpe)

CityScope frame, the CityScope team worked on the development of an additional feature of the CityScope project that would focus on understanding the impact of regulations in the scenario approach of the CityScope projects to highlight how regulations can hinder the development of better urban design and planning, at least according to the CityScope´s principles. This feature has both been denominated Zoning Playground (Winder, Lee, Wi, 20xx?) or Tangible Regulation Platform (TRP) (Noyman, 2015). These approaches put a particular focus on how regulations affect the quality of urban scale projects and questioned the predetermined form making of cities. According to them, technology could allow to find less rigid, more flexible solutions to specific urban conditions.

> *These new technologies and devices are set to question the effects, roles and authority of regulation, guidelines, zoning and code on contemporary urbanism, as a critical aspect of information driven society. (Noyman, 2015, p.228)*

Fig 4.6 Summary – Computangible tools in Kendall (Ben Joseph, 2000; Winder, 2015 Alonso et al. 2018)



VII / The limitations of tangible computing tools in the CityScope project

The CityScope project represents a specific approach to technology for urban design and planning that frames the technology, its processes and outputs. In the following, I outline the limitations described by the team behind the CityScope tools of their particular technological approach for urban modeling and decision-making.

Limitations of physical models, scales and levels of definition

Given the possibility to evaluate existing regulations and proposals against CityScope´s benchmarks and to propose alternatives, it was surprising to learn that CityScope was mainly used to analyze the quality of stakeholder interaction processes, putting the modeling outcomes themselves aside (Alrashed, al. 2015). No analysis of spatial outcomes of the best data-driven iterations nor of their relation to existing proposals or the regulatory framework it intends to amend have been carried out. This is due to the technical limitations to inform spatial planning and design with enough granularity. Unlike digital software-based tools and their seamless zoom-in-and-out, CityScope tools such as the CityMatrix are highly limited by the 'resolution' of the table, or the density of the grid subdivision of the model. As such, a very detailed data-based approach is confronted with obvious physical limitations. While it can provide an approximation, its scale is not detailed enough to provide enough level of detail for spatial design as precise as its data-analytics can be. For example, when the block employed are pieces of the well-known game LEGO, one 4 × 4 LEGO tile represents a 26.7 × 26.7 m area in a weird 1:762 scale for a 1kmx1km area. It is also unclear how CityScope codes the preexisting conditions that surround development sites, making It dubious whether it could be applied in-fill sites as opposed to `tabula rasa´ sites.

The team argues that the abstraction provided by the model avoids high levels of detailed building-form and urban-design in order to allow users to focus on the land use and planning aspects of the urban environment (Zhang, Yan, 2017). At the same time, the processes of design with CityScope, which invert traditional methodologies hold great potential for the practitioner. For example, CityScope allows to reshape urban design by altering parameters that are non-spatial, such as diverse mobility patterns, to obtain a particular, parameter-optimized urban configuration, putting process in front of result. At the same time, its promising potential scalability to be employed in many large urban development projects is limited by its advanced, and costly, technology, which requires building a specific model for each site to be analyzed. On top of that, despite suggesting that through the opensource operating system IO any site can be analyzed, it would still require a complex process of coding every site´s regulations by an extremely specialized workforce.

Communicating and consensus-building

At the same time, the computangible tool´s principal goal of better communicating complex planning issues and facilitating consensus-building in the design and planning of complex sites is invalidated by an overly ambitious approach to incorporate many diverse aspects and types of data into only one platform. This becomes burden for the effective communication of specific results that can be assimilated by the less knowledgeable public that is meant to interact with the tool (Noyman, 2015). Indeed, Noyman points out the need to reduce the complexity of the feedback information users are confronted with as it can be counterproductive for a better understanding of certain issues. Therefore, he proposes to focus on particular aspects targeted at the specific interest of each stakeholder group, such as potential impacts of a specific designs to support amendments to regulations or examine the impact of new regulations for planning departments – something that could have found its way into the proposals, amendments and rezoning petitions in Volpe or MIT East Gate.

On top of that, CityScope provides a new model of participatory design, due to the technical complexities of its costly development only adds to the problem that participatory design is time- and cost-intensive (Mueller, J. et al., 2018). As per its “consensus-building” capacity, while it holds the potential for it, it has not been proved yet within the complex negotiations around any of the complex project in Kendall, right outside the doors of MIT´s Media Lab, and where CityScope´s approach aligns well with many of Cambridge´s regulation and quest for quality urban design.

