THE NEW FRONTIER FOR SUSTAINABLE DESIGN IN THE AGE OF INFORMATION: RAHM'S METEOROLOGICAL APPROACH TO ARCHITECTURE

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ABSTRACT

In various sources, the contemporary age is characterized by the issues of sustainability. In the field of architecture, sustainable design has created a new architectural discourse as well as a new domain which involve cutting edge computational techniques, processing information, and innovative formal repertoires. This study aims to answer several questions regarding the relationship between the changing form of science, energy and sustainable design: What is the future of architectural space? What will be the parameters of new architectural space? How do invisible and soft factors, such as humidity, light, temperature and air relate to the more general questions of space and the formation of space?

The above questions are investigated in the present study through the works of Philip Rahm whose tectonic logic crystallizes into new paradigms for architecture.   Rahm's overlapping ideas of epigenesis and parameterization create new typologies for architecture based on his motto, "Form and Function Follows climate." Rahm proposes a new life practice with a renewed idea of form and a fluid dimension of space in which he uses computation as a tool and environmental conditions as parameters. These parameters can be the material quality of the building location as well as the invisible condition of the human metabolism.

In the light of these issues, this paper argues that what is offered by such innovative and creative approaches to sustainable design is not just a new style or building material for architecture, but a change in the core principles of tackling design problems. This new way of dealing with design tasks requires a new conceptual framework, and formulating new aims, methods and values. Innovation in basic principles and methodologies creates a "paradigm shift" towards a dematerialized architecture, which in turn creates not only new forms of space but also new ways of living, as well as new perspectives to architectural design.

Keywords: Technology, Creativity, Sustainable Design, Philippe Rahm, Parametricism

1 INTRODUCTION: THE CHANGING WORLD

According to Kwinter (1993), after 1960s, especially after the emergence of "Soft Sciences", the focus has shifted from the physical to the fluid quality of spaces. This fluid capacity of interconnectedness, how the interacting materials correlate themselves to external movements has become of increasing importance throughout the years. This changing form of science, as Kwinter claims, also triggered a transition from *Age of Competence* to *Age of Performance*. In his essay, he argues that the techniques of mimesis,

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representation and reproducibility transformed into pragmatics and modeling where geometry has become a form of experiments. Some disciplines influenced greatly from these transformation both in theory and practice. It is not wrong to argue that Architecture is among those.

In 20th century, especially in the last quarter, it becomes harder to differentiate architectural movements since most of them overlaps with each other in timeline. Each movement has its own characteristics traced mainly on the visual qualities of form. Now in the contemporary information age, after the explorations of new forms and geometries in 1990s, the focus of interest is shifted from architectural forms to the underlying formulas and complex algorithms (Terzidis, 2006). In 21st century, computational techniques, formal repertoires and tectonic logics that are the main characteristics of this mainstream became more popular (Schumacher, 2009). When these developments in computer technologies, environmentalism, architectural theory and practice are taken into consideration, a new question rises concerning what the future of architectural space will be.

The relationship between architecture, human and environment has always been a critical issue mainly because the energy and health of people depend largely on the environment. In the mid-20th century, it was acknowledged that the physical environment consists many elements in a complex relationship. Olgyay & Olgyay (1963) describes the environmental constituents as light, sound, climate, space and animate which are directly upon human body that can either absorb them or try to counteract their effects. In 1980s and 1990s, as a consequence of this increasing concern, Green (Sustainable) Architecture was developed. Today, in literature, Green Architecture is considered as the other dominant movement of 21th century beside Parametricism.
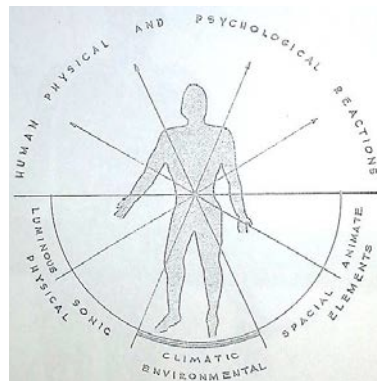

