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## Upgrading Design: A Mechatronic Investigation into the Architectural Product Market

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Upgrading Design:  
A Mechatronic Investigation into the Architectural Product Market

by

Matthew Gaboury

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Architecture  
School of Architecture and Community Design  
College of The Arts  
University of South Florida

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UPGRADING DESIGN:  
A MECHATRONIC INVESTIGATION INTO THE ARCHITECTURAL PRODUCT MARKET  
MATTHEW GABOURY  
ABSTRACT

It was first stated 200 years ago, and reiterated numerous times since, that “architecture is frozen music”(see note). While this romantic analogy sufficiently satisfies many in the realm of architecture, it actually is a sad way of defining an idea so inherently lively. Goethe’s quote conjures up the notion of a world that is silent, one in which we can see the notes but never hear the music because we are trapped by stasis in time. Like the note admired on a piece of paper, architecture in this world is static regardless of the changing conditions around it.

What if the “frozen” part could be removed from this concept, and the element of time could play an active role in the built environment? An architecture that can exist in a sense of time is one in which the musical note can be played. Through the ability to change with time and be changed by time architecture can directly respond to its inhabitants, environment, and contextual factors. A rich melody of interaction can

then be initiated in which the built world can talk back.

Naturally, the first point of this contact would be the building’s façade, and it is here that there is the greatest opportunity to reach the largest audience. The outer “face” of a building has always been a feature of significance for both designer and customer. For centuries the ornamental features of a building were what distinguished its purpose and place in society. From the elaborate pediments of the Greeks to the intricately carved reliefs of the Italians, the ornament of a structure told a static story about the creators and inhabitants of the structure. Now, the technology is available to make this aspect of architecture talk to us by becoming a dynamic, interactive, and kinetic component.

In order for this façade system to transcend the boundaries of conventional architecture it must utilize precocious architectural means, methods, and materials. These new communication systems include, but are not limited to, touch, light, sound, and electromagnetic fields. As any of these stimuli are perceived by the façade, it

can have the ability to react proportional to the input. Essentially, the façade system will be able to customize itself depending on the conditions presented. Similar to a computer operating system, the new façade will provide a generic mass producible platform that can be individualized by its user. The users of this system may be the architect, client, occupant, viewer, environment, regional context, technologic connection, or global community, depending on the specific installation. And most importantly, both the user and the façade have the capacity to be changed or altered at any time, meaning that the fundamental characteristics of the project will never be frozen. In this manner, the new architectural ornament will go beyond the static nature of its predecessors and become one that the viewer can actively communicate with.

# THESIS OBJECTIVES

The goal for this project is to design a system of modules that can be programmed at different scales and in alternate ways to make customizable facades. Ideally, the façade should have the ability to be manipulated to match the conditions presented. This means that at every stage of its conceptions and implementation its must be able to change to meet the needs of the particular situation. Allowing for programming opportunities (both in the traditional sense and in a more progressive manner like open-source implications) is one of the prime ways that this will be accomplished.

Thesis strives to answer the following questions:

- How the exterior of a building interacts

with the viewer, client, and surrounding space?

- How does technology effect/influence this interaction?
- How can an interactive display become integrated into the building's architecture and not be simply a billboard posted on a building?
- What if a building could be upgraded with the click of a mouse?
- In what way can the public play a proactive part in the appearance of architecture?
- The new generations of people are native to the digital age. What types of media do they create and use
- How can the above answers influence the style of modern architectural ornament?



In doing so, it will address the following issues:

- Programming Scales:
- Types of interaction
- Dynamic elements / Time-based media
- Production means and methods
- Computer integration
- Module design
- Customization
- Sustainability

#### Modern ornament

- What is the modern conception of architectural 'delight'? One of the objectives of this project is to answer this question and explore new ideas to make architecture appealing in a temporal sense. Since the face of a building has historically tended to portray the greatest concentration of ornament, it is fitting that this new façade system have inherent features that allow designers to shape aesthetics.



Fig.1. Thesis poster design

# ORNAMENT OF ARCHITECTURE

John Ruskin points out in the second line of his book *Seven Lamps of Architecture*, "it is necessary in the onset of all inquiry, to distinguish carefully between architecture and building" (3). What then, is architecture? Perhaps the most basic definition of architecture was written in about 25 BC by the ancient Roman architect Marcus Vitruvius. In his book titled *The Ten Books of Architecture*, Vitruvius writes that architecture must provide "utility, firmness and beauty" (18). Later, in the 17<sup>th</sup> century Sir Henry Wotton paraphrased those sentiments and listed "commodity, firmness and delight" (203). These basic elements of true architecture have remained essentially unchanged since antiquity. In order for a building to be classified as architecture, it must possess all three of these features.

Another useful definition was written by Louis Kahn who believed "architecture is what nature cannot make" (24). Humans are not the only creature that builds. Indeed some structures built by birds, bees

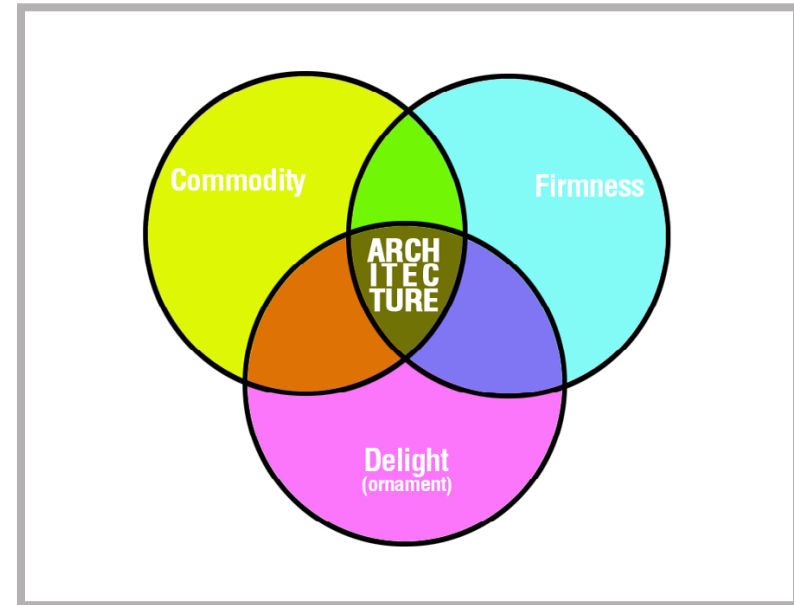


Fig.2. Tripart architecture diagram - architecture lies in the combination of the three key vitruvian elements; commodity, firmness, and delight