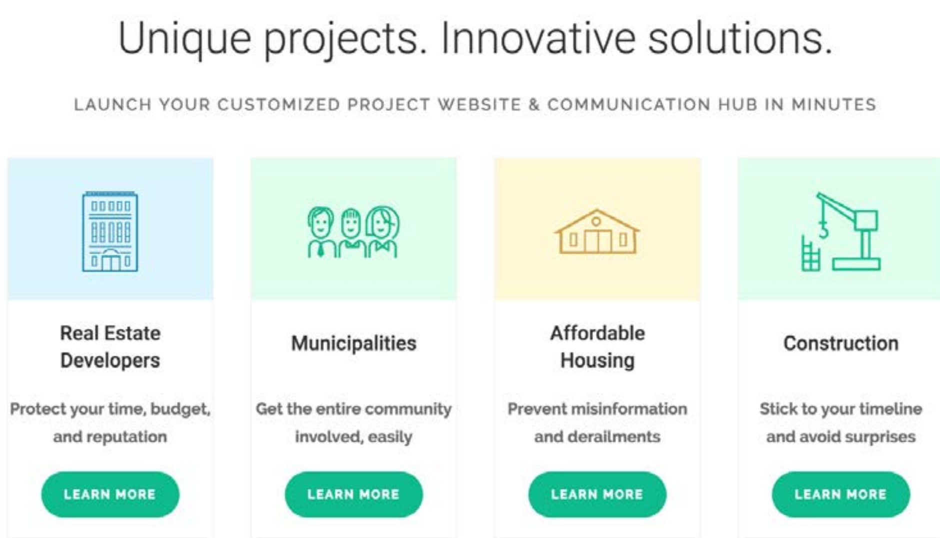
VIII /

Simplifying for impact – the case of coUrbanize

Understanding the relevance of enhancing communication channels between groups affected by development projects and real estate developers and planners in order to speed up development processes, Karin Brandt, an alumnus of MIT´s Department of Urban Studies and Planning, founded coUrbanize in 2013. CoUrbanize is an online community engagement platform for real estate developers and planners. While it aims to hep community planning processes, it seems to put a particular focus on allowing real estate developers to retain control of the development process.

*Our platform gives developers the tools to control the conversation about their projects, from conception to approval to ribbon cutting. (*coUrbanize website, April 2019)*

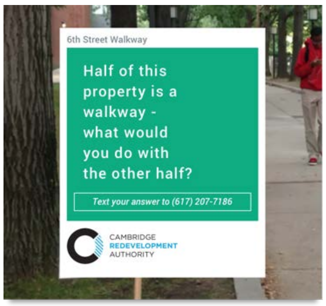
Fig 4.7 Courbanizes solutions (CoUrbanize.com, March 2019)

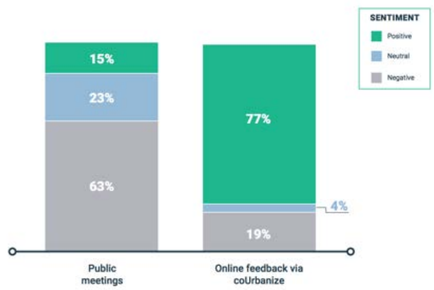


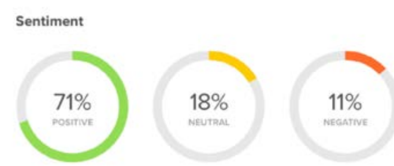
As opposed to advanced digital design and planning tools, coUrbanize operates as a portal where project proposals and their updates are displayed, allowing registered community members to share concerns and complaints independently from scheduled public hearings in a two-sided interaction with developers. Many community members cannot attend these due to various reasons – the main one being the rigid scheduling of in-person meetings as opposed to the universal accessibility of a website. As claimed by its website, coUrbanize has an excellent track record in improving the development process through faster and less problematic approval and avoiding costly hurdles and delays through community opposition, particularly from "hijackers," individuals who falsely pretend to represent a whole community. As the main feature, Brandt affirms that the platform "helps developers be a little more like planners"[9] and focus on the relevance of community outreach and engagement.

Fig 4.8 Collecting feedback through SMS (CoUrbanize.com, March 2019)

Fig 4.9, 4.10 Measures of public feedback to development through "sentiment" (CoUrbanize, 2019)







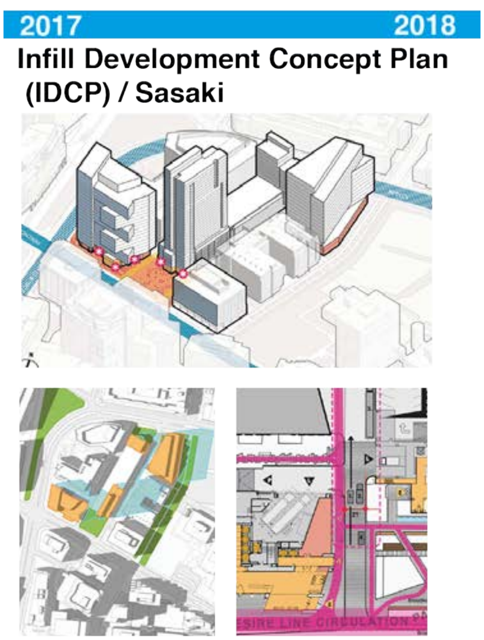
coUrbanize also intends to bring "transparency early on in the process and disseminate facts," as underlined by Michael Cantalupa, ex CEO of Boston Properties, one of the largest developers in the Kendall area. The facts chosen mainly emphasize the public benefits of the development, such as the amount of affordable and middle income housing or the grad housing numbers. The issues that interest the community – and that, required by law, are not a concession of developers to the public.. At the same time, coUrbanize tracks public participation to showcase positive engagement through percentages in a more quantitative than qualitative approach – more participation is not better participation. CoUrbanize argues that it does not intend to substitute traditional engagement, but to amplify it. However, others argue that more open access to information is not a synonym for transparency and that technological means cannot substitute traditional participation (Raford, 2011).