Figure 1- Man as the control resource in architecture (Olgyay, 1963)

Sustainability or Green Design is also one of the concepts that is transformed with the development of technology. Vicari (2003) states that it is difficult to establish a position against sustainability in architecture when it is defined as a set of design decisions that allow a more cost-creative design solutions that consumes less energy and does not impact environment in negative ways. According to him, sustainable morphology should work like a natural organism; its design including the formal qualities should be compatible with the environmental characteristics of the site, place and time. Parallel to this discussion, for Stang & Hawthorne (2005), Green Design is a flexible and holistic approach that involves making careful, ecologically conscious decisions at every point in the planning, design and construction processes. Two issues related with

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Green Design are the eco-friendliness and energy efficiency of building materials.

In this paper, it is argued that there is a transition of form from physical to physiological/atmospheric architecture which certainly changes the paradigms of built spaces. The aim of the study is to explore this transition of metric composition to thermal composition in Architecture. In order to analyze the alternative route this transition took towards sustainability, Philipp Rahm's experiments in this new domain which is called "atmospheric architecture" will be studied as a case study. The reason is mainly because his design parameters and constraints that shape the architectural space are set according to macro scale (such as the location of the building and invisible-soft- dimensions of space) and micro scale (such as the sensual and physiological relations between the residents and building) which are different. Each chapter revolves around certain research questions and how they are related with the bigger picture of environmentalism.

2 A NEW READING ON ARCHITECTURAL SPACE

> Architecture is as much about the event that takes place in a space as about the space itself.
>
> **Bernard Tschumi**

Erk and Uluoğlu (2014), brought the concept of space and its changing paradigms to the attention and introduced a conceptual framework to classify the theories of space in 20th century (Table 1). In their essay, studying through the works of Anthony Vidler, Michael Foucault, Paul Virilio, Henri Lefebvre and many others, they read the last century's architectural history through the development of spatial theories. According to them, in the late 19th century, when the concept of space entered architectural history, the interest was in "time" and the arguments were on temporality, history and historical styles. In the 20th century, the space has become a "timeless time" and the critiques were made on the spaceless and "spatially absent" rather than a history. With the rise of technology, late 20th century (to be precise after 1980s) is called "second machine age". According to Virilio, after then, both the concept of time and space has disappeared. "Digital space" has emerged as a "counter space". In the beginning of 21st century, the space has become a "temporal space" where the concept of time takes over the concept of space.

Space	Dominant Influence	Related Theorists	Period
Space	a new concept	von Hildebrand, Schmarsow, Riegl, Wölfflin	1890-1900
Modern space	Architecture as art	Worringer, Spengler, Brinckmann, Frankl, Sörgel, van Doesburg, Gropius, Wright, Le Corbusier, Lissitzky	1900-1930
(interval)		(Giedion, Zevi)	(1930-1960)
Place	Architecture as science	Rossi, Alexander, Lefebvre, Norberg-Schulz, Rapoport,	1960-1990
Digitally supported space	Architecture as technology	Rajchman, Virilio, Vidler	1990-present

Table-1 A classification of space theories in 20th century (Erk&Uluoğlu, 2014)

After looking at this evolvement of the concept of space and time, it is possible to argue that the understanding and construction of contemporary space is

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greatly affected by the "digital". In the last period 0f 1990s and beyond, the concern in architectural space is replaced with digital space based on computer-generated virtuality or computer generated form.

In contemporary architectural theory, the historical research into the origins of computational perspective has rare examples. Rocha (2004) is interested in the cultural, historical and technological contexts that influenced the emergence of a computational practice in architecture. Picon (2010) evoke critical thinking on the common conception of digital architecture by mapping the main issues linked to the development of digital design. In his recent work, Carpo (2011) developed a theoretical basis for the history of digital architecture by setting a perspective through the rise and fall of the paradigm of "identical" from the Renaissance.

