

AFTER THE PARADIGM OF CONTEMPORARY PHYSICS IN ARCHITECTURE:
SPATIAL POSSIBILITIES AND VARIATIONS

The Urban Quanta: Spacetimes of Sofia

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LORA DIKOVA

Miami University

Oxford, Ohio

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Advisor _____
(*Robert Benson*)

Reader _____
(*Mary Rogero*)

***The significant problems
we have cannot be solved
at the same level of
thinking with which we
created them.***

A. Einstein

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Abstract

Living in the age of scientific, technological and digital revolution changes our attitude towards information. It is inevitable to start approaching information not only as a product of fashionable digital media behavior, but also as a particular accumulation of facts and activities, transferable bits of matter, which influence our environment. Architecture not only exerts spatial influence on our environment, but also it structures its processes. Acting as such, architecture is involved into direct representation of informational flows via organizing spatial systems. Therefore, in the digital era, design gets more related to transforming different informational modes into spatial structures.

Transformations of information provide rich possibilities for conceptualizing space; such transformations could be achieved by different methodologies. This paper uses the concept of space in contemporary physics, namely the self-organizational behavior of the spacetime framework, in order to explore various ways of coding information in design. Analyzing String theory and its follower M – theory, the research derives a method for spatial organization of cause-and-effect activities resulting in a unified approach towards design methodology.

This paper explores the concept of movement in the space-time framework, namely the movement in various dimensions and in non-Euclidean geometry, in order to develop a system for achieving a particular design control over informational activities. Using the topology of spacetime in String theory and M-theory, a topology produced as an outcome from that particular movement behavior, the research proposes a way to handle an informational status in the environment spatially. Such a design approach, becoming more and more necessary in the age of the digital, opens room not only for mere spatial variations, but also for a direction towards new design morphology; a morphology in which architecture obtains new spatial value, reaching beyond the label of visionary design.

After the Paradigm of Contemporary Physics in Architecture:

Spatial Possibilities and Variations

The function of Art is to imitate Nature in her manner of operation. Our understanding of "her manner of operation" changes according to advances in the sciences.

John Cage ¹



Figure 1. Reminiscences of Form, by the author

Architecture in Space and Time

We, as architects, handle space in a very peculiar manner. We transform data into spatial structures by organizing physical, technical, cultural, functional, aesthetic and economic information. Therefore, we participate in the design process by analyzing restrictions in space, time and culture. Later, we convert them into non-accidental spatial artifact. This process of repetitive organization, namely defining the multitude of elements and their connections, requires particular methodology. This paper explores a possible approach for achieving such design methodology by using spatial concepts from the area of modern physics. Employing an indirect analogy with String theory and M theory, the paper encompasses a variety of questions bringing architecture, philosophy, and science together and investigating how the interconnectedness of these questions could affect contemporary design, providing different modes for organization of the design elements in space, time and context.

To focus on why I bring architecture, philosophy and science together I would like to introduce a question asked by the physical chemist Ilya Prigogine, when referring to the organization of the embryo.

"How can an inert mass, even a Newtonian mass animated by the forces of gravitational interaction, be the starting point for organized active local structures?" ²

Representing a philosophical paradox in the sciences, namely the mystery of the act of processing organization, the question might as well be ascribed to architecture, because even though the final result from design is a spatial artifact, that artifact is not a direct product of spatial elements merely put together. In spite of its peculiar attitude towards physical, technical, cultural, functional, aesthetic and economic restrictions, initially, each design process deals with structuring pure states of information about objects and their possible relations. Therefore, the primary cause of any designed artifact is a transformation of information; a transformation, which is in fact "the starting point for organized active local structures".

Moreover, it is namely such informational transitions, which connect the facts, science configures in systems, and their interpretations, philosophy presents. Prigogine stated that, "It is science, not its results, that is the subject of philosophy;"³ And the diversity of the tendencies in philosophy frame our culture. Therefore, by processing the information about how science and culture relate, new patterns of organizational structures could be derived, giving multiple and challenging answers to Prigogine's question.

Living in the 21st century, we experience the impact of the informational revolution marked by the rapid alterations in the sciences, technologies and consequently in cultures. These alterations affect the way we make and comprehend architecture. Inevitably, they impose an impending change in the design process. Such a change becomes necessary namely because our appreciation of space alters as well. Space has become a diverse mixture of the developing scientific, technological, and cultural activities; space has turned into a spatial and temporal layering of information, constantly accumulating and altering the very comprehension of space itself. Therefore, in order to make and comprehend spaces in the 21st century, we need to frame a language of relevant organization of the design elements, namely because the alterations in science and culture change the way architecture signifies. As mentioned before, designers, in particular architects, refer to these alterations by transforming spatial and temporal information. Architects like Marcos Novak, Kas Oosterhuis, Stephen Perrella have already undertaken their quests for such a shift in the attitude towards the relation between science and culture.

In relation to the beginning of such a new approach towards space and time this paper investigates the possibilities for designers to take advantage of the various methods for transforming cultural and scientific informational patterns into spatial artifacts. To do so, I specifically relate to an analogy with the spacetime framework in modern physics. I consider the main concepts of movement, dimension, and topology, as they are specifically framed in String theory and M theory, and convert them into a design tool to mediate transformations of information

in a spatial way. To do that I investigate two ways of how these concepts could contribute to the design process: first, providing a conceptual ground for organizing cause and effect structure of design elements, and second, exploring the possibilities for form creation.



Figure 2. The Topological City, by the author

Even though the indirect analogy with contemporary physics represents one of the many ways to form particular organizational structures in design, its concepts corresponds to architecture in both, providing a particular method of organization of spatial elements in a system, and also providing means of manipulating the organization of complex dynamic systems, such as architecture. The theories used in this analysis, String theory and M theory, are recent examples of ongoing scientific attempts to combine quantum mechanics with the theory of general relativity into a unified theory of everything⁴. Their main concept is that particles, considered point-like in classical physics, are in fact incredibly small strings, vibrating in a sub-quantum world of mathematical multidimensional spaces, and producing the properties of bigger particles, as those of the electron, for example. In the later M theory, these strings are assumed to surpass the dimensions of the sub-atomic scale and to form huge membranes, "branes" for short, which collide and produce multitude of new universes. Highly controversial, because being unable to be tested by experiment, and radically strange, because digressing from our general understanding of the physical world, these concepts cannot be applied to the design process directly. However, the inner logic for organization of spatial and temporal

elements, these theories define, could successfully be applied in design as a way to transform spatial and temporal information, namely because they frame a challenging connection among the concepts of movement, dimension and topology. These concepts, derived from modern physics, but interconnected with mathematics, art and philosophy, could similarly be applied in architecture as design tools for organizing spatial and temporal information.

Architecture after the paradigm of modern physics could, therefore, result not only in new morphology, but also could widen its contextual framing. Design might turn into algorithms of informational patterns, which change the x, y, z, time variables of objects. Such a change would influence the subjects in the environment of these objects. Therefore, such a change of the variables of the objects would contribute to achieve a diversity of spatial and temporal events.

Architecture and Movement

The architect Kostas Terzidis stated that, "motion involves time as a measurement of change"⁵. In String theory and M theory, "the wild vibrations of the different strings"⁶, different from ordinary vibrations, because accounting for the quantum fluctuations at that scale, still could be considered as a form of alteration in time, on the condition that we accept time, even without being able to measure it in the quantum world. Moreover, the distinguished difference among the elementary particles, tested by classical physics, results from the difference in the specific vibrations of the strings in multi-dimensional spaces, according to String theory and M theory. Therefore, such spacetime framework represents not only a repetitive movement and energy exchange, but also leads to the subtle relation of movement as a tool for organization of elements by creating informational transitions.

To transform this concept of movement in architecture, we should consider both, the dynamic possibilities of the design elements, as well as the option to trace motion into a static form. The first would imply the use of movement as a tool to transform information about space and time in

architecture, and the second to impose a form onto a designed artifact.



Figure 3. Temporal Sequence of Form over Time, by the author

As an organizational tool movement in n-dimensions could be applied both to objects and subjects in the design process to either force or imply a particular structure of connectivity. Such a structure inevitably would create specific frame of information. The awareness of this specific type of communication between objects and subjects provides opportunities for the designers. For example, in his design "Articulated Cloud", the designer Ned Kahn takes advantage of this by designing in space and time a four-dimensional (three spatial dimensions and one temporal) movement. The dynamic façade of the building, made of flexible, wind sensitive and reflective exterior panels, alters naturally with the change of wind and the dynamics of the reflected sky, thus communicating any change in the spatial and temporal information of the immediate building environment.

Such investigations of animating architectural objects by introducing movement to unconventional for those purposes elements allow for assigning new identification to the architectural object. In relation to this the architect Kas Oosterhuis stated that the architectural object turns into a "building body"⁷, encompassing all design elements, objects and subjects, by forming a homogenous environment of body structures, which respond to common informational flows.