Fig 4.11 CoUrbanize in Kendall (CoUrbanize.com, March 2019)

[9] Int 12 Karin Brandt, Founder coUrbanize. 03/04/2019

Boston Properties employed coUrbanize during the redevelopment of the Golden Triangle, which still held potential for development under the new height allowance following the 2013 K2C2 Guidelines. The 2015 Kendall Square Redevelopment Plan led to the densification of the Triangle through the residential 200,000 sq ft Protos High Rise, completed in 2018, and foresees a new Google Headquarters on the site of one of the little public spaces the Center had for decades: its rooftop garden. Further north, coUrbanize is also part of the conversations around the 2016 Infill Development Concept Plan (IDCP) was crafted to increase development in what long had been parking or low office structures in the PUD MXD (Sasaki and VHB, 2016 and 2017). The IDCP study shows a high level of detail of the conditions leading to the proposal, with building massing conforming to the K2C2 guidelines, detailed analysis of environmental impacts of the proposal such as shadows or thermal comfort, as well as studies for the distribution of retail and pedestrian flows across the site. MITIMCO also used coUrbanize for public feedback for the MIT East Gate Project.

Fig 4.11 IDCP Plan (Sasaki, 2017)



However, beyond the proven benefits of the two-sided interaction for both groups, East Cambridge residents are well aware of the explicit intention of coUrbanize to serve developers, leading to a certain level of distrust on the platform. Peter Crawley, an East Cambridge Resident in the Volpe Working Group ([Int 13,] 03/08/2019) with yearlong experience in assessing the impact of development scenarios, underlines that bringing the main forums of communication online reduces the quality of the interactions and the involvement of citizens in the planning process to pure statistics.

Chapter summary

CoUrbanize brings a two-sided communication channel that seems be effective in enhancing some development. However, while it can also serve collaborative processes of design and planning, the main focus seems to be to balance in favor of development once projects have been defined and proposals face public scrutiny. Here, simple is better.