After the computation's involvement with the discipline of Architecture, there were major changes in the relation between theory and practice (Rocha, 2004). These changes can be roughly categorized into three:

- The correlation between "software" and "architectural processes"
- The blur in the architectural processes with the involvement of rules of creation, constraints, definition of variables, emergence of forms and architectural criteria.
- The integration of the "software design" as a part of the design process and of theory development

Being parallel with the development of computational thinking, Schucmacher (2009) claims that after 2000s, there is a global convergence in avant-garde architecture that justifies the designation as a new style called "parametricism". This practice has been developing in the last 15 years and it succeeds Modernism as the next long wave of systematic innovation. These new techniques, such as form-finding tools, as well as parametric modeling and scripting- have inspired "a new collective movement with radically new ambitions and values". He explains that parametricism- which succeeds modernism as the second long wave of systematic innovation is a new style rather than a new set of techniques. When we look at this bigger picture, Erk and Uluoğlu's argument about whenever the tools of Architecture changed, it renewed the idea of form is supported. Architecture after computational turn was no exception.

The development of technology and the increase usage of computational means in the design process transformed the discipline of Architecture into a platform where other disciplines come and work together. As a consequence, architecture's responsiveness to both human and environment became an issue. In the process, design approach has changed and new materials emerged. Pavilions are the structures that experiment with new materials and methods. That's why, in contemporary age, pavilions transformed into an interdisciplinary field which is shaped by the algorithmic thinking and modeled by advanced technology and computational means. With the environment becoming a forefront of architectural debate at the end of last century (Fieldson, 2004) and parametricism becoming the single style for avant-garde practice today (Schumacher, 2009), paradigms which adopt these two has become. In the following examples, how computational means are adapted in a climate-based design approach in pavilions are going to be explored.

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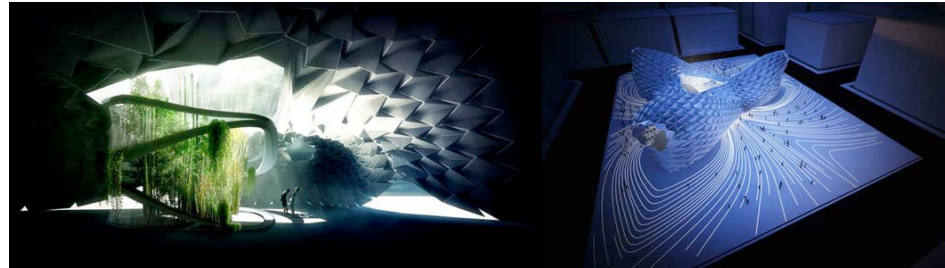PARIS SORBONNE UNIVERSITY
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Figure - 2 The Breathing Shelter (2013) (Source: www.arch2o.com)

The first example titled as "The Breathing Shelter", which is designed by Rhina Portillo and Matthias Urschler in 2013, is a pavilion that is designed to adjust to different climate conditions. Its main feature is "flexibility to its environment"[1]. It has 3 modules that are able to *breathe* independently, reacting according to interior needs. The model interacts with the airflow which balances the interior temperatures by taking in and exhausting air and changes its basic position depending on the season. Airflow in the interior is controlled by the folded surfaces on the skin which open or close according to weather conditions. To reduce the amount of energy consumed by the act of conditioning the air, the overall building shape can reduce its volume in winter in order to prevent heat loss and can enlarge it in summer which challenges the idea of envelope as a static thing. But in the end, as designers indicate, the sole purpose is to *"design a responsive envelope that provides an ideal interior environment for a building located anywhere"[2]* so the focus is not the human in the interior of the structure but the envelope as controller of interior comfort.