Fig.3. Nest of Rufous Breasted Castle Builder (Roth 1)

and sea mollusks, to name a few, are much like human engineering in their economy and form. The Rufous-Breasted Castle Builder of South America weaves two chambers connected by a cantilevered tube, creating a double-chambered nest in the form of a dumbbell (Ruskin 78). Certain North American bears create a den structure that is ingeniously constructed and insulated to withstand the harsh weather of the tundric regions. Yet none of the creations produced by animals constitute architecture. Even though what these creatures build shows brilliant utility and, in some cases,

outstanding firmness, they all lack Vitruvius' third element of architecture. They have no features designed purely to delight our senses and inspire our minds. As Sir Henry Wotton stated, this missing third element is delight, the most complex and diverse of all components. It involves how architecture engages our senses, and how it shapes our perception and the enjoyment of our built environment (101). This is perhaps the area with which most people, architects and users alike, have difficulty.

Similar to the animal dwellings, many of the houses we live in and the buildings we encounter on a daily basis are missing the fundamental element of beauty. They contain rooms or offices and tower into the sky, but do nothing to appeal to our eye. These buildings are the product of strictly functional and economic pursuits. They fail the ultimate test of architecture; not appealing to the senses and providing a full measure of satisfaction or enjoyment.

One of the primary ways an architect corrects this problem and adds beauty to a building is through the proper incorporation of ornament and decoration. The term ornament is often tainted by contemporary use of the word itself. Ornament comes loaded with conflicted and even negative connotations. Some pair 'ornament' with lavishness, trivia and excessiveness while others choose to relegate it to a history of repertoire frozen in time (Bloomer 16).

Prejudice has, of course, skewed the understanding of other fundamental terms over time, as well. Up until recent decades, the word 'sex' was attached



Fig.4. Siena Duomo facade ([www.shafe.co.uk](http://www.shafe.co.uk))

closely to a negative stigma and steeped in connotation. Likewise, in the start of the 20<sup>th</sup> century, the word 'feminine' was synonymous with weakness and inferiority. Not to mention the laundry list of ethical and derogatory terms employed as vernacular. It is not odd then that the word 'ornament', which was praised for centuries, is now in question (Bloomer 17-18).

The English word ornament, originated in Latin as 'ornamentum'. The modern meaning, found in Merriam-Webster dictionary, is "something that lends grace or beauty" (546). The term, by most accounts, originated from the Greek "Kosmos", which meant something like "order, universe and ornament" (397). Through this root definition, we can confer that the Greeks felt the use of ornament lent a high sense of order to that which it adorned. From an architectural viewpoint, ornament and decoration encompasses all of the elements that are consciously added to strictly enhance the visual perception of a place.

A fairly simplistic metaphor for architectural ornament is fashion in respect to clothing. Clothing is a necessity, and at a basic level a woven burlap sack will suffice. However, a Prada suit would be much more pleasant. Where the burlap sack would provide Vitruvius' utility and firmness, it would fall short in the beauty department. The designer suit would, conversely, provide the trifecta. Clothing serves, fundamentally, to protect the body. Fashion, however, serves to enhance the image of the body. In the same way, ornament adds a visually

stimulating element to a building, raising it to a higher level.

This metaphor can be extended to the physical manifestation of most ornament as well. Since, the exterior of a building usually contains the majority of its ornament, its tangible expression can be compared to the clothing of an individual. The common phrase, "the clothes makes the man", applies in this way to the facades of a building as well. Many structures have similar layouts or programs, but it is the way in which they are wrapped, or dressed, that gives them distinguishing architectural features. In this way, it is the fashion of the building, the way the designer chooses to cloth their structure, that makes the largest impact on the way it is perceived.

At this juncture, it is proper to make the important distinction between ornament and decoration. To the layman, these two terms are often intermingled and frequently confused. Architecturally speaking, these two terms represent two separate forms of sensory enhancement. Ornament is the more powerful medium of the two in an architecture sense, and also the one that is harder to grasp. Ornament is dependant on the structure and has a symbiotic relationship with the architecture.

If we compare a building to a culinary dish and an architect to a chef, ornament would be one of the main ingredients used in preparing a meal.

Ornament is built into the essence of a structure, if a building's ornament is removed; it no longer functions in the same way. Likewise, our chef's recipe is changed and the dish tastes different. On the other hand, decoration is added after the fact and is independent of the recipe. It is added for additional flavor, to only enhance the existing ornament and other structural elements of the meal. Almost comparable to a condiment, sea salt or cracked pepper, decoration is the finishing touch. An important distinction should be made here with respect to Vitruvian theory. A structure which includes decoration but no ornament is simply a utilitarian building. A structure that possesses firmness, utility and ornament on some level, however, can be classified as true architecture, even if it lacks any sort of decoration.

Decoration can be seen in such features as the way in which a building is painted, the choice of furnishings or in other interior décor selections. All of these elements are interchangeable and designed wholly to suit any occupant's needs. Decoration should not be dismissed as an unimportant feature of design, however. Especially in the context of the interior of a space, decoration has a powerful ability to enhance the look and feel of an area (Smith 87-91). Most architecture is not meant to be immediately inhabitable, as most dwellings require the addition of decoration in order to be comfortably occupied.

