of moisture and water away is architecturally framed in such a way that it becomes the very reason and logic of moisture and water production.

CONCLUSION

While this architecture embraces the notion that all nature is constructed, it turns this concept on its head. It does not simply frame and juxtapose nature, but rather produces the very site of nature's production and its concept thereof. Architecture-as-frame opens up the possibility of superstructural effects or imaginaries to emerge and unfold at the very site of the production of space and nature, at the site of encounter of technological, social, and cultural processes. The superstructural effect or the aesthetic dimension of this architecture is not so much the result or extension of superego, but rather the result of disparate juxtapositions and conflations of technological, natural, and cultural *readymades*. Shrouded in a vague mist of condensed water, the domestic body is wrapped with a layer of geothermal topography that silently, yet persistently furnishes and connects with the social body. The domestic body becomes social. This is not only an optical body but also a dermic and thermal one: It emerges in between the eye and the skin. The spatial and thermal production of this body participates in a social process of exchange, conversion, and volatile entropic production. ◆

ENDNOTES

1. Neil Smith, in the Foreword of *In the Nature of Cities: Urban Political Ecology and the politics of Urban Metabolism*. Edited by Nik Heynen, Maria Kaika, and Erik Swyngedouw. London: Routledge, 2006, p. 3.
2. Reyner Banham, *The Architecture of the Well-Tempered Environment*. University of Chicago Press, Second Edition, 1984, p. 312.
3. Reyner Banham, *The Architecture of the Well-Tempered Environment*. University of Chicago Press, Second Edition, 1984, p. 312.
4. Luis Fernandez-Galiano, Fire and Memory: On Architecture and Energy. MIT Press, Cambridge, 2000, p. 248.
5. Reyner Banham, *The Architecture of the Well-Tempered Environment*. University of Chicago Press, Second Edition, 1984, p. 302.
6. Mark Jarzombek, Eco-Pop: In Praise of Irony, Hyperbole, and Readymades, in *The Cornell Journal of Architecture*, Volume 8, 2010.

Natural and Artificial Light as Energy: Experiments in Space

OBSERVING LIGHT

It is not uncommon for light to be designed for either a daytime experience or a night experience: on the one hand, there is a sophisticated architectural window (an opening or envelope treatment) through which one can enjoy patterns of sunlight, and on the other, there is avant-garde light art[1] "designed" for dark environments capable of emphasizing neon, fluorescent, or simply dramatic light expressions.

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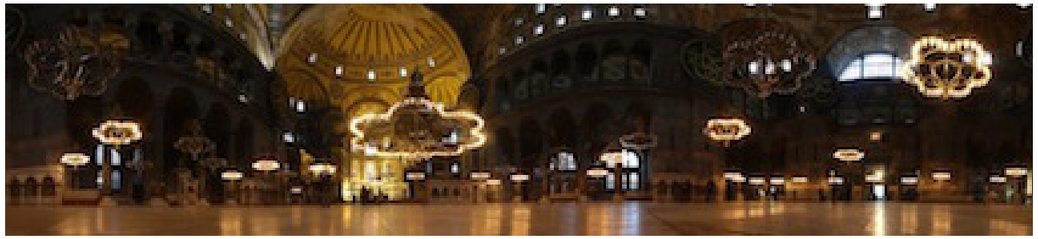
An interesting example of a historical building, to reflect upon this polarity, is Aghia Sophia in Constantinople. Aghia Sophia's multiple levels of fenestration expand one's visual perception to register the church volumes through sunlight, creating a divine experience during daytime. However, once the sun starts to set, the newer addition of Muslim (artificial) lights interrupts the experience previously described through a surface of light constellations[2] forming flower shapes and circles that now dominate the vision while excluding or dismissing the original spatial experience (Fig. 1).

Another light polarity is the relationship between light pollution and lack of light. Light pollution happens usually due to the excess of light (e.g., in cityscapes during nighttime or through a computer screen's illumination). Lack of light occurs in northern climates along with health problems such as vitamin D deficiency and depression. In both situations, the biological cycle of humans is either interrupted or appears in irregular patterns. Scandinavia, as well as any place in the Arctic or Antarctic cycle, constitutes an interesting case study to explore the limits of having more or less light, as people—being born, growing, and living in these geographies—have problems adjusting to the extreme light conditions.