However, if we consider the architectural artifact as an overall static structure, excluding the movable elements,

like doors, windows, equipment, but rather referring to the massing of the architectural object, the tool of movement also provides possibilities for informational transitions, as a result from cause and effect design organization. Kas Oosterhuis, for example, treats the classic house as "vectoral body whose direction is frontally oriented to arrival and departure"⁸. Thus, if we consider the duality of architecture, being static and yet imposing dynamic vectoral orientations in space, we could investigate, following the analogy with String theory, movement in n-dimensional spacetime as a mode of dynamic organization of static objects. The multi-dimensional aspect of the theory does not denote that we impose these dimensions literally, since additional dimensions merely mean additional information. Moreover, that aspect allows for more connections between the static and dynamic states of the objects. In four-dimensional space and time, for example, the architect Zaha Hadid has developed such an approach in her early designs; however, applying predominantly visual organizational patterns to limited elements and using collage design, rather than producing austere articulated static places in movement.

Movement in multiple dimensions could as well allow us to create a form in architecture. Even though the architect Kostas Terzidis stated that, "form itself does not involve time"⁹, it could capture the change of time in spatial configurations, depicting the consequence of movement through time and space. Form as a consequence of the movement in multiple dimensions through spacetime does not necessarily demand an "animated building", as Greg Lynn would argue, but rather implies the inevitability of tracing movement onto the integrity of the form. For example, the Casa Guardiola, designed by the architect Peter Eisenman, is a result of the rotation, translation, cutting, mirroring, unification, duplication of a cube in space. The final architectural form and structure of the house possess the notion of these processes of violation of the integrity of space, achieved by the movement of geometrical structures in time. Therefore, the form of the house is "animated" in a way that it preserves traces of the series of movements in spacetime as a geometrical projections articulated in the final form. Therefore, a form could be considered as a spatial memory of

certain movement in space-time. Moreover, Michael Leyton argues that shape is memory storage and vice versa. When discussing the two-dimensional structure of the paintings, he states that the memory storage is also a reflection of the information about the past.¹⁰ Thus, we could consider the possibility of a form, as a consequence from n-dimensional movement, to provide informational transitions in space and time, being aware that,

"The designer is a stylist of the entire flux through the building body. However, the modern designer is more than that. (S)he also gives shape to the flux of the physical building body itself. The designer shapes the building body that will eventually change its shape and content in real time"¹¹

Architecture and Dimension

Dimension is the measure of the information on the location of elements in space. Therefore, an element in the design system of four dimensions, relevant to our classical physical reality, is identified in space and time by one temporal and three spatial separate measures. However, according to String theory and M theory, there are respectively ten and eleven dimensions in our physical world; therefore, more complex informational structures exist among the elements in these theories. Even though we design in three dimensions and time, we should be interested in the consequences of the possibility of higher dimensional spaces as providing more states of information about objects, therefore, more options for them to relate technically or contextually in intriguing manner.

The importance String theory and M theory play in providing analogy to architecture is that the mathematical meaning of dimension is not isolated on its own, but it is woven into the structure of space and time. Thus the tool of dimension sets very particular conditions on how space and time operate together. "Now although it is hard to picture in more than three dimensions, this conclusion - more dimensions mean more vibrational

patterns - is general."¹², states the physicist Brian Greene. Therefore, the concepts of dimension and movement are interconnected. How such an analogy would refract into the design process? As mentioned before, the concept of movement in architecture, even in static structures, proliferates with design possibilities for meaning and form. Therefore, by altering the concept of dimension, we disturb the tool of movement in the design process, changing the connectivity of the designed elements and also altering their form. That inevitable dual transformation allows controlling the design in a more flexible way and also gives additional modes of framing information into spatial structures. The artist Tony Robbin, for example, uses the concepts of movement and dimension in his sculpture for the Center of Art Science and Technology at Denmark's Technical University. Working on the geometry of quasicrystals, "three-dimensional projections of higher-dimensional objects", Tony Robbin appreciates the "richness of four-dimensional geometry" by investigating its possibility for "multiple objects in the same place and time, objects appearing and disappearing by rotation, objects passing through one another without interference". Describing his sculpture, Tony Robbin emphasizes on the importance of combining concepts of movement and dimension to "allow the viewer to pass under, over, around, and through the work, and to happen upon the many and unexpected occurrences of fivefold, threefold, and twofold symmetry"¹³, caused by the change of light and of the viewer's position.

Since the concepts of movement and dimensions are interconnected, as discussed above, and since the influence of movement as a design tool could shape a particular form in architecture, we can assume that the use of dimension can also indirectly achieve it. Moreover, knowing that a common way to experience a form is by processing visual information, technical manipulation of multi-dimensional projections could serve as a tool to generate form. Tony Robbin expressed his awareness of that fact by referring to Henri Poincare, who "repeatedly suggested that successive models of the projections of four dimensional figures when seen in sequence could lead to a vision of the fourth dimension"¹⁴. Therefore, such possibility of framing whole structures, for example, in building sections or on urban level, would

provide an immediate tool to generate form in the design process. Moreover, this form would differ from other morphologies in architecture by providing a new appreciation of spaces, namely the visual experience of n-dimensionality.

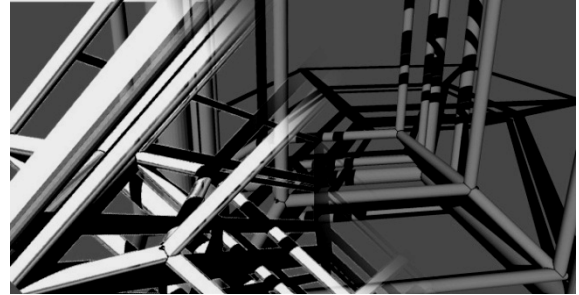


Figure 4. N-Dimensional Variations on Tracing Form, by the author

However, being used to the restraints of our four-dimensional world, any representation of n-dimensionality could pose a challenge. Treated as a structure of connectivity among elements, n-dimensionality could take another direction in influencing the design process by increasing the possibilities for informational transitions. "And since a string's vibrational pattern determines its mass and charge," in String Theory and M theory, "this means that the extra dimensions play a pivotal role in determining particle properties"¹⁵, as Brian Greene would argue. In architecture, the concept of dimension, considered as the link among all design elements in a system, might be investigated in context, not necessarily by technical geometrical projections. The architect Stephen Perrella, for example, tests such contextualism in his studies of the richer in informational transitions hyperspaces. Moreover, for him the hypersurfaces "are thought to render a more complex notion of spacetime information" than the mathematically defined ones, because in the hypersurfaces "the abstractness of these mathematical dimensions is shifting, defecting or devolving into our lived cultural context."¹⁶ Unlike Stephen Perrella, Marcos Novak considers the concept of dimension in M theory as a way to comprehend the identification of the design elements. Therefore, he suggests that dimension serves

not as a tool to combine elements together in a system, but to differentiate their typology.

“both are manifolds, the difference between hyperspace and hypersurface of a hyperspace of (n)-dimensions is a submanifold of (n-1) dimensions. Thus the hypersurface of a hyperspace of four spatial dimensions is a space of three spatial dimensions, produced by an act of projection or section or screening.”¹⁷

Architecture and Topology

Deriving a form from topological spaces is predominantly direct way to structure a “sculptural drama”¹⁸ as Kenneth Powell would frame it. The concept of topological forms applied in the arts provided intriguing results in the two-dimensional art of M. C. Escher, curving spacetime visually, for example, as well as in the sculptures of the artist Eva Hild, improvising with the pressure, curvature, and intensity of a form. Moreover, topology has been already highly utilized in architectural theory from architects such as Greg Lynn, Peter Eisenman, Kostas Terzidis. The “weak form” of Peter Eisenman and the “fold” of Greg Lynn have tested topological structures and the way they relate to morphology in architecture. Greg Lynn implements topology as a tool to investigate flexibility and continuum in a form as well as its signification, affected by “programmatic, structural, economic, aesthetic, political and contextual influences”¹⁹. In similar way, UN studio, for example, derive directly from topology the Mobius strip into their design for the Mobius House with the concept of infinite interaction of the users’ activities.

However, the mathematical approach String theory and M theory reveal towards the concepts of topology and n-dimensionality suggests an intriguing relation between topology, dimension and movement in organizing elements in structures, as a fundamental cause for organizing spatial elements into temporal structures. The strings vibrate in the sub-quantum world, in six-dimensional mathematical spaces, called the Calabi-Yau manifolds, thus forming the properties of the various particles. Brian

Greene explained further that the, “vibrational patterns of the strings are influenced by the twists and turns in the geometry of the extra six dimensions”²⁰. Therefore, the tool of topology, dealing with deformations of form, which preserve its integrity, such as stretching, twisting, folding, scaling, influences the tools of movement and dimension and vice versa. Moreover, the architect Kostas Terzidis argues that form, subject to topological deformations, would reveal particular properties as it would “allow time to be imprinted on form”, as well as be an “object in disguise” in the case when object is “composed of the topology of the one object and the geometry of the other.”²¹. This implies that by applying topological transformations to the design elements, we change the concepts of movement and dimension. Therefore, topology could be used to control the design mechanisms and organization in their unity. Kas Oosterhuis, for example, suggested that, “The tension between the dimensions can be made visible and tangible by stretching them almost physically, like a baby in a bunting bag.”²² Similarly, movement, as a design tool, could also be transformed, stretched, folded or scaled, which would result in a change of form and connectivity of design elements. Therefore, topology provides rich possibilities for manipulation of the design elements in form and context.