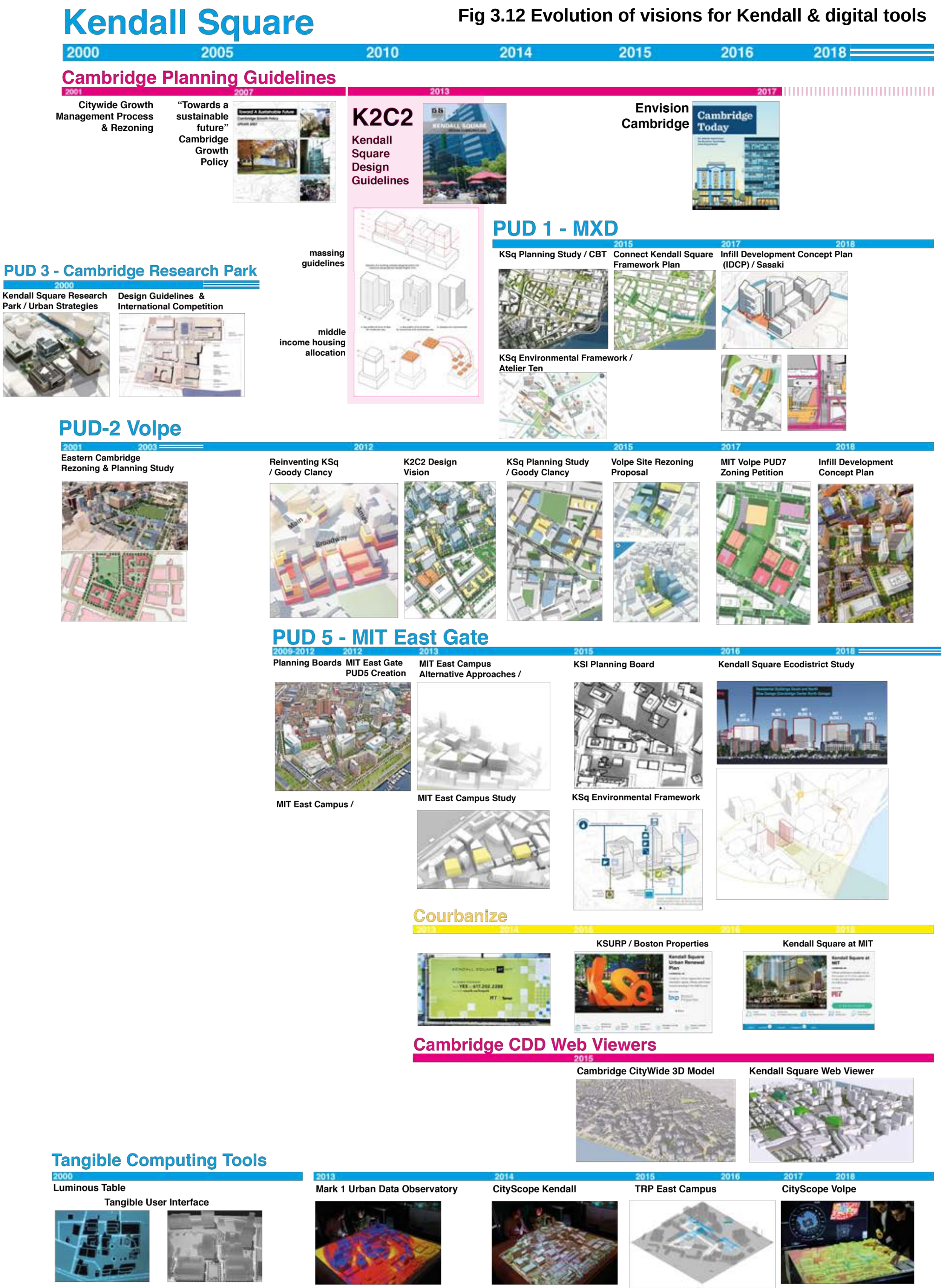


Fig 3.12 Evolution of visions for Kendall & digital tools

5

Analysis

Learning from the evolution of tools, Kendall & theory

Beyond plans and tools

Interviews with stakeholders in Kendall Square

Interviews with diverse stakeholders in the design, planning and development of Kendall have helped understand the strategies behind the different proposals, the factors that guide decision-making for different actors and their relation to the use of computational tools in the area, as creators, users or involved public. From designers, researchers, and developers to city planning officials and community members, these semi-structured interviews have helped establish a link between development processes, regulations and the pros and cons that digital and computational tools can play in this context to steer more collaborative design and planning processes and the implementation of better urban design practices. As, interviews relate both to past and present use of digital and computational tools as well as speculations on their future use. The Cambridge CDD testimonials helped understand how digital modeling tools can help the planning agencies achieve its policies for urban design, steering the planning debate and guiding development. Interviews with designers, developers and consultants clarified how the use of advanced digital modeling tools can enhance the design and development process and influence the opportunity space in shaping urban design established by regulations. Conversations with researchers devoted to the development of the computangible tools helps gain an understanding of the limitations they found in the tools and the paths for improvement towards the future. Lastly, together with the interviews to community members involved in urban design projects I was able to understand how digital tools can enhance or obstruct decision-making and consensus-building in urban design projects for enhanced development and the implementation of better practices. The following section includes information and analysis based on interviews with various professionals and stakeholders in Kendall Square:

> [Int1] Ben Carlson, Director of Urban Design , Goody Clancy. 02/13/2019
> [nt 2] Jeff Amero, GIS Manager Cambridge CDD. 02/13/2019
> [Int 3] Michael Trocmé, Principal, Urban Strategies Design and Planning. 02/14/2019
> [Int 4] Pamela Delphenich, Former Executive Director, MIT Campus Planning. 02/14/2019
> [Int 5] Cliff Cook, Senior Planning Information Manager Cambridge CDD. 02/14/2019
> [Int 6] Ken Goulding, Director, Sasaki Strategies. 02/21/2019
> [Int 7] Suzannah Bigolin, Urban Design Project Planner, Cambridge CDD. 02/14/2019
> [Int 8] Ariel Noyman, Research Scientist, MIT City Science Group. 02/19/2019
> [Int 9] David Clem, Founder, Lyme Properties. 02/22/2019
> [Int 10] Alex Stokes, Consultant, HR&Advisors. 02/22/2019

Int 11 Thomas J. Andrews, co-President, Alexandria Properties. 02/22/2019

Int 12 Karin Brandt, Founder CoUrbanize. 03/04/2019

Int 13 Peter Crawley, East Cambridge resident and member of Volpe Working Group. 03/08/2019

Int 14 Tom Evans, Executive Director, Cambridge Redevelopment Authority. 03/18/2019

Int 15 Michael Owu, Director, Real Estate, MIT Investment Management Company. 03/19/2019

Analysis

Pros and cons of digital tools in the design and development process

As presented in previous chapters, contemporary digital design and planning tools allow for the development of very detailed comprehensive scenarios that could lead to the implementation of better practices of urban design. However, despite technological advances in information management, scenario development, or interactive technologies, several factors condition the tools´ effective impact in the processes of development that can lead to the implementation of these practices. Building upon theory, the analysis of the evolving proposals for the diverse projects of Kendall, and the processes and the people behind them, from planners, designers, and developers, to community members and consultants, I establish three categories to analyze the pros and cons of advanced digital tools: the tools methods and their operations; their relation to stakeholder interests and development regulations; and their potential for interaction and collaboration. After each section, I provide key outcomes that categorize of influence of tools as positive, unclear, or negative. While, again, these results may only apply to similar conditions to those in Kendall, it is likely that they are also valid for many other contexts where computational tools are employed.

I

The tools and their use

Streamlining design and development

Urban design tools increasingly merge the site analysis and program development phase with the schematic and conceptual design phases through the data-based evaluation of the site´s attributes; the development of iterative scenarios that test how use allocation affects the site using rough footprints; and the evaluation of impacts. The optimization of given parameters leads rapidly to the technically most adequate design solution to a specific condition according to those parameters, streamlining a process of accumulation of information and analysis that tended to be extremely cumbersome for the planning and design practitioner (Wallis, 2012). Given the increased amount of information practitioners need to deal with in increasingly complex urban projects, data-driven and / or performance-driven scenario tools provide a very necessary instrument. But beyond planners and practitioners, these tools are also becoming increasingly relevant for the compliance to green building requirements like LEED as their conditions expand beyond individual buildings themselves to the public space or the impacts of large-scale development (Wong, 2013). As in the case of Kendall, providing proof of impact of development is related to a speedier approval and entitlement process. This reduces the economic risk of development operations and thereby also process costs in favor of developers or contractors and which guides the developer´s decision-making and strategy (Geltner et al., 2013).

The complexity of the tools and the adoption gap

However, this level of detail also entails complexity in the use of the tools and their operations that requires of highly skilled workforce. In cities that aim to employ these tools for better planning, this creates a dependency on a trained workforce that most public bodies or planning and design firms do not dispose of. The consequence is a need to outsource work that can reduce the capacity of city agencies to control the process of planning, obstructing workflows instead of enhancing them, as in the case of the City of Cambridge 3D model. Planners are losing their agency as departments become fragmented and complex technology requires new skill sets like data science, as underlined by Cliff Cook from Cambridge´s CDD [10]. At the same time, there is a minimal

[10] Int 5 Cliff Cook, 02/14/2019

understanding of how any of these advanced scenario planning tools relate to the local regulation, which is per se already challenging to visualize. With technology continuing to advance new tools for planning and design at an increasing pace, this disconnect will likely increase. The complexity of the tools could render them meaningless for the decision-making of practitioners and as such hinder their guidance of development processes towards better practices beyond ideal visions.