LIGHT AND THE IMMATERIAL

Sociobiology explores ways in which light affects the body (e.g., how moon patterns affect human cycles or habits), as well as the effect of light in positive (or negative) emotions, the average essential human needs for light, and so on.[3] Architecture and other forms of spatial practice need to engage in their discourse such questions through studies



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of space and the environment in relationship to the well-being of people. How can spatial light, as a major participant of the immaterial,[4] create spatiotemporal registrations—places where one slows down to observe where the ice is melting, where heat is way too strong, where a refrigerating condition is re-created in a desert? What are the properties of structures that define the energies that light carries? Is there a soft envelope of space, sensitive enough to capture and expose the micro-ephemeral changes? Where is (light) energy being held and released in space? How can one feel this when passing through the space, and, therefore, how can one expand his or her personal bubble or apparatus?[5] It is almost inevitable that one's isolation in the desktop environment and work-life detachment from the fields of nature requests the need for space to be the apparatus to map these ever-changing conditions of the world.

EXPERIMENTING WITH LIGHT

As a response to the polar or extreme[6] conditions described, this paper seeks design solutions that explore light continuities between natural and artificial that act as energies to people in space. It essentially defines light by associating it with (patterns of) energy and survival, hoping to reverse the possible transition from light as necessity to light as surplus. Light as an energy carrier may eventually become a "go back to the core" response to the request for sustainability. Light in relationship to energy can be compared to food, which can also be (re)positioned between survival and surplus.[7] An illustrative example for this is the transition of taste from a protective sense, from poison and other dangers (e.g., bitters), toward the potential loss of taste that comes along with processed food and other conditions.

A research initiative that explores spatial light as an essential need is Zitofos. "Zitofos" is an invented word, composed of the three parts "zi," "to," and "fos" (ζει, το, φως) or the two parts "zito" and "fos" (ζήτω/ ζητώ, φως), which, when pronounced in Greek in a phrase, mean "lives the light" and "Hooray, light" or "I ask light," respectively. Zitofos inaugurates the above exploration with the conduction of 56 (initial) table experiments (Fig. 2) studying light along with different materials and methods of manipulating it. By understanding how light responds to the various materials and forms and how those materials and forms accept and transform light, either as natural or artificial, the research aims to identify potential shapes, textures, densities, and transparencies that can be used as architectural elements in space. The experiments cluster around the following themes: water, ice,

Figure 1: Aghia Sophia, Constantinople. Photo by Marcelo Soria Rodriguez.

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and light; peddles and light; bending light; reflective materials and light; constructing fiber optics; magnifying glasses and light; mirrors and light; and fiber optic nets and webs. The documentation of the experiments, as well as the analysis of the results, is archived at the Zitofos website.[8]

In a series of experiments with artificial light, solid transparent plastics (e.g., ready-made objects of Plexiglas or pieces of Plexiglas) are tested in relation to their ability to diffuse the light (e.g., experiment 18), bend (or not) the light (e.g., experiments 14–16), split the angle of the light (e.g., experiment 50), change the angle of the light when finding an obstacle between the light and the material (e.g., experiment 15), project/reflect the light outside of their mass (e.g., experiment 32), make light travel through their thickness (e.g., experiment 51) without losing its intensity, and so on.[9]

Most of the experiments using natural or artificial light and having natural, transparent plastic or reflective materials have shown that light manipulation occurs in three phases: collection of light (to be transferred to the desired place), transferring of light (since it cannot arrive there by itself), and diffusion of light (for "homogenous" lighting). In the case of collectors, solutions include simple mirrors or magnifying glasses "absorbing" the sunlight and directing it to the target, stable systems with reflectors, or structures with layers of transparent materials that act as "lenses." For light transferring, questions cluster around the quantity of light that can travel, the losses of light in different media, and the possibility of condensing the light to travel (e.g., fiber optics). Finally, the experiments related to diffusion explore different materialities and textures that can help light be distributed in space evenly (e.g., the current use of curtains in homes). The development of those experiments evolved to *Photodotes*, where the scale of experimentation moved from the table to space (of a gallery).

PHOTODOTES

"Photodotes" means "light donors." It is the plural form of the Greek φωτοδότης ("giver of light," "luminary"). *Photodotes* is a series of spatial structures that explore the transmission of natural light energy from

Figure 2: Zitofos experiments.

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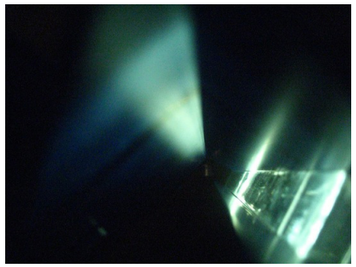

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outdoor spaces to underlit indoor spaces through fiber optic cables. They are architectured to perform in the three aforementioned stages: collecting, transferring, and diffusing light.