Distinguishing the ornament of a building is a slightly harder task. However, as noted earlier, all construction that demonstrates the three key Vitruvian

functions contains some incidents of ornament. Even modern architects who eschewed ornamentation in their designs, like the International Style, inadvertently made their sleek post-modern buildings into rather large architectural ornaments by default. The buildings of glass, straight lines and cold concrete are viewed as large functional sculptural ornaments and monuments to the industrial age. Adolf Loos denounced the use of ornament vehemently by stating "ornament is crime" (Loos 10). Yet, even he created structures that embody unique forms and that let the stark nature and simple lines of the materials become their own ornament. Modernism championed an aesthetic of stripped-down or unorthodox ornament, but not one completely devoid of it. The reasons for using ornament in this way directly reflected the changing collective thought of the time period.

Even in Modernism, architecture without ornament architecture loses an invaluable feature. It is only through the incorporation of all the necessary architectural elements that we are graced by the divinity of "utility, firmness, and beauty" (Vitruvius 18). Ornament is a tool that is impossible to eliminate from an architect's palliate. Although its manifestations may change with the ever-evolving concepts in art and architecture, at the core it will remain the same. Ornament, undoubting, plays with the human psyche's ability to perceive the underlying order in a seemingly chaotic realm (Smith 10-13). "The brain

has a task to obtain knowledge about the world...and architectural ornament provides the needed stimuli to challenge the brain" (Smith 11). Through structure and utility architecture appeals to the rational left side of the brain, but through the device of ornament architecture communicates with the non-verbal right side of our brain.



Fig.5. Adolf Loos, Baker house 1928 (Loos 59)

This symbiotic relationship between the two halves allows architecture to connect to us in a way no other medium can. Architecture is the fusion of science and art, and ornament is one of the agents that aids in harmonizing the two into a unified whole. When the two are adequately combined, the result is "architecture that goes beyond utility...that creates drama out of stone" (Le Corbusier 151). Vitruvius' classical trifecta (utility, firmness, and beauty) is inseparable from the idea of ornament. We, unlike any other creature, ornament where we live, where we worship, and even where we are buried. "Man might well be described as the 'ornamenting animal'" (Bloomer 122). Such behavioral traits are strangely and exclusively Human.

# THE PRODUCT PARADIGM

## THE PRODUCT PARADIGM

In times past, if you wanted something specific, you either had to make it yourself or find someone capable of doing it for you. The individual item was custom produced to meet the standards of the client, and its performance depended on how well the production went. This business paradigm fostered a market where availability for personalized goods was low and price was high. Yet if you managed to acquire such goods, each distinct piece had an idiosyncratic significance to the individual. In many respects, the architect has been providing this type of service and producing this type of product throughout the history of the profession.

When one contracts the services of an architect, a process is initiated where the client becomes the driving factor of the design. An architect acts as an agent for the client in producing the desired outcome. During this process, the needs and desires of the client are of prime focus to the architect and at any point the client may choose to change, remove, add, or discontinue any

aspect of the project. It is purely a one to one loop of cause and effect, with the client being at the beginning of the cycle, the building at the termination, and the architect as the mediator.

However, the recent exponential proliferation of technology and changes in the mode of human life have begun to rendered this singular production model obsolete in most other industries. The desire for personalized products is still prevalent, but the means to obtain and produce them has undergone a profound paradigm shift. No longer is the individual craftsman the sole source for customized goods and specific needs. Instead, new production methods have enabled large corporations to cater to the individual desires of the client. The dichotomy between the mass produced product and the custom crafted good is no longer distinguishable. Whether it is a pair of sneakers or an automobile, the consumer only has to visit a store or log-on to a computer to procure a variation that suits their personal needs.



Companies like Nike and Converse now offer online services where you can design your footwear to match your personal requirements and aesthetic preferences. A myriad of color patterns, sole style, laces, and embroidery options make it possible that no two people have to wear identical shoes (http://Nike.com). And this paradigm is not restricted to just the footwear market. Almost every major industry, from “have it your way” at BurgerKing to “On demand” programming through Comcast, have embraced the personalification of their mass produced product.

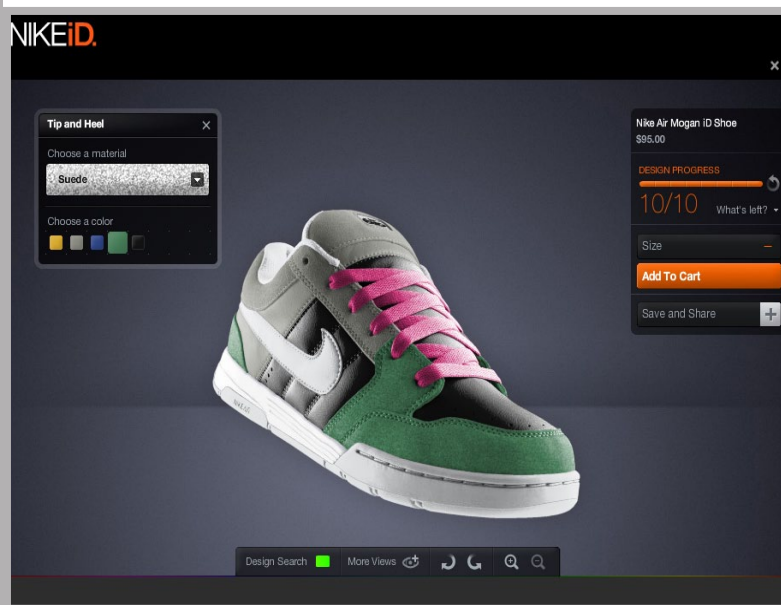


Fig.6. Nike Shoe - the above shoe was designed on Nikeid.com for the sole purpose of this thesis.

This individualization has allowed these multinational corporations to play the part of the craftsman. Yet, there production model is still that of efficiency, automation, and the monetary bottom line, which enables the price and time of the product to be less than that of the traditional craftsman(Barro 133-138). The technologic improvements of manufacturing and communication allow for this customer/corporation dynamic to happen relatively easily for both parties, with both simultaneously benefiting from the experience. Worldwide, customers have become accustomed to the availability of goods and services that they feel an emotive attachment to because of this new business model. The personalized product has exceeded its once trendy or exclusive beginnings to become the social norm for the average customer, and it has done so in a means that is economic.