Figure - 3 HygroSkin, meteosensitive Pavilion (2013) (Source: www.archdaily.com)

The second project called "HygroSkin – Meteorosensitive Pavilion", which is designed by Achim Menges in 2013, uses the responsive capacity of the material (wood) in relation to content of moisture which opens and closes in response to weather changes. As it is in nature of the material, the mechanism doesn't require operational energy or any other kind of mechanical or electronic control

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[1] http://smashingreader.com/eVolo_s62257_p13 (last seen: 30.06.2014)

[2] http://www.arch2o.com/breathing-shelter-university-of-applied-arts-vienna-rhina-portillo-matthias-urschler/ (last seen: 30.06.2014)

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— *the material structure itself acts as a machine*[3]. Robotically fabricated planar plywood sheets that have climate-responsive aperture placed within interact with its surrounding environment. This responsive material system adjusts the porosity of the pavilion in direct response to changes in ambient relative humidity within a range from 30% to 90%, which equals the humidity range from bright sunny to rainy weather in a moderate climate. Climatic changes trigger this responsive quality of wooden skin. Here material computes form in unison with the environment[4] and its responsiveness to climate is achieved by mechanical means.
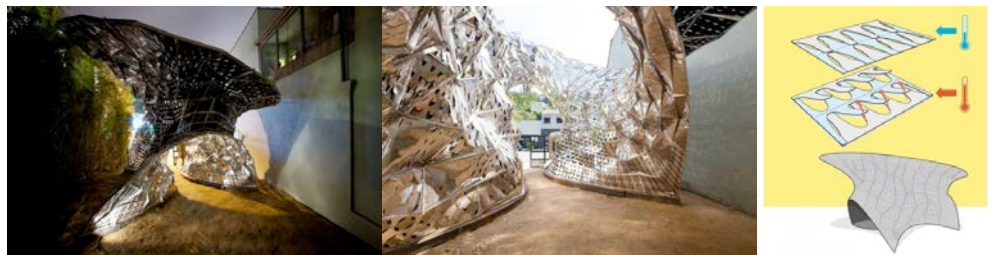

Figure - 4 Bloom Pavilion (2013) (Source: http://www.trendhunter.com/trends/bloom-pavilion)

The Bloom Pavilion is a material experiment which is made out 14,000 smart thermo bi-metal tiles in a tunnel like shape in 2013. It criticizes the permanency and static nature permanent of Architecture and with this approach, it has a similar structure as a plant with a skin that reacts to the amount of light and heat that touches it[5]. The responsive structure of the pavilion is constantly changing under the climatic conditions as it gets more radiance from the sky. The skin of the pavilion has two different materials which have different heat coefficients: The outer side of the tiles has a higher percentage of manganese and iron, which quickly weathered into a rust color, while the inner side has a greater amount of nickel, giving it a silvery finish[6]. When the heat is applied, it causes materials to curl.

In all of these climate-based design examples, what they offer is a different unique convergence of environmental experience provided by the new relationship between exterior and interior while addressing the problems of shading, ventilation and interior comfort. The common thing in these pavilions is they are designed by computational means; material behaviors under certain temperatures, airflow and humidity in different weather conditions are all computed by computers and the result shaped the form of the structure. But in all of these climate-based designs, the focus is on skin only and "people" are secondary to form. All the care was given to skin whereas the "surprise" interiors are left undesigned. As an alternative approach to the examples above, in Rahm's Digestible Gulf Pavilion (2008), the skin was secondary to human comfort in space and the envelope was so insignificant that there is almost no skin at all.

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[3] http://www.evolo.us/architecture/novel-mode-ff-climate-responsive-architecture-hygroskin-%E2%80%93-meteosensitive-pavilion/ (Last seen: 30.06.2014)

[4] http://www.archdaily.com/424911/hygroskin-meteorosensitive-pavilion-achim-menges-architect-in-collaboration-with-oliver-david-krieg-and-steffen-reichert/ (Last seen: 30.06.2014)

[5] http://www.trendhunter.com/trends/bloom-pavilion (Last seen 30.06.2014)

[6] http://blog.archpaper.com/wordpress/archives/52706#.U7AOybFosmt (Last seen: 01.07.2014)

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Rahm claims that in order to face the ecological concerns, architecture should extend the other dimensions and other perceptions - *from physiological, sensorial and gastronomic to atmospheric, meteorological and climatic*[7]. Starting from this idea, 'Digestible Gulf Stream' was designed as a prototype that works between *the neurologic* and *the atmospheric* and developed like a landscape that is simultaneously *gastronomic* and *thermal*[8]. Rahm argues that architecture is a thermodynamic mediation between the macroscopic and the microscopic, between the body and space, between the visible and the invisible, between meteorological and physiological functions. In this sense, thermal comfort depends not only on the temperature of the space but also on clothing and physical activities taking place in it.