PHOTODOTES I: LIGHT IN STRUCTURE

Photodotes I,[10] a site-specific installation, was installed in Brant Gallery of Massachusetts College of Art and Design (MassArt) between January and May 2012 as part of the *Garden Lab* exhibition (Fig. 3). *Photodotes I* consists of spatial elements of mixed materials (plastics, fiber optics, and metals) that display light emission in a blue "origami" modular structure while being light-wired to two sources: outdoor daylight and indoor artificial light. The "machinic" configuration of *Photodotes I* is demonstrated as follows:

Collect: The installation has two light sources: the natural sunlight, collected in the roof of South Hall in MassArt, and the artificial LED box, to be used when there is limited or no sun (cloudy days and nighttime).

Transfer: The light (either natural or artificial) it is transferred via the fiber optic cables to the origami structure, found in the dark, underlit space. The fiber optic cables act as light veins, which give light to the origami structure.

Diffuse: The origami structure is an alternative to the black-box solution often used to expose light. It is designed as a freestanding element of space that can be reconfigured in different forms (wall, cave, surface, and so on) based on locations, needs, and desires. The flexible system configuration consists of folded triangles that provide the dark area (the alternative to a black box), a niche for the light to be seen and diffused.

The change of the light patterns in the usually dark, ill-lit gallery is hard to capture with human eyes, especially during a short or single visit (Fig. 4). For this reason, *Photodotes May-Day*, a 24-hour video documentation, was created.[11] The video is a time-lapse animation of approximately 1,440 photographs, taken every minute for the period of one day/night. From the video, it becomes clear that both natural and artificial light (sources) participate in creating the interior space—light patterns in a cycle more similar to the sunlight cycle experienced outdoors. Through this inseparable duality of natural and artificial, *Photodotes I* essentially proposes a holistic approach to light design. While *Photodotes I* does not necessarily solve any problems related to lack of light, it makes people aware of the effects of light on bodies and space. Having the art as a departure point, the installation aims to reveal or emphasize the essential capacity of light in the built environment and the well-being of people by augmenting the individual and collective perceptual mechanism.

PHOTODOTES II: LIGHT WITH PLANTS

To further understand the effect of light on bodies and space, a series of table experiments were conducted (experiments 100–104). The focus of these experiments is in the third stage of the light transmission sequence, that of diffusion. In particular, the series involve the use of plants as an analogy to human beings. (Also, this is an effort to identify the suitable elements of such prototypical structures.) The hypothesis of this experimentation is

Figure 3: *Photodotes:* structural elements and architecture that "emit" light. Photo by Dominic Tschoepe.

Figure 4: Sunlight traveling 100 feet to arrive in the origami structure via fiber optics.

that light transmitted in space via fiber optics could indeed become energy for plants to survive and grow (e.g., experiment 102). At the same time, this opens up research possibilities for edible structures, interior gardens, modular structures, potted plants, hydroponics, and so on. The experimentation uses water instead of soil in order to provide a good medium for the light to diffuse. The first plants selected for this experimentation are scallions. In addition to scallions, the experiments use water, fiber optics, glass or plastic vessels, and light. Both direct and indirect ways to transfer the light are tested.

Photodotes II: Light Garden[12] is a collaborative installation (Fig. 5) aiming to grow plants in water containers in the (dark) Brant Gallery at MassArt. It is a hybrid structure, a three-dimensional garden that consists of plants, fiber optics, plastic containers, water, and light.

The installation is at the same time a two-part intensive workshop. Initially, the participants create and present their personal substructures by sculpting each of the containers with different criteria or "manifestos," such as to allow growth toward different directions, to follow the form and the intentions of the plant, to help the plant coexist with other plants, to "force" symmetrical development, to create vertical planting, or to change the functions. The second part of the workshop includes the collaborative assembly of the individual garden clusters toward the creation of one (circular) garden space. The collaborative character of the installation registers individual craftsmanship and a signature expression of each author.

Photodotes II is based in smaller experiments, including machines that deal with growing light, stealing light, hydroponics, and plants. Through collecting, transferring, and emitting natural light, *Photodotes II* helps plants to absorb energy in order to develop. Similar to the table experiments previously mentioned, plants are used both as a model system for living organisms and for their potential function to become food energy sources themselves. Through this chain, *Photodotes II* becomes a greenhouse environment that offers light energy in dark places, proposing a new type of sustainable architecture.