It is this notion of economy where the modern conception of architecture fails to correlate with the successful business model of the aforementioned industries. While architects are indeed providing a service of personalification, they fail to deliver a product that is produced in an efficient and cost effective manner (Pressman 22). The realm of architecture has stayed exceptionally static in this regard throughout the course of its existence. The vast majority of buildings constructed are entirely site built with little or no prefabricated components. For example, only 2 percent of the total number of buildings constructed in the United States are made with prefabricated methods, and as a consequence 30% of the total amount of material delivered

to a building site ends up in the dumpster (ask tim for source). It is now time for the way in which buildings are constructed to be radically changed. As Dr. Fisher, designer of the world's first kinetic skyscraper, states, "It is unbelievable that real estate and construction, which is the leading sector of the world economy, is also the most primitive. For example, most workers throughout the world still regularly use trowels that were first used by the Egyptians and then by the Romans. Buildings should not be different than any other product, and should be manufactured in a production facility" (qtd. in Time 44)

#### THE ARCHITECTURAL PRODUCT:

Taking cue from other industries, it is now time for a profound shift in the way clients shop for buildings and how architects dictate the production. The means to produce a building should be addressed in the same manner that many other major industries do so; incorporation of a system of efficient, replicable, sustainable, and multi-faceted components that enable the creation of designable artifacts. A system that favors mass producible parts is key to reducing the overall workload of the architect in design development and the days of the labor intensive on-site construction. As in many other genres, the realm of architecture

must embrace the technology of the future in order to progress. One of the means that architecture can accomplish this is through the concept of the "architectural product" and how it applies to the design and fabrication of buildings. Currently, there are numerous manufactures of building materials and systems, but very few companies producing complex performance components (<http://arch-products.com/>). Through the study of high performance aftermarket products prevalent in other industries one can make numerous correlations to architecture in categories that include: Mass production means, fabrication methods, materials, quality control, improving safety standards, performance modification, target audience application, designing for upgradeability, reaching mass markets, and sustainability.

Data from these product studies can then be synthesized into the design and application of specific architectural components that can aid in the proliferation of a high performance building product market that supports a new culture of design and construction. Ideally, having a more comprehensive product market could help transition the architecture industry into one which produces higher quality building with less effort exerted by the architect and contactor. In addition, having the support of manufacturers that continually upgrades and improves their product line allows designers an easy opportunity to incorporate future change into their initial conception. The notion of 'designing for adaptability' is instrumental in creating a sustainable structure that will outlive its original occupants or intent.

## UPGRADABILITY:

Contrary to what many believe, architects are not omniscient. Their ability to see the future and predict the upcoming demands of a project is quite small. Most are limited to the immediate information given to them from the original client. However, the lifespan of the architect's building may exceed that of client or the client's need may change down the road, either of which may dictate a change in the desired function of the original building. Unfortunately, the static nature of architecture is a hindrance to this desired change and usually is not very easily adapted to meet the altered expectations. A structure's inability to adapt to the evolving demands placed upon it perpetuates a cycle of demolition and rebuilding (McDonough 23). The waste of this cycle could be avoided if the process could be prolonged by a structure which is easily be manipulated.

One way that a building could easily adapt is through the use of components which are initially designed to do so. Products that are made to be upgraded by the manufacturer are a guaranteed way of insuring that there will be an entity in the future that is capable of addressing that specific aspect. A prime example of this is the computer industry and the conglomeration of different manufactures that collaborate in order to make most PCs. If an individual purchases a computer from say Dell, not all of the parts that make that

machine are made by Dell. The processor may be made by a company like Intel or Amd, the graphics card by NVidia, the Bluetooth module by Toshiba, and so on and so forth. If the person's needs change and they want a computer that performs faster, they do not need to buy an entirely new machine, they can just purchase upgraded versions of individual parts. A new Intel processor and upgraded ram may satisfy the individual's immediate needs at a much lower cost, and without the waste associated with throwing away all of the parts of the computer that still perform up to their standards. This solution may not be the final one, but it does extend the life of the original product and save the customer non-necessary expenses.

Another additional benefit to a manufacturer designed upgrade is that it removes the necessity of the original architect in the process. Once a building is complete, the services of the architect are limited. Not all architects are interested in business renovation. The ability of the client to find affordable assistance in adapting the building can be a major hurdle in having the work done. However, a manufacture that is continually upgrading their product line should have no hesitation assisting the previous customer in becoming up to date. Referencing the previous example; if Dell went out of business, the individual looking to upgrade the performance of their computer could still do so because the parts that they required were designed, produced, and distributed by companies independent of Dell. Although it still would be a prerequisite for the original designer of the thing (computer