Input and output – conditioning the process

The operations of advanced digital tools can restrict the freedom of the design and planning of the urban scale by building their computational processes on given input information (i.e., land use, zoning, and associated values) that is adapted to computation through quantification and standardization. Similarly to the determination of the potential envelope for development by regulations, the possible outputs of any operation are highly predetermined by the input information (Noyman, 2015). This is the more so in tools that employ preset libraries such as UrbanFootprint.

At the same time, developing scenarios through overlapping different layers of detailed information of different nature in order to obtain an optimized solution reduces the number of possible solutions that satisfy all cumulative indicators. This can be particularly restrictive in the urban form. As in UI´s Ideal Block, the combination of outdoor thermal comfort of public space linked to the building massing and shadowing together with an energy- efficient configuration of the building itself provides only limited possible outcomes. In the spring of 2018 the class "Modeling Urban Energy Flows for Sustainable Cities and Neighbourhoods" employed diverse performance-driven parametric modeling at the urban scale, in particular UMI (Urban Modeling Interface), introduced in chapter two. The process of design and planning became a trade-off between variables in the quest of finding the solution that better satisfied all indicators for an urban design project in San Juan, Puerto Rico. This resulted in technically adequate solutions according to sustainability indicators, but ignored fundamental values of a human-centered planning and design. If one of the variables has a more prescriptive character, such as sustainability performance for LEED regulation, this will lead to favoring one particular variable to the detriment of others.

The goal to reach a series of established benchmarks puts the emphasis on the ends rather than the means, affecting the quality of the design and planning process (Foliente, 2000). Given the complexity of design at the urban scale, which needs to be able to adapt to continuous changes in its long development frame, excessively detailing projects from the initial phases can be counterproductive. Other tools like CityScope that put the value on the process risk not leading to a tangible and useful solution (Alonso et al., 2018).

> *Modern building is now so universally conditioned by optimized technology that the possibility of creating significant urban form has become extremely limited. The restrictions jointly imposed by automotive distribution and the volatile play of land speculation serve to limit the scope of urban design to such a degree that any intervention tends to be reduced either to the manipulation of elements predetermined by the imperatives of production, or to a kind of superficial masking which modern development requires for the facilitation of marketing and the maintenance of social control. (Frampton, 1980, in Banerjee et al., 2011)*

Questioning the input information - perpetuating inadequate standards

As mentioned, most of the advanced digital tools of today employ set libraries for modeling or employ adopted universal parameters that ignore site-specific conditions, such as UrbanFootprint. As such, incomplete input information can perpetuate inadequate practices if the input information reflects information that does not necessarily align with better planning and design practices for the specific location that they are being used on. Information ranges from specifications of local regulations such as zoning requirements or details like parking standards to the variables that aim to quantify aspects like accessibility or vitality through ratios or algorithms. Input parameters corresponding to diverse scales of design and planning greatly affect the final outcome as scenario tools allow interrelating scales. This affects the possibility of achieving innovation in the form of alternative development proposals (Ben Joseph, 2005). As opposed to the automatization of the process, a critical approach by a practitioner already overburdened with technological complexity and excess of information becomes more relevant.

Thus, questioning the data and processes many of these tools operate on is also fundamental. Performance-driven simulations to support certain features of spatial design, such as sustainability features or energy efficiency, are based on scientific methods relating to building technology or other fields (Reinhart, 2013). However, other values-based parameters that aim to measure qualitative aspects of certain proposals rely on a series of assumptions, from translating Jane Jacobs´ theory for urban vitality to the features of certain cities for urban quality (Gowhari, 2016; Wilson, et al. 2019). Their translation into indicators through algorithms conveys objectivity despite their highly subjective values.

Life follows form?

In a still experimental and evolving field, the validity of many non-spatial factors that affect the urban environment is still to be proven. This is not only the case of value-based parameters, but also of different scientific methods that are used to analyze how urban form impacts the environment remain under question. For example, to measure public space microclimates, there is an ongoing discussion on whether skylight factor is a better indicator than the outdoor thermal comfort trying to provide a better approximation to the environmental quality of public space (Reinhart, et al., 2013). At the same time, while at the building level many elements of design can be defined in detail, there is a risk of idealizing the possibilities of urban design to control non-spatial factors such as urban microclimate or wind [11].

The possibility of measuring and predicting urban patterns such as traffic and pedestrian flows or human activity through new sources of data is one of the assets and computational tools capitalize on as a way to unveil new patterns that can guide better planning and design decisions[11]. There is an idealization of the how urban form or the allocation of uses can impact urban life towards the desired "livability", and computational l tools only empower these predictions (Sevtsuk, 2012; Alonso, 2018). Methods such as the analysis of the urban form, the relations between its features and the allocation of uses have long been employed to understand how a certain urban form can favor more accessibility and permeability of the built environment, which is fundamental for a more connected urban space and an enhanced urban experience (Sevtsuk, 2012). For that reason, Cambridge´s regulations put an accent on smaller blocks and a qualitative and connected pedestrian real for any development in Kendall (Annex B, Art 13). CityScope also employs spatial metrics as block size and density of intersections to analyze urban vitality (Gowharji, 2016).