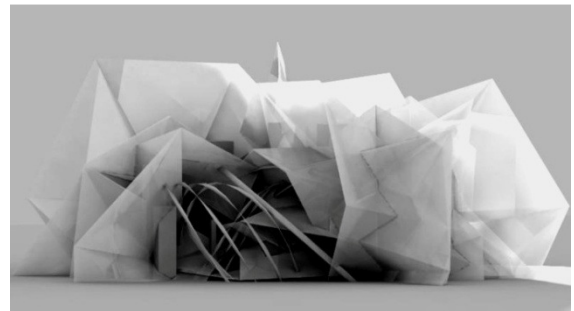


Figure 5. Topological Invariants on Analytical Cubism, by the author

Dealing with the possible structures among the elements in architecture, topology could serve as a tool not only for morphological and contextual, but also for programmatic organization of the relations between objects and subjects. Therefore,

topology could constitute a powerful instrument of how architects transform the data of all design restrictions into spatial and temporal structures, emphasizing specific characteristics about such an organization. Dealing with deformations, preserving the object's integrity, but defining boundaries, in and out conditions, topological transformations could be applied in the design process, for example, as a spatial solution to border contexts. In a single building unit, or on urban level scale, exploring the elements as sets of typologies might serve as a tool to set categories of identities. Therefore, that could help to deal with multitude of objects and subjects at once, by introducing them as part of a single topological structure, giving the advantage of controlling complexity because:

"Rather than assuming a continuous behavior that governs all finite elements, the behavior of each finite element contributes toward a generalized behavior. Finite elements can be regarded not as arbitrary units but rather as localized samples. In this context, general principles are derived from particular instances."²³

Architecture after the Concepts of Modern Physics

"We have our own discoveries to make, based on the mathematics and physics of our own time."²⁴, stated the artist Tony Robbin. Therefore, if we go back to the question of the organization of the embryo, asked by Ilya Prigogine, we might find that in each time and space we accept different answers to that question. Our way of thinking as artists, scientists or philosophers, who organize given information to achieve a developed structure of interconnected elements, is subject to change according to "our own discoveries". This paper presents a way to frame architectural theory through a scientific happening. By applying an indirect analogy with concepts from String theory and M theory, the paper investigates possibilities for interpretation of information in the design process. The analysis of the tools of movement, dimension and topology give

opportunities for both, interpretation and generation of design artifacts. It also reveals the importance of the spacetime framework in String theory and M theory, taken as a design tool, to deal with complex dynamic systems, like architecture, because unlike acknowledged concepts in classical physics, like phase space²⁵, for example, String theory and M theory link the concept of dynamics with the concept of spatial deformation topologically as well as temporally. String theory and M theory, someday might as well prove to be wrong about how they define our physical space and time. However, that would not repudiate any of the places, we might have designed as an animated through multi-dimensional spacetime form, exuberant in the diversity of its topological structure. On the contrary, it would only be one of the various ways to answer Prigogine's question, one more time.

Notes:

- ¹ John Cage, *A Year from Monday: New Lectures and Writing* (Middletown, Conn.: Wesleyan University Press, 1969), 31
- ² Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Boulder: New Science Library, 1984), 82
Prigogine discusses the relationship between physics and philosophy; in this case referring to the viewpoint of the French philosopher Denis Diderot.
- ³ Prigogine and Stengers, 88
- ⁴ The theory of general relativity, including gravity, is mathematically irreconcilable with the theory of quantum mechanics, including electromagnetism, the strong and weak forces. However, scientists assume that under conditions, similar to the ones they suppose formed in the Big Bang or in black holes, these forces should be unified. String theory and its follower M theory represent a way to do it. However, they are only theoretical and due to technological impossibility, unverifiable.
- ⁵ Kostas Terzidis, *Expressive Form. A Conceptual Approach to Computational Design* (London and New York: Spon Press), 33
- ⁶ Brian Greene, *The Fabric of the Cosmos* (New York: Alfred A. Knopf, 2004), 226
- ⁷ Kas Oosterhuis, *Hyperbodies: Towards an E-motive Architecture* (Basel: Birkhäuser, 2002), 38
- ⁸ Kas Oosterhuis, *Architecture Goes Wild* (Rotterdam: 010 Publishers), 114
- ⁹ Terzidis, 33
- ¹⁰ Michael Leyton, *The Structure of Paintings* (Wein: Springer-Verlag, 2006), 1-5
- ¹¹ Oosterhuis. *Hyperbodies: Towards an E-motive Architecture*, 30
- ¹² Greene, 370
- ¹³ Tony Robbin, "Quasicrystal Architecture: The Space of Experience" in *Beyond the Cube. The Architecture of Space Frames and Polyhedra*, ed. J.Francois Gabriel, 434-435 (New York: John Wiley & Sons, Inc, 1997)
- ¹⁴ Robbin, 430
- ¹⁵ Greene, 371
- ¹⁶ Michele Emmer, *Mathland: From Flatland to Hypersurfaces* (Basel: Birkhäuser, 2004), 57
- ¹⁷ Marcos Novak, "Transarchitecture and Hypersurfaces: Operations of Transmodernity" *Architectural Design* 68, no. 5-6 (1998): 85
- ¹⁸ Kenneth Powell, "Unfolding Folding" in *Folding in Architecture*, ed. Andreas Papadakis, 7 (New York: VCH Publishers Inc, 1993)
- ¹⁹ Terzidis, 23
- ²⁰ Greene, 371
- ²¹ Terzidis, 16, 24
- ²² Oosterhuis, *Architecture Goes Wild*, 237
- ²³ Terzidis, 50
- ²⁴ Robbin, 437
- ²⁵ Phase space is used for analyzing dynamic systems by introducing six coordinates to an object, defining its location by three spatial coordinates and their respective momentum, relating to the movement of the object.

Design Overview



Figure 6. The Urban Quanta: Spacetimes of Sofia, by the author

The Weak Formation

“The Urban Quanta” is a design project developed by exploring interdisciplinary design methodologies which use informational patterns from contemporary physics, in particular String theory.

The design process included investigating separate fragments from String theory’s framework which presented possibilities for design applications. Thus during the research design work concepts of discrete movement, n-dimensionality, topology and related topics were examined for their possible applications in art, design and science. The analysis of the case studies and design experiments revealed that all chosen fragments from string theory’s framework could be used in the design process as independent design catalysts. Their applications opened multiple possibilities such as providing tools for creating versatile morphologies or forming abstract connections between design elements. /see drawing on p.16/

In the next stage of the design investigation particular methodologies from String theory’s framework were analyzed. The main objective was to explore different ways of framing the major logical chains among the theoretical events in String theory. Later one of these possible logical chains was analyzed in respect to the design process. As a result from the analysis a relative logical chain of design objectives was framed. The project “The Urban Quanta” is produced by following this logical chain of objectives, where each objective corresponds to a set of objectives in string theory’s framework. /see drawing on p.18/

Thus String theory was used in the design process differently than in the initially researched written thesis document, where fragmented interdisciplinary concepts, mainly borrowed from mathematics, were examined in relation to art and design. Analyzed further as a coherent methodology, String theory was applied in design as a possible mode for producing chain of particular logical events. This approach allowed for the necessary theoretical demarcation between the scientific goals of string theory and the design objectives of architecture. Taken as sets of logical connections between analogical structures string theory provided a very specific and unique set of rules that were applied as connectors between the design stages, while the very design structures within these stages underwent only architectural iterations. In short, the design objective to create a historical museum in Sofia relates to the main objective of the scientists to bring the theories of Quantum Mechanics and General Relativity together in a Theory of Everything. Any theoretical details after that starting point unfold independently for each field; in architecture as design stages and in physics as scientific stages. It is only the logical connections between these theoretical stages that relate.

I call this kind of interdisciplinary relation between String theory and architecture “the weak formation” because on one hand there are crossing points in the methodology between the disciplines and on the other both fields maintain their sovereignty in their own development.

The Urban Quanta

The project "The Urban Quanta" is a design for a history museum, encompassing the cultural, historical and urban heritage of the city of Sofia, the capital of Bulgaria.

Predeceased by several urban studies */see drawing on p.20,21 /* at different locations in the city "The Urban Quanta" forms an urban event, which unfolds in the urban tissue of the city as series of discrete sub-events which mark historical presence or absence in the existing urban form. Each event disintegrates into smaller urban entities. The challenge in this approach is to create an ambiguous difference between urban and local forms. The design questions which architectural elements belong to the city, being strictly urban, and which elements belong to the existing buildings, being local.