LIGHT AS ENERGY

Zitofos and *Photodotes* experiment with light not as a medium not to create effects but to energize space that was previously inactive. The use of both natural and artificial sources (with emphasis on the natural) creates the continuity of patterns throughout day and night. The research acknowledges the need for space occupants to obtain or/and reinforce their biological rhythms to sustain themselves.

NATURAL AND ARTIFICIAL FORCES OF THE IMMATERIAL

Beyond Zitofos and *Photodotes*, in the recent dual exhibition of Hans Haacke and Otto Piene at MIT List Visual Arts Center, there is an evident relationship between space and the immaterial, form and natural or/and artificial invisible forces.

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Figure 5: Photodotes II: Light Garden helped plants absorb solar energy in order to develop. Photo by Dominic Tschoepe.

Hans Haacke's re-created artifacts capture and map the immaterial elements of the environment—wind, light, motion, and gravity—through the manipulation of elements such as nature/soil, textile, and liquids. Haacke has been dealing with physical and biological systems, such as living animals, plants, and physical states of water and wind,[13] since the early stages of his career. The use of water and air in his work links this involvement with Group Zero,[14] which often worked with kinetic materials.[15] At the same time, the exhibition space seems to be a symbolic, abstract representation of the environment, such as sun, sea, hills, and some man-made objects. In this stage, one can observe patterns of change, rhythms of aliveness. Things are simple but interesting, scientific but humorous, rich in form but never stable.

In this either symbolic or pragmatic but definitely energetic field, it is hard to create barriers between the natural and artificial states of things and forces. What is the role of technology in this human-made landscape? On the one hand, the "natural" wind comes out of a machine, the fan, and the "natural" green is geometrized in a conic configuration. This machinic nature (of the fan, the motor, the precut or industrial volume to host the liquid, the growing grass, the seeds to be grown) constantly shapes the intangible, the forgotten (in the industrial time of the '60s), the immaterial elements of space. On the other hand, the man-made fabric fluctuates in space like waves, and the hellion balloon fights with gravity, both shouting toward the creation of well-crafted objects allowing the existence of blowing masses, zephyrean fields,[16] airy movements, soft sounds, repetitive rhythms, and other phenomena that are usually unobservable.

How much artificial reaches the real? Both natural and artificial states participate in the construction of a constantly evolving landscape. The design of the exhibition itself plays with this idea of nature or natural. Even the reveal of the usually covered window in the gallery participates in this natural-artificial dialogue by reminding viewers of the presence of real nature, one of the MIT outdoor yards. In a way, the ambience is differentiated from that of the next-door, dark *Lightballett* wherein life, as light, is born in darkness and evolves in the room.

IMMATERIAL LIGHT PATTERNS

Before coming to the two MIT shows, visitors of these exhibitions had probably already experienced *The Divine Comedy* exhibition in the area and most likely had challenged their spatial perceptual habits through Olafur Eliasson's *55 Machines*.[17] Initially created 50 years ago, Otto Piene's progressive (light) machines would seek new, nontraditional ways of making art, as a response to what was believed to be the era of painting's death. Reconstructed for MIT and astoundingly contemporary, *Lightballett* (meaning "light ballet") suggests the possibility of an architecture not made out of blocks, bricks, or concrete pieces but constructed through the orchestration of quiet, calm sounds and soft light movements that choreograph the ever-changing rhythms and patterns of space; it is experienced in darkness and silence through projections, reflections, illuminations, and glows that evolve and flow into energy, infinity, imagination, and memory.

Lightballett is an inspirational and innovative light-based sculptural work that constructs space through a multisensory artistic experience. Its creator, Piene, is a pioneer of multimedia and technology-based art; his work often uses light, smoke, fire, fire, air, and other intangible media. As the exhibition's curator, João Ribas, explains:[18]

Light ballets as light performances … Otto Piene: Lichtballett highlights the artist's exploration of light as an artistic and communicative medium … causing what he described as "the steady flow of unfurling and dimming, reappearing, and vanishing light." These light machines evolved into kinetic sculptural environments of mechanized effects.

What are the instruments of this spatial orchestra? *The Electric Rose* (1965), a polished aluminum globe covered with neon light bulbs that emit light in four sequenced phases; the two interior lamps of *Light Ballet on Wheels* (1965) that continuously project light through a revolving disk; the sculpture *Electric Anaconda* (1965), composed of seven black globes of decreasing diameter stacked in a column; the site-specific *Lichtballett* (2011), a wall sculpture; and *One Cubic Meter of Light Black* (2010–2011). These pieces are synchronized through an original score composed by the artist for his first light performances in the 1960s. In his exhibition talk at MIT, Piene praised silence through the soft qualities of his score:[19]

One enjoyable phenomenon that was kind of new was silence. The war was incredibly cacophonic, incredibly dramatic and disastrously loud; and silence was something that was almost new to me. So the silence that comes from the light ballet was, to me, something really important; it was an artistic phenomenon that was almost physically present and enjoyable. So that's also what I see in the night ballet and I did write some sound for the light ballet but is very basic and is certainly not cacophonic.