Figure - 5 Digestible Gulf Stream (2008)

In this pavilion, there are two horizontal metal planes which are located at different heights. The lower plane is heated to 28°C, the upper one is cooled to 12°C. With this, a natural movement of air (convection) is used in which rising hot air cools on contact with the upper cool sheet and, falling, is then reheated on contact with the hot sheet, thus creating a constant thermal flow, akin to an invisible landscape. With this approach, rather than physical spaces, architecture is literally structured on a current of air which creates fluid, airy, atmospheric spaces.
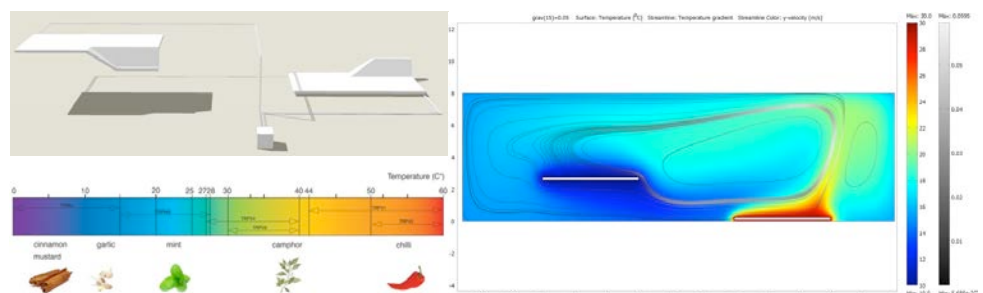

Figure-7 Digestible Gulf Stream; convection

In this pavilion, what Rahm offers is a new approach to spatial practices which is similar to nomadic life. The inhabitant may move around in this atmospheric landscape between 12°C and 28°C – the two extremities of temperatures of comfort- and has a freedom to choose a "climate" according to his or her activity, clothing, dietary, sporting or social wishes.

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[7] http://www.philipperahm.com/data/projects/digestiblegulfstream/index.html (last seen: 26.06.2014)

[8] http://www.philipperahm.com/data/projects/digestiblegulfstream/index.html (last seen: 26.06.2014)

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When we compare the previous examples and Rahm's "Digestible Gulf Stream", although they all have an environmental approach to architecture and use computational tools in the creation of their designs, with Rahm's creative out-of-the box thinking, it differs from others in great sense. Even so, when we look at the latest designs, we can see that this creative approach hasn't been adopted by other architects and designers. The most probable reason may be "aesthetic concerns". Since architecture is a discipline where "the outlook" has extreme importance, Rahm's pavilion utterly fails in the aesthetic realm since it doesn't have anything to 'show-off'. Stang and Hawthorne (2005) argues that architecture is a field, like fashion, where style matters more and more and is separated from the man on the street less and less with each passing year. Rahm's new reading of architectural space and building materials is going against this mainstream which makes it significant to study. But then, how do invisible and soft factors such as humidity, light, temperature and air relate to the more general questions of form and formation of space?
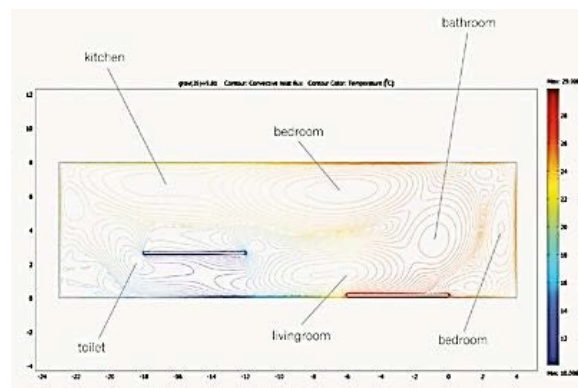