For the purpose of spanning the difference in scale, from urban to local, specific basic element was introduced – the urban hypersurface. In String theory physicists propose extended particles, called strings, in order to define the point-like and wave-like behavior of particles. The geometry and topology of the so-called strings allow for this transformation without losing particular properties belonging to one or the other types of particles. In the proposed design for Sofia the urban hypersurface plays the role of the string in physics. Geometrically the typical two-dimensional surface is a two-dimensional object but with reference to three-dimensional geometry if considered as a boundary or an intersection between three dimensional spaces. Thus the surface as two-dimensional object starts to embrace higher dimensionality than its initial one. The hypersurface on the other hand is a surface of multiple-dimensions. These dimensions could be mathematical, as in the case of string theory, or could be assigned to different types of variables they define. It is important to note that n-dimensionality in String theory rises as a requirement only due to mathematical reasons. The necessity to input extra information about the typologies and behavior of the particles is the major reason why scientists introduce more dimensions than we physically know and experience. Therefore, n-dimensionality is merely a tool to define

particular amount of information about elements and their relations in various systems. Going back to the urban hypersurface the question of what its dimensions could represent can arise.

During the design process several experiments with n-dimensional geometrical projections were made. */see drawing on p.21/* These experiments and the case studies examined revealed that the spontaneity and artistic unpredictability of design and art could be challenged using only strict logical rules of how geometrical projections of higher dimensions are formed and depicted. Since n-dimensionality could be assigned to different variables, the variable of direct geometrical transformations was rejected as a design approach. Instead, several other variables were tested in urban experiments. As a result from the site specificity n-dimensionality was explored in the design process as contextual and cultural layering.

The rich historical layering of the city of Sofia allowed for transforming n-dimensionality into the merging of contextual information. */see drawing on p.17/*

The design proposed to develop specific critical points in the city by applying urban hypersurfaces, */see drawing on p.22/* which carry the information about history and context and physically challenge the contextual information on the site. The choice of the critical events was based on their richness in historical and cultural background. */see drawing on p.17,18/* Some points were exposed on street level; others were to be excavated from the remains of the ancient Roman city of Serdica. Mosques from Ottoman rule, religious buildings such as the modern Catholic church, the Early Christian basilica, the Eastern Orthodox church of Sveta Nedelia and the Synagogue exist in the city within only several urban blocks. This extraordinary co-existence of multiple monuments, belonging to different religions and cultures, is not only historical artifact; it refers to current programmatic issues, since the monuments still function and embrace different users. Due to the relations of these various locations in the city a uniform urban approach of connecting and separating was developed.

Therefore the design proposes an urban historical museum, connecting all these

important locations in the city by means of urban hypersurface deformations. */see drawing on p.18/* In this respect the historical museum becomes urban event made of discrete critical points of reference in the city, all of which connected by the way the urban hypersurfaces change. For the purpose of this Master thesis a specific location, called the critical point Y, was developed in more detail, exploring how the urban transforms into local.

The critical point Y represents the City Garden in Sofia. The site used to be the garden of the former Royal Palace, built in 19th century. After change in the political regime the garden was transformed to host the mausoleum of the communist leader Georgi Dimitrov. The mausoleum was built in 1946 and demolished in 1999 after the political regime changed again.

The City Garden at present functions as one of the many green areas in Sofia. The urban development of the city formed radial urban fabric with green zones in the four world directions. */see drawing on p.17/* The urban master plan from 1934 proposed the transformation of Sofia into a city as a garden. That is why the City Garden holds not only historical relevance to the urban heritage of Sofia, but also conceptual one.

After the specific site was analyzed in terms of traffic and pedestrian flows, types of users, historical and cultural influence, the design for the historical museum at critical point Y was developed. The program includes underground parking area, underground museum part, underground pedestrian crosswalks, underground commercial area with shops, cafeterias, restaurants and green park at street level. All programmatic zones are designed physically connected for the purpose of forming n-dimensional connotations between the various contexts. The design also proposes a new subway stop in front of the former Royal palace, now being National Art Gallery. */see drawing on p.19/*

The designed urban interventions in the City Garden exclude the two existing buildings on the south from the territory of the garden by introducing new street pattern and above-ground row of pavilions as a boundary between the new garden plot and the old urban fabric. */see drawing on p.19/* Also the urban pattern is reshaped in a way to

return the axial procession towards the National Art Gallery, the formal Royal palace, which was broken in early 20th century by the artificially created new axis towards the theater building to the east. The intervention does not have the intention to embrace the system of monarchy, which the Art gallery might evoke, being the former Royal palace. The reasons for such urban shift are purely formal and aesthetic.

The spaces proposed in the thesis design for the City Garden serve all users on site: pedestrians in the green area; office workers in the adjacent bank building; visitors of the National Art Gallery and the City Art Gallery; visitors of the Sofia Grand Hotel; visitors of the National Theater and tourists.

The museum spaces and the parking spaces are related morphologically as part of the urban hypersurfaces which rupture and create their own sub-spaces. */see drawing on p.19/* The contact zone between the museum spaces and the parking spaces is divided in two areas: one forming continuous inclined and declined floor slabs and one forming a transparent glass separation wall, which exposes the museum spaces in front of the parking structures. Also the entrance and exit ramps for the parking are separated by glass partitions in order to allow for the constant experience of the moving city in all its forms. The subway tunnel is partially exposed as well, providing constant visual and sound information about the passing train. The lights from the parking intrude the museum spaces through the glass partitions and form the pattern of the daily routine of the users on site. The museum spaces are adjacent to the main pedestrian flow of the underground crosswalk, allowing for the museum to become intrinsic part of the city life and civilian routine. The museum spaces are to host mainly interactive information about the history of Sofia, such as media and sound performances, conferences and happenings. The museum has a connection with storage spaces in the parking premises; however the proposed design suggests that mainly urban activities would take place in the museum, rather than permanent expositions of physical historical artifacts. The museum spaces flow into the city garden by means of repetition of declining ramps and stairs from street level to -11.00 meters. The open garden space at level -11.00 is formed by the forces of urban

absence of the mausoleum building, which cause the urban surface to invert along the Z coordinate negatively. The footprint of the mausoleum is kept at height of 50cm above level -11.00. It serves as bench structure which is positioned in and outside of the underground building spaces.

The materials proposed in the design are wood and concrete, mixed with the presence of vegetation and water as landscape elements. Water is used also as a design tool for the reflection of the memory of the obliterated urban form. Several garden ponds are used at ground level +0.00, as well as at level -11.00, accompanied with series of water channels running through the whole site of the City Garden.

The ground level of the garden, designed as a roof of the underground spaces, is fragmented into series of declining and rising surfaces, which allow for different views inside and outside of the underground spaces. Also the wooden surfaces define all bench structures as well as some of the museum floor slabs. The use of wood is dictated by the need to introduce a new for the site material, which would link the spaces not only formally but also conceptually. Since the existing building environment is mainly made of monolithic stone and concrete structures, wood was chosen as a material to form the contrast between the old urban patterns and the new ones, as well as to form a link to the aesthetics of the green area.

Thus the proposed design for the City Garden explored the possibilities for exaggerated formal and contextual connections of spaces, which by the individual appreciation of the different users could turn into few of the spacetimes of Sofia.

The Critique

The review of the design thesis project was challenging and posed intriguing theoretical questions. The main issue that I noticed in the reviewers' comments was the difficulty to relate to the complex scientific theory and its mathematical range and how the specific theoretical details were applied to the design process. The most repeated question was related to where the multiple

dimensions of the project were, however it appeared that it was not quite clear for some jurors what n-dimensionality in mathematical terms is in fact. This meant that because the meaning of n-dimensionality was not fully understood by the general public in terms of its mathematical essence, it was hard to appreciate the design concept from that perspective. However, the head of the jury, Paul Lukez, noted in response to a question from another juror that the multiple dimensions were informational.

Further opinions about the design again revealed to me that the interpretations of String theory by the general public varied and were often visual, while this thesis design project explored more analytical and logical connections between the two fields of architecture and science.

There were questions about the politics of the location since the site is related to a demolished communist monument. However, the main objective of the proposed design was not to deal with politics, but to deal with historicizing contexts spatially and temporally.

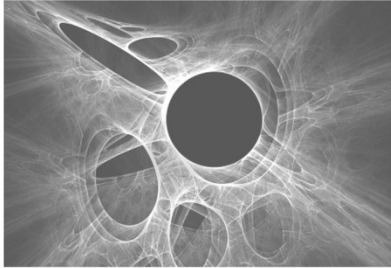
There were questions of how the design relates to the work of Peter Eisenman, since he deals with absence and presence. The proposed design, however, utilizes programmatic, rather than only formal syntax of deconstruction, which is very different from Eisenman's approach.

Overall the discussion of the thesis design was related to the theoretical approach towards the crossing between science and architecture.