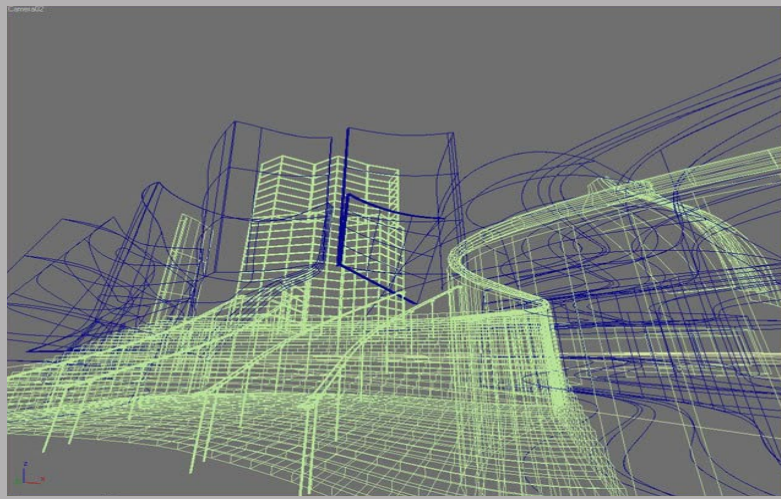


Fig.8. Catia model of walt disney concert hall

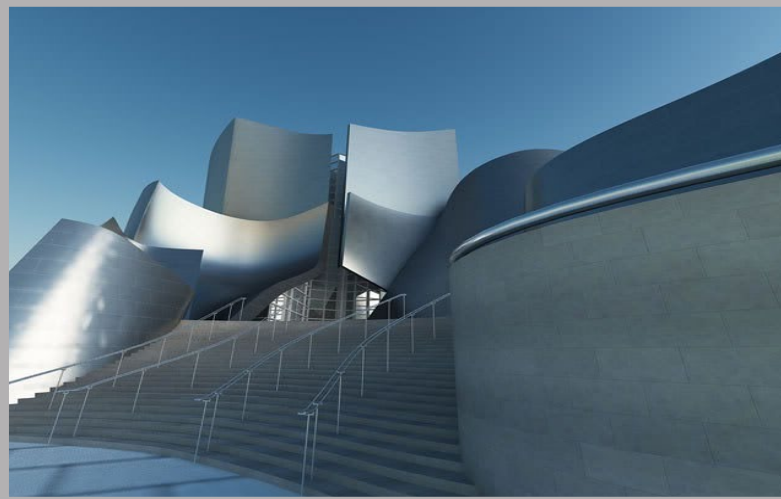


Fig.9. Catia rendering of Gehry concert hall

are all highly developed means of productions that are non-mobile. Complex computer fabrication techniques with these tools are instrumental in making the advanced architectural elements of the future and only available to implement remotely.

“Integrating computer-aided design with computer-aided fabrication and construction fundamentally redefines the relationship between designing and producing”(Mau 193). In 1981, Dassault Systemes of France invented a new software platform called CATIA. This innovative program gives manufactures the ability to simulate different industrial design processes from the conceptual phase through analysis, simulation, assembly, and maintenance. It has since percolated throughout the industrial realm and has established itself as the worldwide standard in product development. It is the most used software in the aerospace, shipbuilding, automotive, plant design, electrical and electronics, consumer goods, and fabrication and assembly markets (Need CATIA source). CATIA along with IBM and Boeing are responsible for the new generation Boeing 737, which is being classified as the most technologically advanced commercial aircraft to date. From designing to building, and even aerodynamically testing, the whole process of making an airplane was reconsidered. Dassault Systemes gave Boeing engineers and designers the ability to visualize each part of the aircraft as a solid image, then simulate the assembly on screen, easily correcting miscalculations and other fit or non-compatibility issues (Travi 19).

Even though this powerfully software application has a proven track record in projects like the Boeing 737, is the benchmark tool in a wide spectrum of technology and production fields, and enables industries to perform unprecedented tasks, it has been almost completely ignored or underutilized in the architecture profession. Currently there are only a handful of architects that utilize the CATIA software in their firm's design protocol. One of which is Frank O. Gehry, whom uses the computer-modeling aspect of the program in the development of his structurally complex building. Without CATIA, the realization of projects like the Experience Music Project or the Walt Disney Concert Hall would not have been feasible. It was only through the use of this software that many of the complex elements of his building could be designed in-office and then sent to an off-site production facility to be precisely fabricated through automated processes (Mau 193). If more architectural product manufactures incorporated CATIA software, it would become easier for architects to use the powerful features of the program in their design work, while also benefiting from all the positive aspects of prefabrication.

#### COMPUTER INTEGRATION:

In the sphere of architecture, the possible applications of the computer go far beyond design and

production. While its use in these phases is of great value (as demonstrated in the previous examples), there are many other aspects of the completed building that could be enhanced through computer augmentation. Global society has embraced the computer in a multi-faceted manner, welcoming its presence into almost every aspect of life. So too in architecture, computer application can be integrated into the tangible artifact itself in ways that have not yet been explored.

The personal computer has opened up dialog between places and people that were once completely devoid of connection. And it has done this in a manner that is fast, effective, and extensive. Through means like email, Twitter, instant messaging, and social networking sites, machines around the world can interact with a multitude of other machines. It is time for the computer to enable the occupant to communicate with their physical surroundings on a more personal level. More complete architectural integration could give the user greater control over their environment, and allow for the customization that is expected in our modern society. No longer should architecture be exclusive and elite. The more control the occupant has of the architecture, the greater their ability to adjust it to fit their needs. A computerized system of control is one approach that could enable that connection with the building in an efficient way. Buildings designed in this manner don't merely enable people to develop their own ways of responding to the architecture, they are actually enriched by them doing so. As people become architects

of their own spaces (through use of mechanisms like computer interaction) the word “architecture” ceases to be a noun: instead it becomes a verb (Haque 46). Such an architecture is explicitly dynamic, a shift that opens up a wealth of poetic possibilities for designers of space or form.

#### THE INTERFACE:

How the communication occurs between the user and building is very important. In order to accomplish this new technological enhancements are necessary. Technologic enhancements, however, are complex and can create self perpetuating complexities as a result. Good design augments human possibility and reduces complexity. “When we have problems interacting with technologies, it’s a direct result of our not having asked the right questions in the design process. To be effective, we must shift our focus from the techno-centric to the human-centric” (Bill Buxton, qtd in Mau 99)

We operate by making using the collective memories of a lifetime of experiences. Cognitive abilities enable us to logically analyze things. Motor/ sensory abilities enable us to perceive and navigate through the world. Social abilities enable us to acts as members of a society. All together, these abilities are not only critical and valuable, but they essential make

us human. A properly designed interface addresses these innate humanistic qualities.

Every school today teaches its students how to perform long division based on the principals of the decimal point brought to use by the Indians. The chronograph enabled seaman to determine location and navigate celestially. The microscope allowed us to see a world that was invisible to the naked human eye. The telescope brought the stars into reach of our vision, and let us explore space. Imagine the delight in the experiences that exceptionally crafted musical instruments, paintbrushes, cars, and tools provide to us. Now think about computers. They also have the ability to profoundly augment human capacity. Yet in order to do it well, the information about human qualities must match the technical knowledge of engineering. The human must be balanced with the technological or else innovation becomes, as Henry David Thoreau stated, “an improved means to an unimproved end” (47). The challenge in creating an interface to interact with architecture is as great as the potential. (Mau 99)

# INTERACTION MANIFESTO

## INTERACTION MANIFESTO

The term 'interactive' is widely used in our society. Yet, most do not analyze what 'interactive' means and if what is presented is actually performing in an 'interactive' manner. Many times the phrase 'hi-tech' is used synonymously with 'interactive', but the two are not interchangeable; something can be 'hi-tech' and not the 'interactive' (and vice-versa). Technology simple enables interactive properties to be obtained easier and in a more efficient manner through smaller special, temporal, and interrelated scales.