However, Tom Evans, director of the CRA and responsible for supervising some of the latest projects in the Kendall area, argues that data-driven modeling aimed at also coding livability and other intangible aspects of urban environments ignores that it is "the most unpredictable, the non-codable, what creates some of the aspects that make particular urban environments more attractive. In an analogy to music, we have not got computers to make songs that we would like," and it is equally difficult that computers can plan the cities we want." [12]

[11] Int 6 Ken Goulding, 02/21/2019
[12] Int 14 Tom Evans, 03/18/2019

I. The tools and their use: Key outcomes

+ Advanced tools for design and planning promise enhanced planned, design and development processes. By easing the path to fulfilling regulations and requirements, they help to the implementation of better practices.

/ Tools allow to better understand urban patterns and the impact of development projects in non-tangible aspects of urban life, helping develop better urban design solutions that enhance urban living – although success is not guaranteed.

- However, the complexity of their operations, the lack of knowledgeable practitioners and their operations mostly based on preset parameters can negatively influence the design and planning process and reduce the practitioner´s agency to find adequate solutions despite the potential to develop detailed comprehensive scenarios.

II

Computational tools, development regulations and stakeholder interests

The counterproductive effects of excessive information

The regulation of the urban scale navigates the undefined space between the zoning regulations and the building code that creates an "opportunity space" for the involved stakeholders. Even in Kendall, under Cambridge´s detailed regulation, the regulations and guidelines for urban design remain relatively vague. While some have prescriptive character and others are more informative guidelines, fundamental phases of development such as the approval of Special Permits follow these non-normative criteria. On top of that, when ordinances such as Mixed-Use Districts or Overlay Zones overlap, different readings are possible. In this context, the use of digital tools that excessively define urban projects early in the design and planning process is not particularly favorable for the involved stakeholders. Planning agencies want to keep their agency in negotiating the final outcome of development (Int 5 Cliff Cook) and developers who do not want potential additional restrictions in their already limited margin of action (Int 11 Thomas J. Andrews, co-President of Alexandria Properties. 02/22/2019). This results in a purposeful pursuit of ambiguity in the early definition of urban design projects in order not to reduce the "opportunity space".

This intentional ambiguity responds to a need for flexibility to address legal requirements and demands from multiple stakeholders (Banerjee, 2011). Notably, an excessive definition can be counterproductive when petitioning for zoning variances such additional height or density or other alterations to regulations. While simulations and scenarios are fundamental to provide proof of positive impact, they can equally provide contrary evidence and release excessive information to a public that often wrongly understands proposal. This often results in community opposition to development [13]. The level of definition of urban design proposals is fundamental not to restrict the opportunity space. The vague definition of many design proposals for Kendall supports this idea. Consequently, documents aimed at the public like the K2C2 Guidelines employ techniques that pursue a certain indefinition such as false hand drawing or watercolours – surprising when the teams behind them actively employ digital tools for modeling in detail the same complex spaces [14].

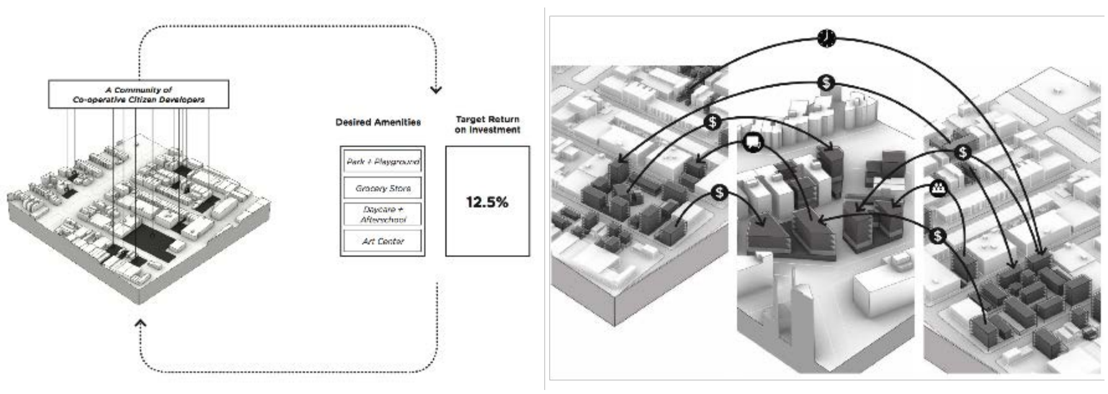
Tools such as Tangible Regulation Platform introduces possibilities to rethinking regulations and establishing more flexible approaches to development that could streamline site-based rezoning or special permits. However, such an approach can question the power of planning agencies to establish the conditions to development and the "opportunity space" for all players. In the end, every project can achieve the alteration of the regulations that apply through petitions and amendments[15]. This requires a much stronger understanding by a city of the technology through trained workforce as well as the development of new legal foundations. As a result, the City of Cambridge purposely limits itself in zoning tools and of informative guidelines[16]. Thus, advanced detailed modeling may not be particularly welcome by many stakeholders in urban design as it restricts the "opportunity space" and is unfavorable for them.