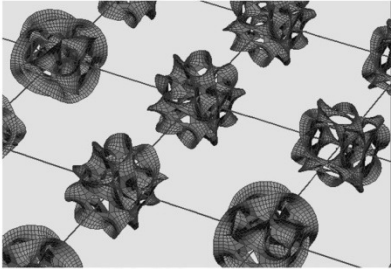
Design Drawings

The design drawings included in the thesis document are in chronological order and are a visual representation of the different theoretical design stages in the thesis process. They start with providing visual information for the Research Thesis Document and continue with site analysis. The results from the site analysis were combined with the research study to form the major urban and local theoretical frameworks. The drawings also refer to major urban and local studies for *genius loci* and for morphological opportunities.

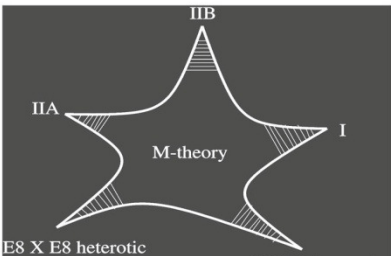
STRING THEORY



String Theory proposes extended particles as main units of the matter

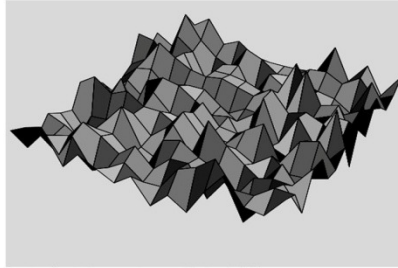


6D - Calabi-Yau manifolds in which the strings "vibrate"



E8 X E8 heterotic

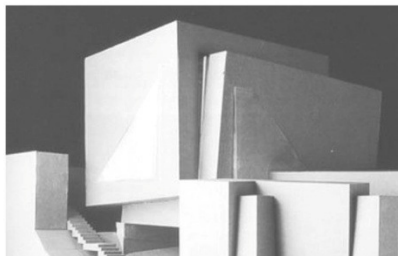
MOVEMENT



Quantum fluctuations - a strange world of probabilities



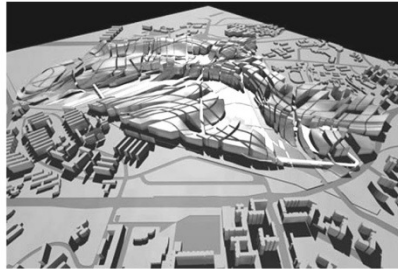
Boccioni - Unique Forms of Continuity in Space, 1913



HYPERSURFACE



Ned Kahn, Technorama Facade, The Swiss Science Center, Winterthur, 2002

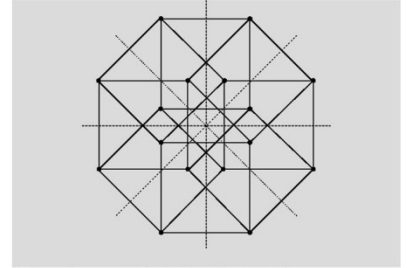


Zaha Hadid Architects, One North Masterplan, Singapore, 2001

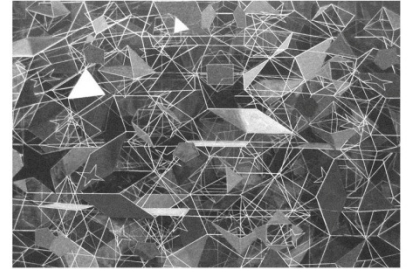


Stephen Perrella, The Haptic Horizon-hypersurfaces and culture

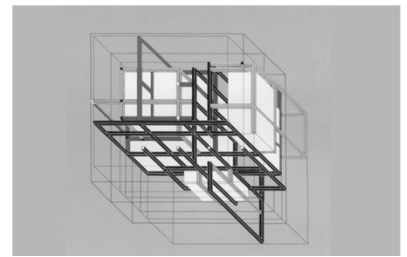
DIMENSION



The Hypercube - geometrical projection of 4D cube onto 2D space



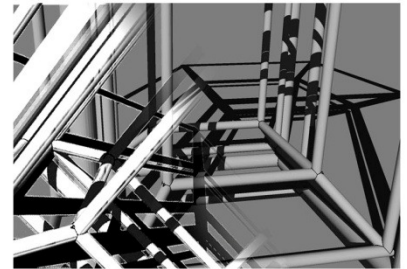
Tony Robbin - Hyperplanes - 2005-2003, 56"x70"



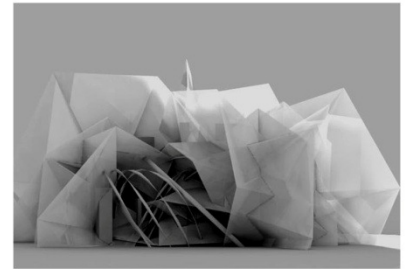
EXPERIMENTS



Lora Dikova, Temporal Sequence of Form Over Time, 2008

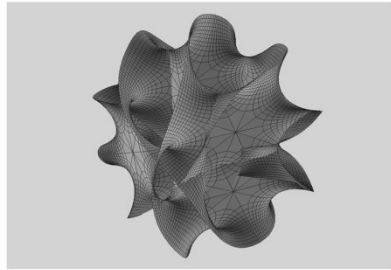


Lora Dikova, Non-dimensional Variations on Tracing Form, 2009



Lora Dikova, Topological Invariants on Analytical Cubism, 2009

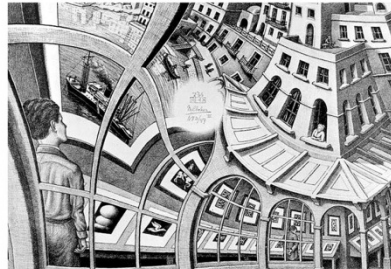
TOPOLOGY



Calabi-Yau manifold, 6D mathematical form



Eva Hild, Funnel loop, 2007, 90 x 70 x h 57 cm



M.C. Escher, Print Gallery, 1956, Lithograph

SOFIA CONTEXTS SOFIA CONTEXTS SOFIA CONTEXTS



ROMAN CHURCH 4TH CENTURY



ALEXANDER NEVSKI CATHEDRAL



BULGARIAN PARLIAMENT



THE SYNAGOGUE



THE CHURCH OF SVETA SOFIA



FORMER PARTY HOUSE, NOW PARLIAMENT BUILDING



SOFIA HISTORY

SOFIA ANCIENT

SOFIA URBAN



1887



1912



1924



1937



1946



1959

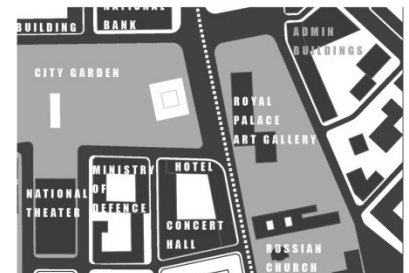
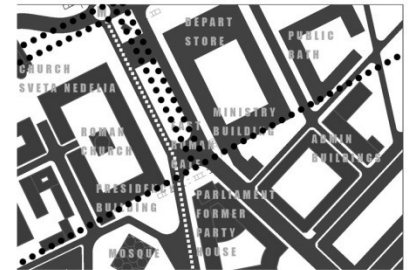
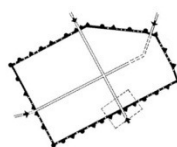


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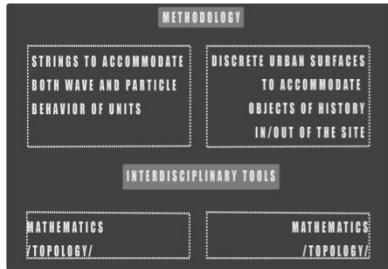
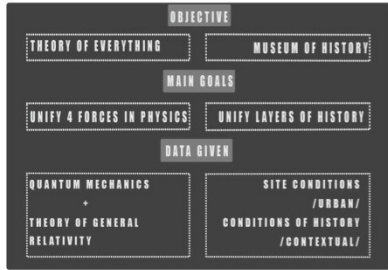
GREEN ZONE
SUBWAY
ROMAN CITY