From an architectural point of view, a building degrades and breaks down over time; environmental factors chip away at walls, rust steel, and warp wood. Is the building 'interacting' with the environment? Many would contest that the it is not 'interacting' but simply 'reacting' because the effects are not reciprocal between the building and environment. Other than possibly at the sub-molecular level, the building is not having any effect on the environment. There is no circularity

because the building falling down does not directly influence the behavior of the environment. Causality is easily ascribed in this example because the event is happening in a linear fashion and in a single direction (Haque 2). At its core, interaction concerns two or more entities mutually exchanging energy (i.e. between two humans, between two machines, or between human and machine) (Manovich 45). The key however is that these transactions should be in some sense circular otherwise they are what artist and engineer Jim Campbell calls "merely reactive" (7).

Consider the following example: When you withdraw money from an ATM (cash machine), is it an interactive experience? (you input in some information and the desired amount of money is returned – closing a circle). Before answering that question, lets first consider what happens when we go into the bank to withdraw funds and actually talk to a live bank teller. We walk up to the counter, provide the teller with the appropriate information, and then get the requested amount of cash from the person. Even though it is rather simple, a two way exchange of



information has happened that resulted in both parties getting what they had anticipated (Haque 2).

This idea of getting what is expected is instrumental in this transaction. There is an interaction, in means of a transmission of information across a divide that has resulted in a reciprocal thing being given back to us (Haque 2). Yet, the instructions that we gave the teller were expected (though it came from a list of possible standard scenarios) and in return we got what we expected (a sum of money). Some may call this type of transmission 'interactive', but it is, in my opinion, the weakest form of interaction. The strict boundaries that the process adhered to make it not nearly as interesting as some other forms of interaction.

The process that an individual goes through with an ATM is very similar to the teller in that there are a fixed set of inputs and the machine produces a set outcome depending on them. This can also be seen in the mechanical systems in a building, in which a thermostat allows a user to set a desired temperature and the system attempts to match the spatial conditions to what was requested. In these case, both input and output criteria are predetermined solely by the designer of the system. This kind of interaction is what designer Usman Haque calls a "single-loop interaction"(3).

A significantly more rich interaction occurs when we actually engage the bank teller in conversation. This might be about some local news, or concerning a specific financial issue that needs to be addressed,

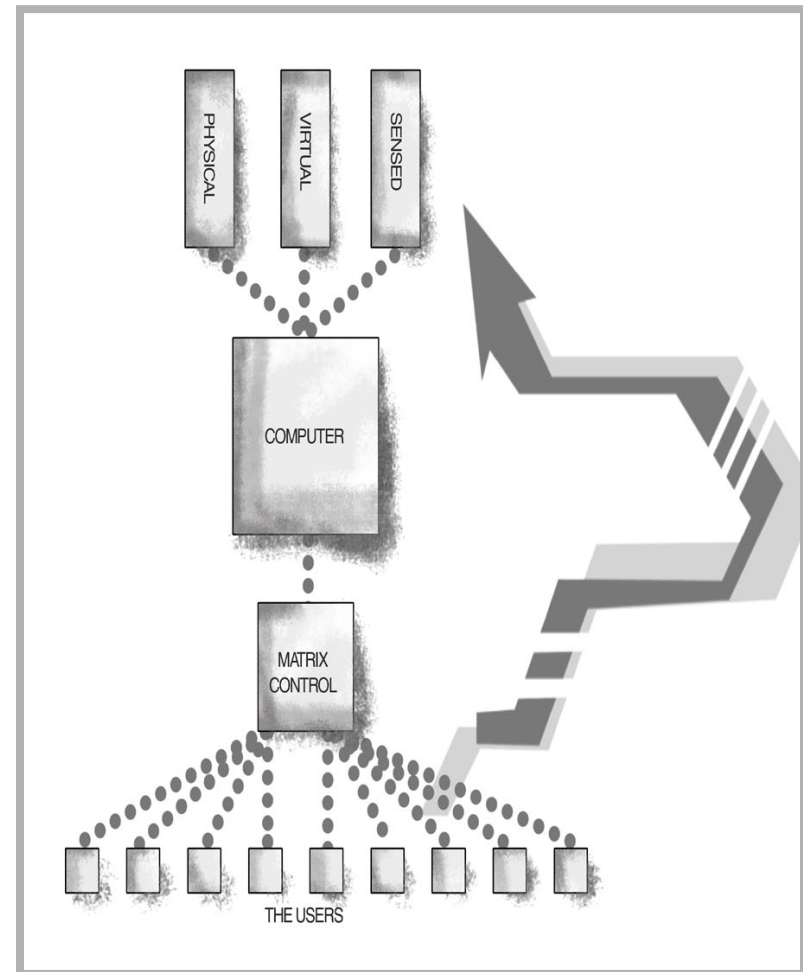


Fig.10. Interaction diagram - the nature of true interaction is continuous and circular, but not necessarily always verbal or linear

or simply just personal banter (which may happen after become familiar with the person). The important point is that the platform of the interaction is open, and through communication a connection is formed that is stimulating and productive. In this process new information will probably be delivered, which may benefit either party or simply further the ease of future interactions. Many psychologists and anthropologists have suggested that it is our propensity to encourage continual interactions that make us 'human' (Haque 3).

In such Haque-like "multiple-loop" interactive systems, causality is much more difficult to ascribe than in merely reactive systems: A provokes B, but B affected A in the first place, in a self-repeating loop. It should be noted that hi-tech thermostat systems such as those that take into account other environment input data are not necessarily "multiple-loop" interactive systems. "Multiple-loop interaction is not dependent upon complexity, it depends upon the openness and continuation of cycles of response. It also depends on the ability of each system, while interacting, to have access to and to modify each other's goals" (Haque 3). This is the kind of interaction that is just not present in a cash machine; it is, although, an interaction that I believe is possible to achieve with machines.