In *Lightballett*, the artificial light, along with "natural" sound and movement, starts to shape space. Can this anti-cacophonic spatial light cure people's war (and other) traumas or simply improve well-being? Can architecture invent machines that can map those small changes, the subtle, not loud movements and sounds that perhaps can cure war (and other) traumas?

NATURAL AND ARTIFICAL LIGHT AS ENERGY

In the case of both the *Photodotes* experiments and the MIT exhibitions, the natural forces, including light as well as other intangible media, play with the man-made machines and environments. They create spatial maps of those essential microchanges that register continuities between natural-artificial and exterior-interior conditions. One could say that *Photodotes* and Piene's and Haacke's machines start to define the energies that are being held and released in space. The immaterialities that define this architecture are directly and indirectly explored and documented or possibly integrated in this architecture's structures similarly to other mechanical systems, louvers, and so on, reaching the occupants through varying modes, both artificial and (mostly) natural. The spatial elements eventually become living structures and environments that affect the human cycles, participating as catalysts in the improvement of well-being. ◆

ENDNOTES

1. Architecture and art are used here to "caricaturize" the two extreme approaches.
2. All positioned at the same height, defined by a previous version of lighting with candles that need to be reached by those who light them.
3. Smail, Daniel Lord. *On Deep History and the Brain* (University of California Press: 2007).
4. Hill, Jonathan. *Immaterial Architecture* (Routledge: 2006). As the author explains: "My concern is not the immaterial alone or the immaterial in opposition to the material. Instead, I advocate an architecture that embraces the immaterial and material."
5. Harvard ecologist Edward O. Lifson talks about the experience of night in a rain forest in Brazil as an experiment on sensory deprivation. While we transfer light from one space to another, we can seek for the kind of space in the transfer zone.
6. That is, having or not having light.
7. The research is inspired by models of symbiosis, cooperation, or coevolution between human hunters and animal prey, in gift economies—foraging cultures where animals and humans are coparticipants in the energy circuit.
8. Zenovia Toloudi, Zitofos, online blog.
9. Most of these experiments can be found under the label of transparency at Zenovia Toloudi, Zitofos, online blog.
10. *Photodotes I* credits. *Design: Zenovia Toloudi. Research: Zenovia Toloudi, Ute Meta Bauer, George Toloudis. Construction: Zenovia Toloudi, George Toloudis, Panagiotis Stamboulidis at Stamboulidis Panagiotis Workshop in Alexandroupolis, Greece. Gallery Installation: Zenovia Toloudi, Dominic Tschoepe, Dimitris Papanikolaou. Exhibition Curators: Evelyn Rydz, Jonathan Santos.*
11. Steven Lemanski and Zenovia Toloudi, "Photodotes May-Day," Vimeo website.
12. *Photodotes II* credits. Idea and project instigator: Zenovia Toloudi. Research: Zenovia Toloudi, George Toloudis, Ute Meta Bauer. Light Garden Collaborators: Dominic Tschoepe, Amir Banihashem, Dimitris Papanikolaou. Exhibition Curators: Evelyn Rydz, Jonathan Santos. Workshop Assistants: Yamilah Kenny, Christian Keebler Restrepo. Participants: Lydia See, Brianna Dawes, Juliet Demasi, Colin Cardinal, Anika Catterfield, Georgia Kennedy, Julie Chen, Hayden Lemire.
13. "Past Exhibitions," MIT List Visual Arts Center website.
14. Group Zero is an international group of artists.
15. Caroline Jones, *NYARTS Magazine.*
16. Name borrowed from Project on Spatial Sciences/ Etien Santiago.
17. Similar play among the natural-artificial can be found in Olafur Eliasson's recent work where natural phenomena are constructed through artificial means. Nature grows in artificial forms. It has been said that there is no such thing as artificial nature; it is just nature.
18. João Ribas, "Otto Piene: *Lichtballett*," *Notes and Queries*, João Ribas, online blog.
19. Otto Piene, "Otto Piene: *Lichtballett, Hans Haacke 1967: Artist Talks*," MIT List Visual Arts Center website.