CITY as a GARDEN

4th CENTURY
ROMAN SERDICA



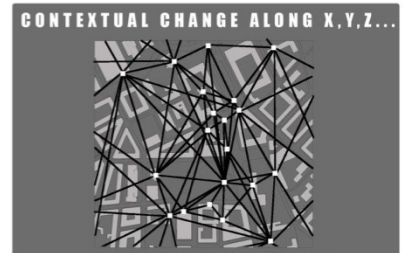
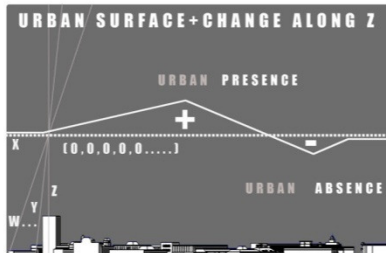
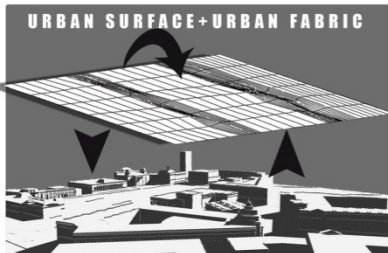
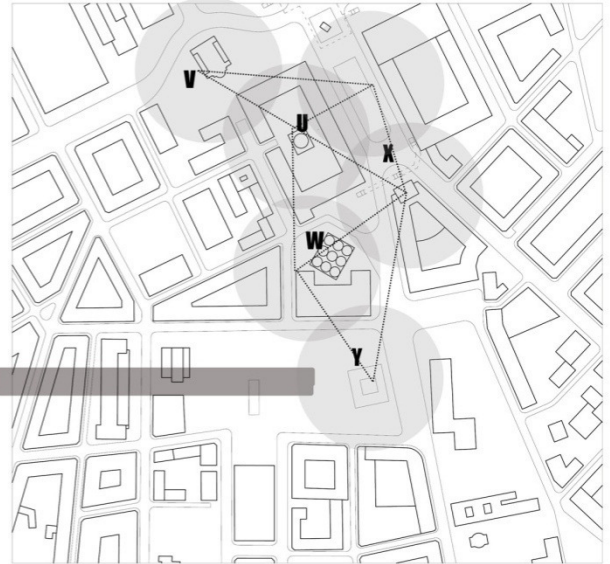
STRING THEORY



ARCHITECTURE

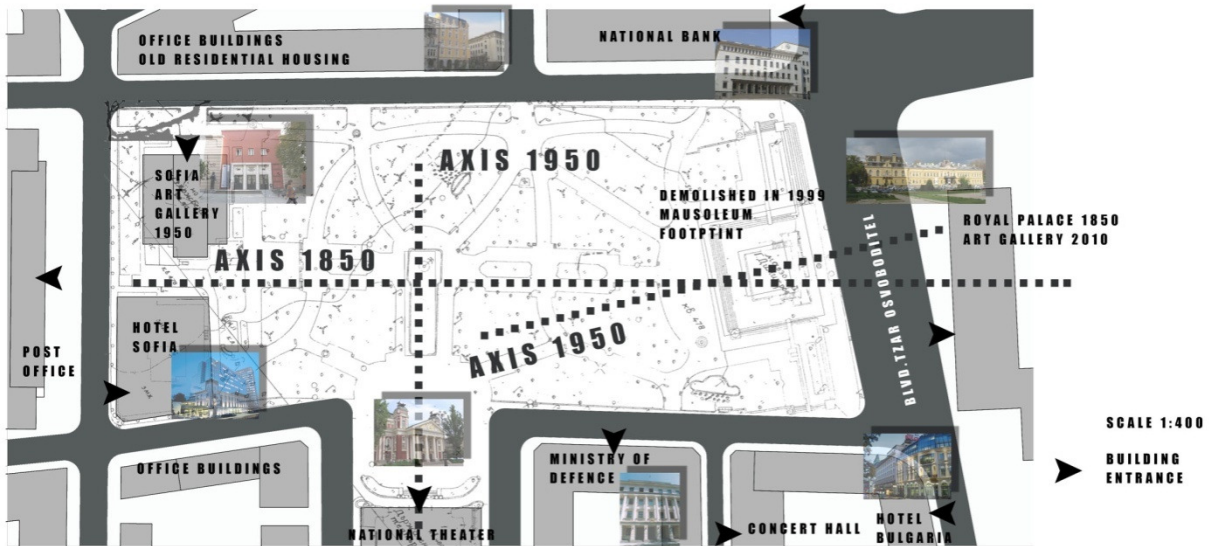
URBAN SURFACE
=
SUM OF DISCRETE
CRITICAL POINTS
IN THE HISTORY
OF SOFIA
=
URBAN MUSEUM
THE SPACETIMES
OF SOFIA

URBAN EVENT

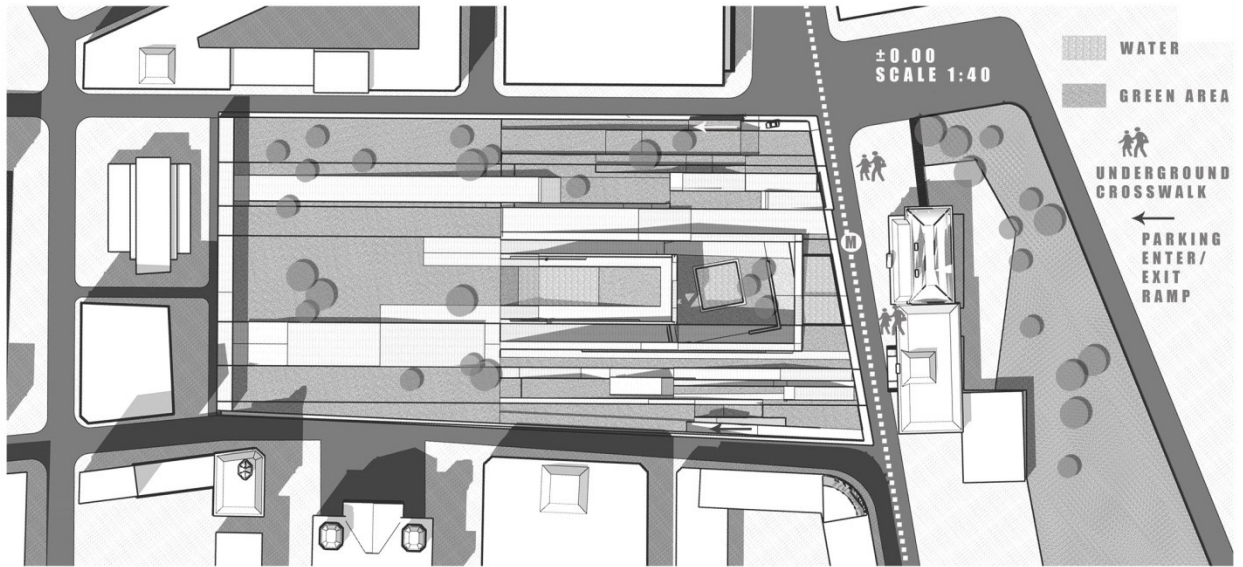


SPACETIME Y

URBAN DEFORMATIONS



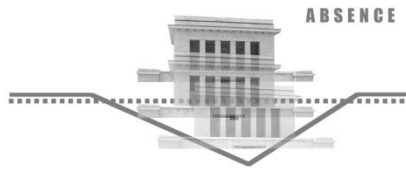
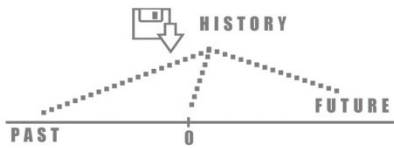
SPACETIME Y: CITY GARDEN: URBAN DEFORMATIONS



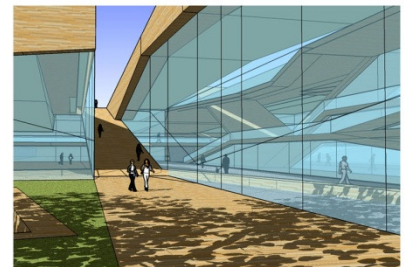
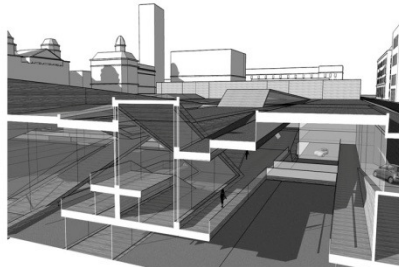
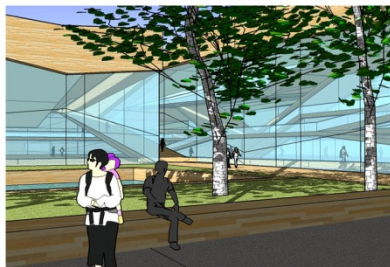
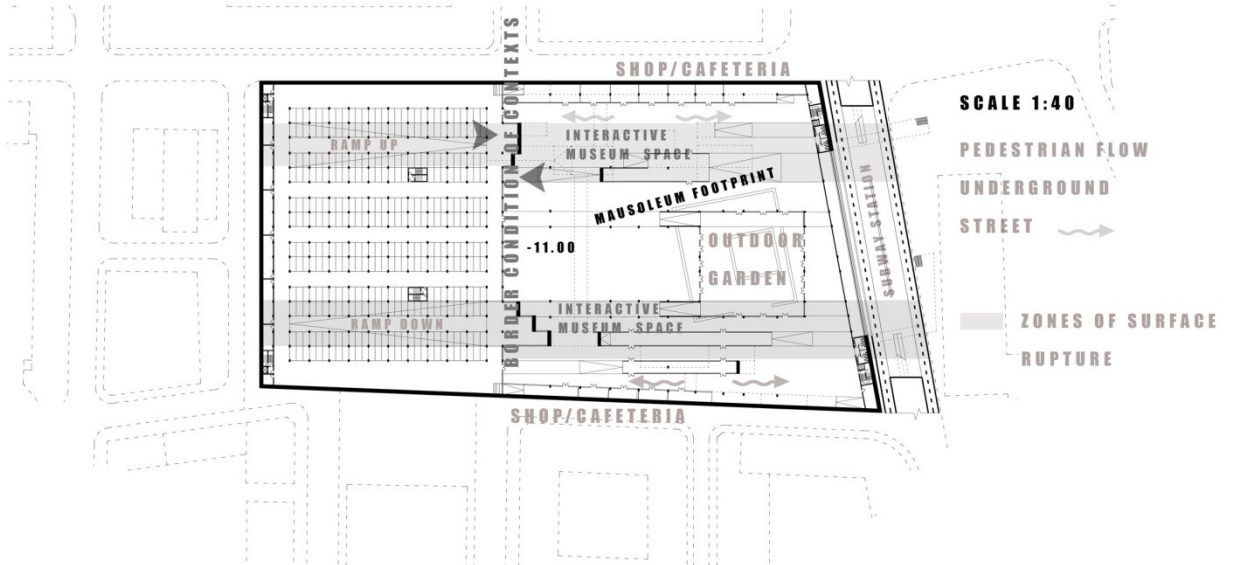
MERGING OF CONTEXTS