In the three different scenarios: one in which there was no interaction; a second in which there was interaction, in quite unrefined terms; and a third in which there was a productive and continual interaction. It is my

contention that the third scenario is most fascinating and also the most constructive in terms of designed spaces and architecture. If the desire is to have the user of a building to have the sensation of agency and of contribution, then the most interesting situation would be a system in which individuals create their spaces through "conversations" with the environment they inhabit, where the progressive compilation of interactions builds new possibilities for sharing goals and sharing outcomes. In such architectural systems, the occupants themselves would be able to establish what is the most efficient criteria. Only in a system like this would the Merriam-Webster's definition of interaction being "mutually or reciprocally active" actually occur ([www.m-w.com](http://www.m-w.com)).

#### GORDON PASK

"There's no such thing as input or output. . . Every process produces a product. Every product is produced by a process."

- Gordon Pask. *An approach to cybernetics*, 1961.

Gordon Pask is most noted as being one of the pioneers of cybernetics. However, the Englishman was also a prominent scientist, inventor, designer, academic and author. His contribution to the study of control and

communication of both natural and mechanical goal-driven system has become the foundation for the modern conception. Of primary importance are his concepts involving second-order cybernetics as a basis for viewer, interactions, and participants in cybernetic cycles (Holland, Husbands, Wheeler 122).

In 1968, the curator of London's ICA, Jasia Reichardt, held an exhibit entitled 'Cybernetic Serendipity' in which Gordon Pask was the keynote presenter. The interaction loop cybernetic systems on display at the show became the inspiration for many future interaction designers. Exhibits like Pask's SAKI, where stimuli initiate forces on the environment that lead to sensing and additional actions, established the basis for the Paskian environment (Reichardt 34-36). He is also credited with the Conversation Theory, which is possibly the most productive theory on multi-participant and common framework interaction.

Pask's influence and involvement in architecture dates back to the early 1960s, with the majority of the work being performed with the Architecture Association in London and the Architecture Machine Group at MIT (now known as the Media Lab). One of Pask's notable early projects was the Fun Palace, where he worked as the resident cybernetician for the architect Cedric Price. This project is considered to be the first example of an architectural system that operates on the theory of underspecified goals. Through the use of numerous automated systems and devices, the building was

able to use the modified behavior of the inhabitants as a feedback control. Not only did the building act on the occupants, the occupants acted back. If the user wanted change, the architecture could be altered to do so. The building as tool conditioned human behavior but it also served the individuals changing intentions (Haque 46-48).

While Pask's direct contributions to architecture established a foundation for dynamic, responsive and authentically interactive environments, they were seen by many as far too ahead of their time to be fully appreciated by the profession at large. Fortunately, the extent of Pask's other research, writing and artifact design/construction was massive. The huge collection of theories and experiments provides ample fodder for creative inquiry into architectural interactive systems. One such project of interest is a construct built in 1953 titled The MusiColour Machine.

The MusiColour Machine was a performance device of actuators that illuminated in concert with audio stimuli provided by a human performer. Unlike the popular disco lights of today, MusiColour did not simply respond directly to audio in a preprogrammed or predetermined manner. Conversely, Pask's invention analyzed the frequency and rhythm produced by a musician, then outputted a unique light response. The nonrandom multicolored manipulation produced by the machine enabled it to become another performer in a performance. From moment to moment the MusiColour would be continually adjusting its output depending on the rhythms and frequencies it could hear. If, however, the audio input became overly static

or consistent, the machine would become bored and change the criteria for output. The MusiColour “listened for certain frequencies, responded and then got bored and listened elsewhere, producing as well as stimulating improvisation, and reassembled its language much like a jazz musician might in conversation with other band members” (Haque 48).

The interesting aspect of this project is that the output action (multicolored lights) only occurs after the users (the performers) enter into a conversation with the machine. Due to this, the process is varied enough to keep the musician engaged but not varied to the point of appearing totally random. The way in which the criteria of novelty and boredom are calculated is key to the system (Pask 144-145). This is continually re-quantified depending on how an individual responds to a response. An architecture constructed with this sort of system differs greatly from the efficiency oriented methods commonly used by ‘reaction’ based environmental systems. Pask’s concept would constantly promote novelty and enable interactive relationships with human users.

Many of today’s interactive systems are not nearly as rich and complex as the creations of Gordon Pask. Most of the modern machines are prescriptive in their reactions, producing deterministic responses in a disingenuous manner. These systems contain a finite amount of data that the user simply wonders through until it has all been revealed. The concept of these

works is actually rooted in the philosophy pertinent of the industrial revolution; user does x to machine, machine responds with y action. It is unsustainable because the machine is ultimately going to experience situations it was not preprogrammed to process (Haque 48). Therefore, the individual is at the mercy of the machine. Truly interactive dialog is not accomplished in this type of environment because nothing novel can emerge when all the possible outcomes have been programmed in advance.

For Pask it was about creating evolving and unique conversations between human and machine in a valid sense. It is not about having a concealed amount of information that is just waiting to be revealed, but rather about creating a holistic data exchange. In an architectural sense, this approach enables occupants of a building to communicate directly with their environment in a way that is more than trivial. Paskian principles would promote an environment in which the individual could work with the artifact in a constructive, engaging and productive way. Imagine a building that responded to your needs, not a preprogrammed generic abstraction of you, but actually your personal input. An interactive system like this would be able to provide the circularity necessary to make it more than simply a reactive element. A façade designed in this manner would go beyond the ATM metaphor, and engage the user in a “multiple-loop” and reciprocal set of interactions.