[13] Int 11 Thomas J. Andrews, co-President of Alexandria Properties. 02/22/2019
[14] Int1 Ben Carlson, Director of Urban Design, Goody Clancy. 02/13/2019
[15] Int 5 Cliff Cook, 02/14/2019
[16] Int 7 Suzannah Bigolin, 02/14/2019

Coupling finance and design

While scenario and performance-driven computational tools include increasingly sophisticated parameters, they do not conventionally consider the economic cost or savings associated with the design performance strategy in question. Unsurprisingly, finance is a main guiding factor for developer decision-making. Specifically, this is borne out through employing long term financial modeling to make assumptions for return on investments (ROI) of costly development operations (Geltner et al., 2013). As such, its incorporation into scenario modeling tools, while technically complex, could help to introduce financial variables in the trade-off process between parameters. Indeed, it is precisely during the early stages of a project that the measures can add the greatest value with minimal additional cost, which in turn could lead to better practices (Fink, Turan, 2017). However, the many locally specific regulations that target the economic aspects of development, such as the incentive zoning for inclusionary housing, make it extremely difficult to effectively introduce the financial factor into modeling. Even MITIMCO despite its in-house expertise had to seek advice from consulting firm HR&A to navigate the extensive set of requirements of the neighboring Volpe site to achieve the financially optimal allocation of mixed-income housing – with housing being the main hurdle on the path to public approval[17].

Fig, 5.2 Linking Design to Finance (Fink, 2017)



II Computational tools, development regulations and stakeholder interests

Key outcomes

- The capacity of digital tools to develop detailed models and scenarios early in the process of urban development is often not favorable for diverse stakeholders. An excess of

[17] Int 10 Alex Stokes, Consultant HR&Advisors. 02/22/2019

> information on the many diverse features of a development proposal early in the development process reduces the opportunity space and negotiation potential.
>
> / While introducing more detailed financial factors in scenario modeling could help better decision-making and empower introducing more public benefits in urban design, either through space (open spaces, urban form) or through programming (affordable housing, facilities), this has not been proven yet.

III

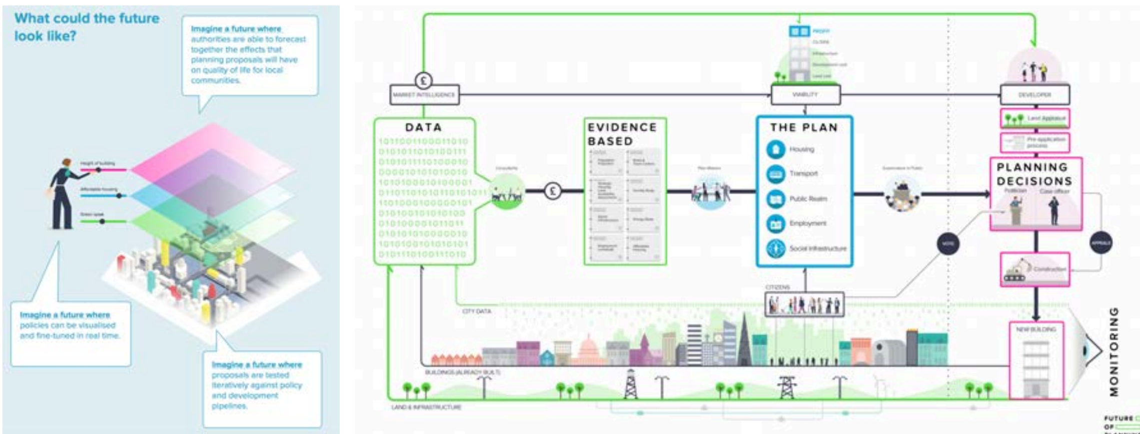
Enhancing or diminishing communication, interaction and collaboration?

Will digital tools and ICT erase disciplinary boundaries, or increase them? How can accuracy, truth, and legitimacy of data and information be guaranteed? Will the sheer free-flowing volume of information and data create an information overload that will overwhelm planning processes, thus preventing decision-making? (Ben-Joseph, 2011, City design in the age of digital ubiquity, p.272)

One of the main goals of many of the digital tools explored in this thesis is to enhance the understanding of complex planning and design to the public in order to achieve meaningful collaborative processes that result in the implementation of better practices (Wilson, Luc, et al., 2019). Indeed, tools market themselves as tools to convince the general public "through the power of data", as UrbanFootprint accentuates on its website. However, the reality is that this understanding is still very limited despite the many efforts to overcome the different barriers to communication. As noted on the limitations of the CityScope platform, the complexity in the decision-making process often overlaps with a poor understanding of information and the interdependencies between decision scenarios in planning processes where stakeholders from different backgrounds and with varying levels of expertise and domain knowledge are involved. The lack of adequate knowledge can result in a restrictive approach to development by communities, and inclusive participation risks not resulting in productive input (Noyman, 2015).

Without adequate education about both the process and the decision-making criteria, the public process can become meaningless (Mueller et al., 2018).

Fig. 5.3 Enhancing collaborative design and planning (CatapultCities, 2018)



Aware of the disadvantages of approaching communities with the information they cannot fully understand, many developers and their design teams pursue the strategy of reducing any complexity or an excessive level of detail by presenting documents, images and models that are easy to understand and do non revelatory. This not only reduces potential “opportunity space”, but also places the value on facilitating the discussion of the attributes of a development proposal in a manner which people can understand. Portraying the qualities of proposals in a public-friendly and familiar way, with a certain "open-ended" feeling can help build trust in the community – and lead to less conflictive public phases of development [18]. As Michael Owu from MITIMCO points out, "complexity is pointless if its content is meaningless to other stakeholders”. He underlines that advances in virtual reality can facilitate an immersive experience for outreach to communities, "bringing it down to what people see as they experience the street" instead of confronting them with models they may have difficulty understanding [19].