URBAN FORCES

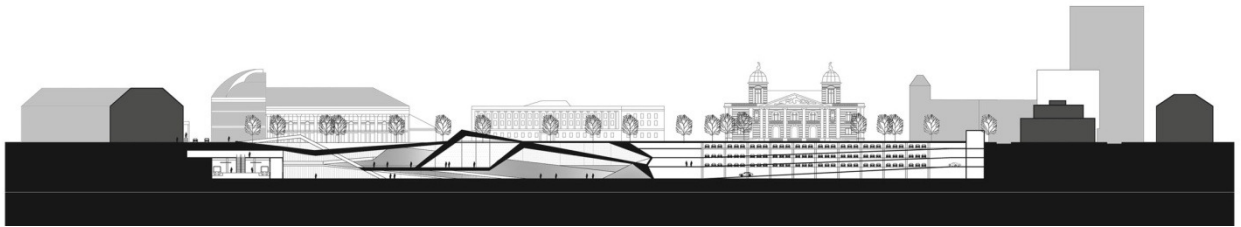
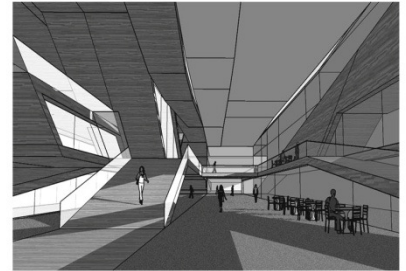
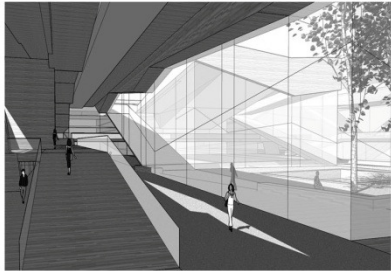
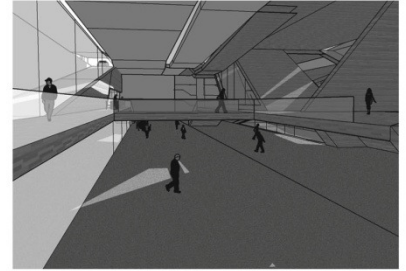
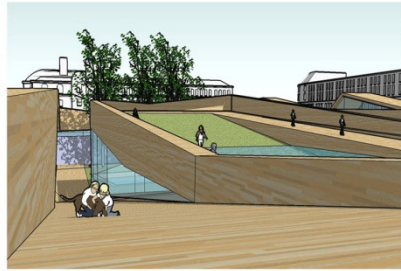
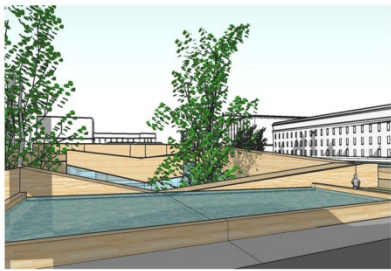
MORPHOLOGY



CITY UNDER THE CITY LOCAL CONTEXTS



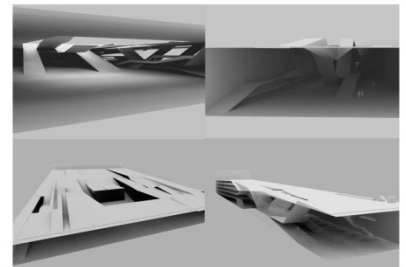
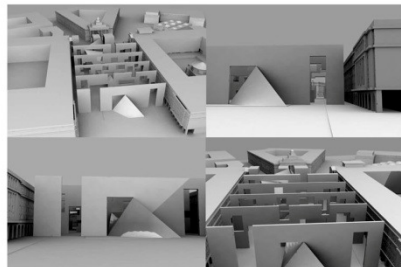
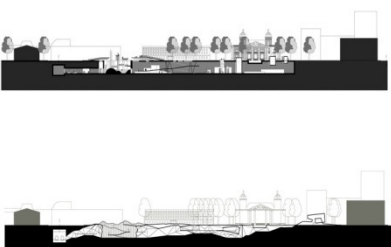
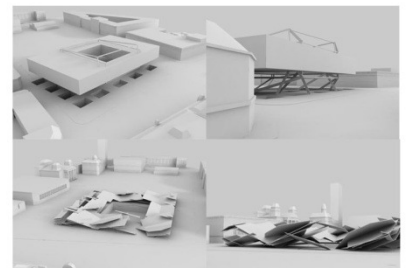
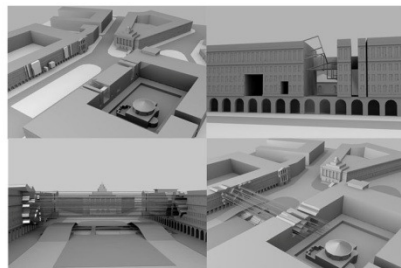
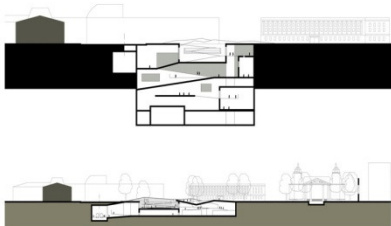
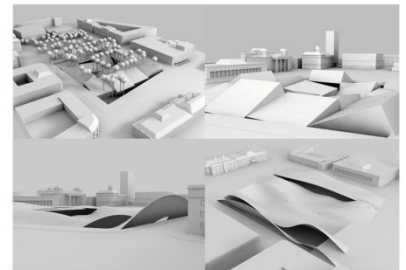
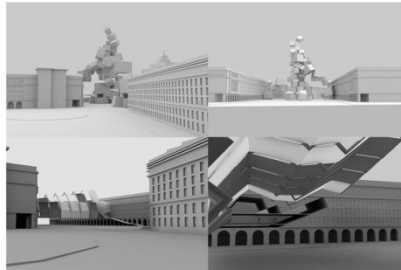
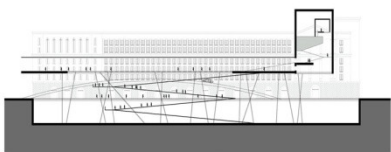
CITY UNDER THE CITY: LOCAL FRAMING