Image8. Digestible Gulf Stream; typology

As the age of Competence has changed into Age of Information, how the energy is used in architecture also changed in this transition period. In the past, energy could only be used through mediums such as energy panels and there were limited HVAC solutions for the environmental control. Today, energy can be used without any need of such mediums and buildings can accommodate to climatic and even hourly changes in the atmosphere. In this sense, with the help of computational and information technologies, two different types of "environmental architecture" emerges: The first one is about the ongoing developments on sustainability in terms of heat insulations and renewable energies that has ecological objectives. As an alternative, Rahm proposes a second type of sustainable architecture that is rethought with meteorology and climatic phenomena such as convection, conduction, pressure or evaporation in mind.

Rahm sees the building as an "atmosphere" and argues that there is a need to correlate the relations between biology, physiology and ecology. The starting point of Rahm's projects are to link building techniques to sustainable development. While doing so, he avoids adapting these techniques to a preconceived architectural project. In his "architecture of void" where boundaries and structures blurred, architectural forms are generated according to the building techniques.

Tschumi (2000) argues that function does not follow form, form does not follow function or fiction though form and function certainly interact with each other.

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With a similar approach, Rahm argues that "Form and Function follows Climate" due to the interrelation of humidity levels, temperature and air circulation and architectural space. In his designs, he considered both the macroscobic scale (the environment) and microscobic scale (human metabolism). The aforementioned cases above are several examples of Rahm's atmospheric architecture. In all of them, a flexible, nomadic life-style is proposed for the inhabitants. The interpretive spaces are organized according to the immaterial qualities of space such as air, light, temperature and humidity. Without parametric modeling and computational tools, it would be impossible to compute the atmospheric qualities of space that are vital in these projects. Another point to mention is that, these projects are mostly depicted with plans and sections. It is hard to see any elevations except few even though there are lots of diagrams and images. The main reason is skin of the building is secondary to the inhabitants and their daily practices and the experience of building itself.

3 CONCLUSION: TOWARDS A NEW DOMAIN OF ARCHITECTURE

> Every new material means a new form,
> a new use - if used according to its nature.
> **Frank Lloyd Wright**

Erk and Uluoğlu (2014) argue that every revolution comes with a technical revolution. In 20th century, with the industrial revolution, machine technology was changed. With the digital revolution in 21st century, the information (software) technology is transformed. These changes influence not only architecture but also how humans interact with the environment and eventually how they live.

In Rahm's approach to architectural design, the space is based on this relationship between architectural space and digital space. The unique characteristic of his works is that, as in soft sciences, the building materials such as light, air, temperature and humidity are interconnected by a series of chemical, physical and biological transformation. The main argument of this article is that these new (un)materials transformed the conception of space in which the mass is secondary to void. As a consequence, this creative use of soft qualities of space made a paradigm shift since the terminology, design methods and even the materials of architecture has changed.

The importance of this article is according to two main factors:

- The computational technologies provide new tools and techniques to create spaces. Even so, since the discipline of architecture is like fashion, projects started to separate further from people more and more while building skin became more and more dominant. In order to create environmental buildings, architects should design spaces instead of skins.

- Meteorological Architecture of Rahm where the invisible takes presendence over the visible (Rahm, 2009), atmospheric dimensions of architecture in which unseen and soft factors of architecture are explored. With this approach, Architecture shifts towards the atmospheric, the biological and the meteorological where the human in the space becomes a dominant figure once again.

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This brief study on Rahm's creative approach to architectural space suggests a connection between the formal implications of invisible tools of architecture and the significance of this new approach to environmentalism as Rahm claims that "the design of the atmosphere is now the domain of architecture".

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http://www.philipperahm.com/data/projects/convectiveapartments/index.html (last seen: 04.07.2014)