III Enhancing communication and collaboration: Key outcomes

> / While digital tools aimed at facilitating communication can lead to more interactive and collaborative processes, their capacity to lead to effective outcomes remain under question.

[18] Int 1 Ben Carlson, Director of Urban Design, Goody Clancy. 02/13/2019
Int 14 Tom Evans, Executive Director of Cambridge Redevelopment Authority 03/18/2019
[19] Int 15 Michael Owu, Director, Real Estate, MIT Investment Management Company. 03/19/2019

/ Making the data-driven or scenario-based planning tools really useful to inform the planning debate and help the implementation of better urban design and planning practices requires additional work from practitioners or planners to avoid excessive complexity that cannot be understood by the non-knowledgeable public.

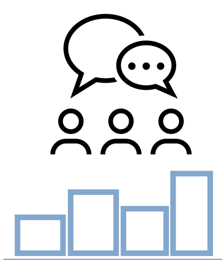
6

Conclusion

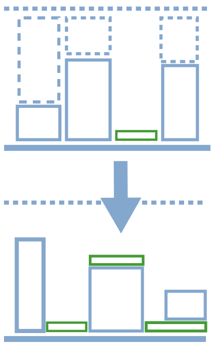
Learning from models, learning from reality

The analysis of this research displays how the outcomes of this thesis are not unilateral – while the use of digital tools can enhance urban design, planning or development processes, there are also many factors that affect their potential for doing so. In the Digital Age, it is very likely that these diverse tools will become widely employed by planners and practitioners and increase their capacity to inform urban design, planning or development by introducing new methods, measurement variables and indicators towards "better" urban design and planning. This will probably entail additional complexity in their operations and in their results, while probably leading to an increased automatization of the process of modeling and information management. This process of automatization will probably make it easier to translate local regulations into the tools and result in a scenario modeling that can really guide the decision-making of practitioners. However, despite technological advances, the current limitations of the tools to become more interactive and collaborative to facilitate better negotiation and consensus building will probably remain. Advances in CityIO that aim to free the CityScope project from its current limitations as a costly, fixed, site-specific model towards a web-based immersive experience provide a path to employ additional technology to facilitate communication and understanding.

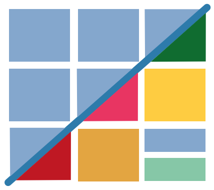
Given the multisided findings of this research, it is difficult to provide recommendations or next steps for a future where computational urban design tools can lead to the implementation of better. However, some affirmations or more speculative points can be made:



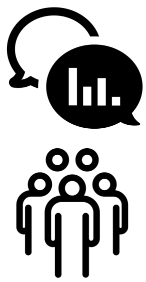
I / Planning agencies will most likely invest more into the adoption of technology for urban planning and design processes, including digital modeling tools for urban design, as a way to steer and retain control of the planning and design debate. A more knowledgeable workforce will help tackle the problem of fragmentation of planning agencies that results in their loss of agency to drive the design and planning process.



II / Planning agencies need to facilitate access to a more visual way of communicating regulations and their implications in urban design. This will help visualize the opportunity space and lead to more transparency that can enhance consensus-building. A clear relationship between existing conditions, regulations, and development potential or restrictions can contribute to address the limitations of regulations for supporting better



urban design. Digital modeling tools play a fundamental role in rethinking traditional regulatory instruments such as zoning towards more dynamic and adaptive regulations that can foster the development of high-density mixed-used cities with all the benefits this implies.



III / Planning agencies need to rethink the way processes like design review are carried out. The use of advanced models in initial stages of project inception can be beneficial to provide feedback earlier in the process by facilitating trade-off and consensus-building. This can help implement better practices by better balancing the interests of all involved stakeholders and lead to faster development that incorporates better practices.

These are only some speculative recommendations, but they accentuate that the transition into a Digital Age of design and planning will mainly require an effort to public agencies and practitioners to control and steer urban design and development. Hence, that the role of practitioners as mediators between technological and on-the-ground process will only increase. In the face of advanced technologies and automatization of processes, traditional tools and critical approaches may gain increased relevance.

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Appendix

Interviews, bibliography

I. Interviews

[Int1] Ben Carlson, Director of Urban Design , Goody Clancy. 02/13/2019

[Int 2] Jeff Amero, GIS Manager Cambridge CDD. 02/13/2019

[Int 3] Michael Trocmé, Principal, Urban Strategies Design and Planning. 02/14/2019

[Int 4] Pamela Delphenich, Former Executive Director, MIT Campus Planning. 02/14/2019

[Int 5] Cliff Cook, Senior Planning Information Manager Cambridge CDD. 02/14/2019

[Int 6] Ken Goulding, Director, Sasaki Strategies. 02/21/2019

[Int 7] Suzannah Bigolin, Urban Design Project Planner, Cambridge CDD. 02/14/2019

[Int 8] Ariel Noyman, Research Scientist, MIT City Science Group. 02/19/2019

[Int 9] David Clem, Founder, Lyme Properties. 02/22/2019

[Int 10] Alex Stokes, Consultant, HR&Advisors. 02/22/2019

[Int 11] Thomas J. Andrews, co-President, Alexandria Properties. 02/22/2019

[Int 12] Karin Brandt, Founder CoUrbanize. 03/04/2019

[Int 13] Peter Crawley, East Cambridge resident and member of Volpe Working Group. 03/08/2019

[Int 14] Tom Evans, Executive Director, Cambridge Redevelopment Authority. 03/18/2019

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