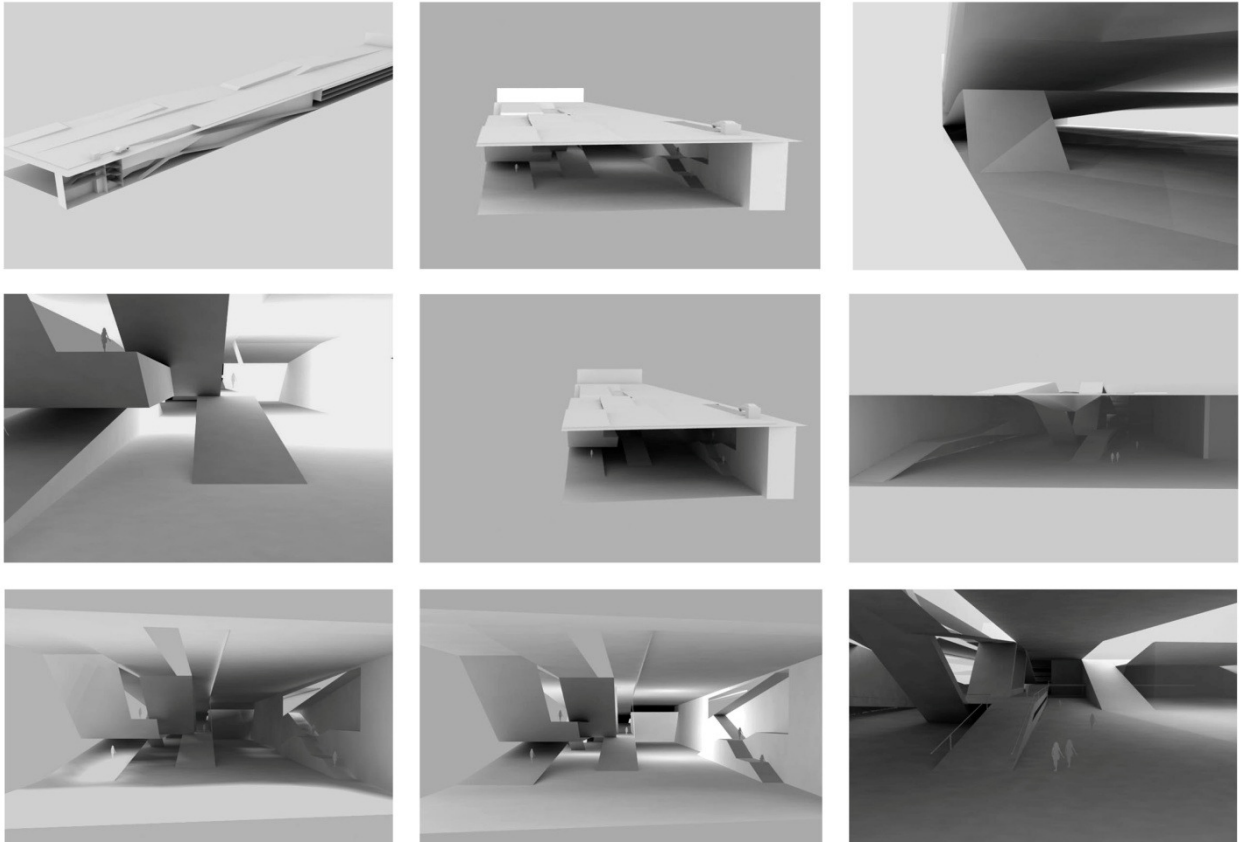
POSSIBILITIES

SPACETIMES X

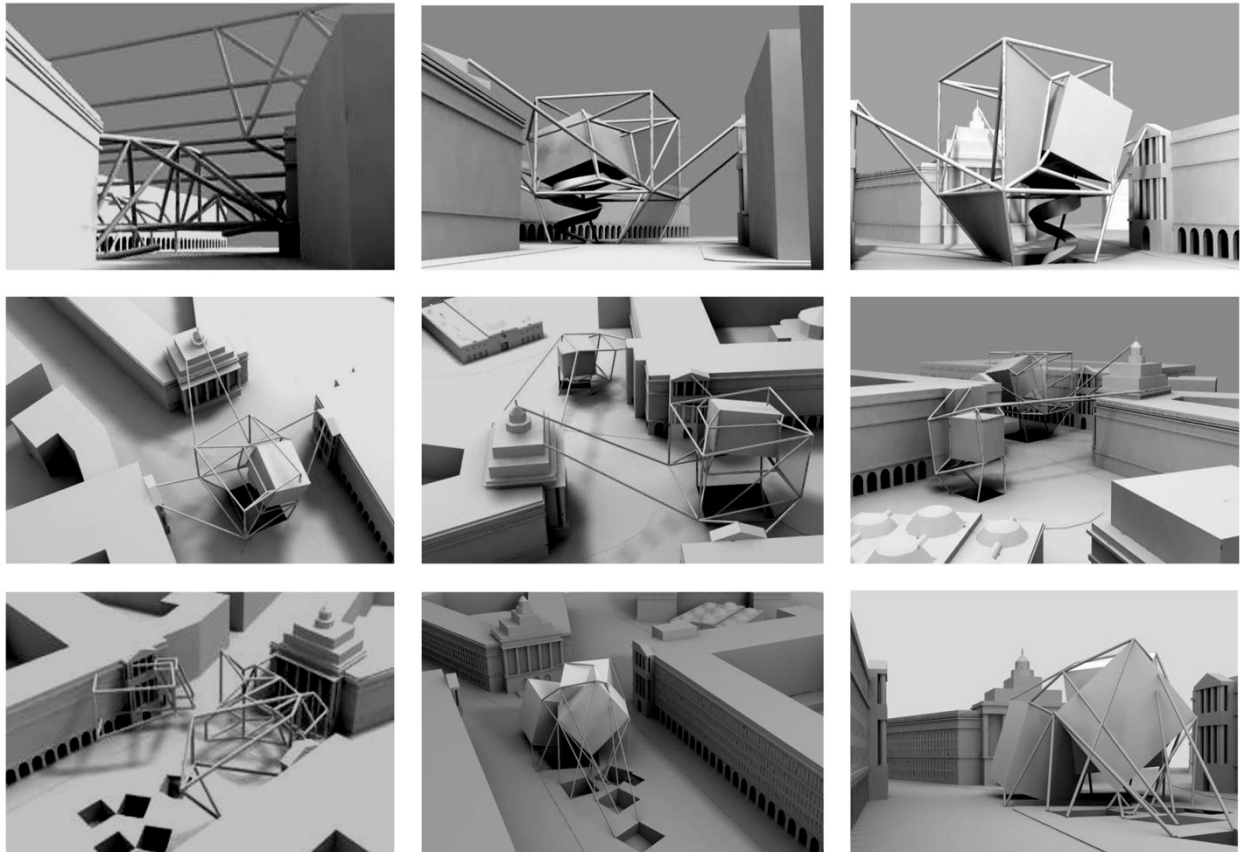
SPACETIMES Y



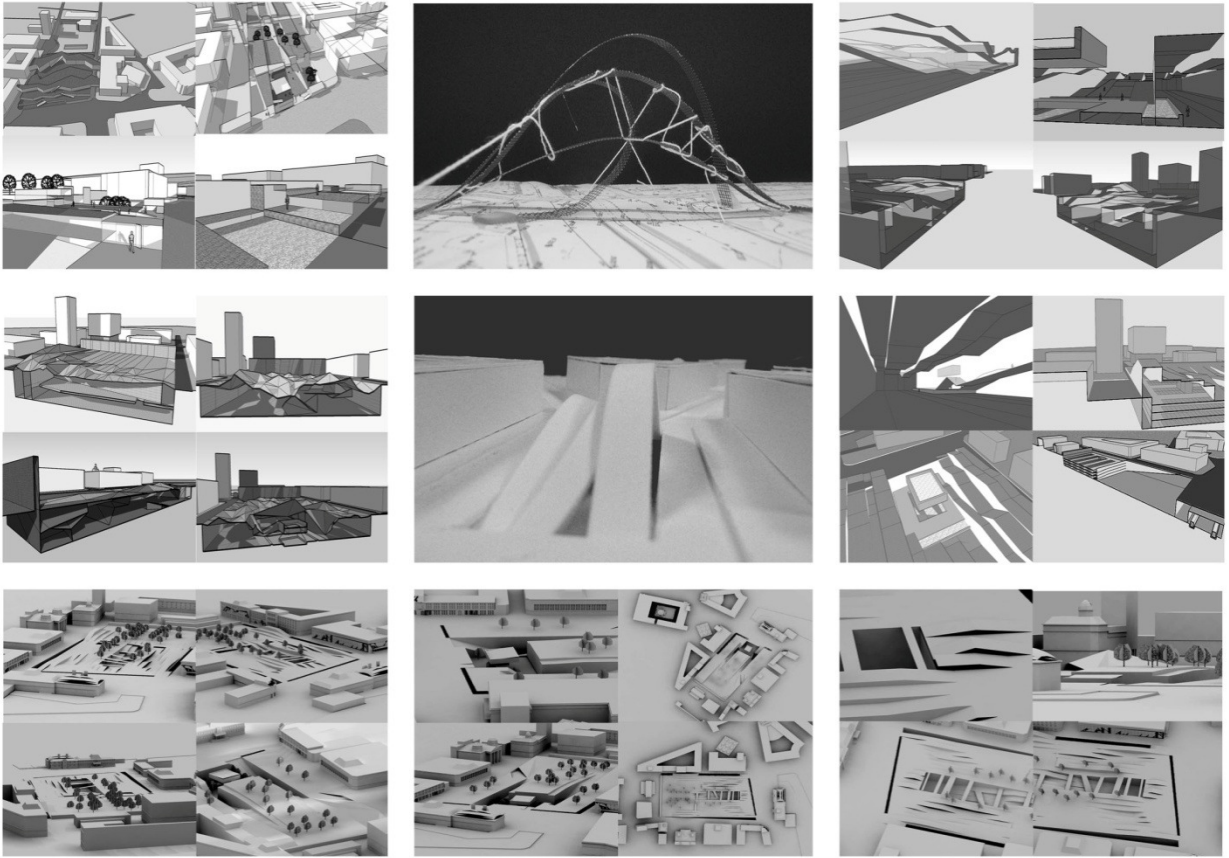
MORPHOLOGY STUDIES



VARIATIONS OF CONNECTIVITY



POSSIBILITIES FOR LOCAL URBAN SURFACES



Sometimes attaining the deepest familiarity with a question is our best substitute for actually having the answer.

Brian Greene