## THEUSER:

'The User' is an important term when a situation or environment becomes interactive. In the world of human-computer interface the user is a continually evolving concept. In the past decade there has been a surge in research and development focused on the concerns of the end user. A more refined ethnographic design process has evolved from this growing concern. Some of the more notable work in this field has been performed by Jan Chipchase from the User Experience Group of Nokia reach in Japan (16), and Aditya Dev Sood in the Centre for Knowledge Societies in India who works with "users in emerging markets. . . to conduct contextual research studies to help technology companies determine the kind of devices, interfaces, features, services and power needs these groups of users require" ([www.cks.in/](http://www.cks.in/)). These individuals propagate a design approach that places importance on the actual needs of a user group. In a user-centered system, the idea is that a first-time user can intuitively communicate with the device. The prime objective is to allow new users interface with the system in a natural manner rather than being forced to learn a nonnative protocol.

Overall, this means of designing for user control is successful, but in the realm of architecture there are a few potential risks. Most of the problems in this

approach to architectural design happen when the people are considered mere occupants. First, the dichotomy between production and use, and the gap separating them, is often stressed when focusing on the occupant. Second, as Usman Haque states, "by taking the minimum-common-denominator approach it may preclude the challenge of people learning a new skill that might open up new informational or constructional possibilities. These two factors encourage the notion of design as problem solving (that is, the designer talks to a group of people, identifies the problems they are having and then develops a solution for them), but discourages users from proactively operating in an authentically productive capacity, potentially learning to help themselves"(27).

In a nontraditional architecture problem like an interactive façade system, this notion of the user's ability to play a proactive role is a prominent concern. Since the role of 'the designer' and the 'the user' periodically change throughout the production and implementation of the product, the system must intuitively respond to the fluctuating demands. At each phase of the products existence there is a different designer and user group, and at each phase the needs of both may vary between installations.

Primarily, there are four main entities that participate in the design and use of the façade system; the product manufacturer, the architect, the client, and the viewer. With the exception of the manufacturer, all of the user groups act simultaneously as designers. For example,

the client commissioning the architect acts continually as the designer and end user. Through communication with the architect and product manufacturer they play a direct role in the design and function of the façade, as operator of the software they have control over the systems final appearance and performance, and as the main occupant they interact with the wall on a one-to-one level.

In this arrangement, there is no entity that is solely a user. Ideally, at every phase and for every individual there is a design aspect to the system that allows for personal control. Kinetic and interactive architecture breaks the molds of the static nature of building, thus reducing many of the design problems inherent in the user-centered approach. Research in social computing by Anne Galloway, lecturer in the Department of Sociology and Anthropology at Carleton University, suggest this type of non-linear usability is crucial in creating a human-device interaction that is successful. She believes that planning user adaption and control into the initial conception is the only way to design for the end user (10). By doing so and creating an effective human-device interaction for every type of user would ensure that the system is accessible to the largest demographic. In order to create the type of interactive environment in which the user enters into a reciprocal conversation with the device, the technology present must be able to holistically process and output data. The goal is a symbiotic interaction between both human and machine.

# OPEN SOURCE ARCHITECTURE

The world in which we inhabit, through its constant evolving and direct personal impact, is a perpetual design project. It is one in which there are many different contributors of a plethora of preferences. There is no one individual or group that is responsible for how things develop, nor would one entity be able to handle the task. It is only through a holistic intermingling of various races, genders, personalities, and ideas that our environment is collectively shaped. Our surroundings for the most part are an 'open source' platform of continual vicissitude.

Computer language has taken much of its vernacular from architecture, now it is time to use some computer terminology to describe the way the built environment may perform. Historically, architecture is a static art, it is the equivalent of computer hardware. There are walls, floors, roofs, made out of solid materials like concrete, steel, and brick (Haque 14). Once constructed, most buildings remain frozen in the

place like unmoving sentinels on the horizon. Conversely, if one thinks of the non-physical aspects of a space (smells, sounds, thermal qualities, even electromagnetic waves), then you can suggest that architecture can also be compared to software.

Combining the two analogies, architecture as both hardware and software, we can picture the entire experience like an 'operating system' which allows people to design personalized programs for interaction. Architecture that emphasizes structure is focusing on the 'hardware' design of the building, while architecture that creates 'softspace' is similar to computer 'software'. Hardspace is the physical framework, and softspace is what animates it and allows for people to become integral parts in their environment (Bullivant 27). Integration of both systems is the key to an effective architecture operating system.

Since the design on our environment is a collective endeavor, the computer term 'open source' has interesting correlations to the realm of architecture. At some point,

everyone has been a pervader of space. Individuals paint walls, hang pictures, furnish in all types of ways, throw parties in homes, burn incense, and use showers as karaoke booths. Some people even go as far as to physically modify their surroundings with additions, subtractions, and improvements, without the need for an architect. However, most people do not consider what they are doing as design. Even in spaces that are architect designed, technologic devices like the thermostat allow the occupant to be the primary controller of their environment. This control, or design, of space renders much of what the architect does as obsolete. So what can the architect do?

In the softspace architecture the production happens at the moment of use. When an architect designs these types of interaction systems the production is in the hands of the occupant. Architectural design then is providing the meta-programs that provide the platform for users to construct their own individual programs. This chorography of senses can be compared to the 'operating system' of a computer, which is the software that runs as the foundation for all the other programs (i.e., Lynx, Windows, Mac OS). It provides the platform to enable a multitude of architectural programs to be executed. In this idea, the user is the designer of their space, architects just provide the meta-systems. These systems also bring into question the role of the designer in creating meta-systems that cater to creativity, promote the customization of personal space,

and permeate the notions of individual logic. The dilemma in this process is designing interfaces controls that allow personalification without compounding layers of regulation.

“‘Open source’ in the software universe refers to a type of source code (with which software is designed and built) that is accessible to all; that is freely distributed as long as it remains equally open; that allows for modification and derivatives as long as the result is equally open; that is non-discriminatory; where patching is possible without disturbing the integrity of the main work; and that is technology neutral.

Similarly, an open source architecture requires a framework in which the distinction between 'those who design' and 'those who use' is replaced by participatory system that encourages a constructed project to be constantly 'patched' or 'performed'" (Bullivant 27).

There are several ways in which architects can take these concepts of open source and apply them to their design process. First, would be figuring out novel and intuitive ways that non-architects can participate more intimately with the design of their environment. This can be done within the current paradigms by creating a stronger and more open relationship with specific user groups of the project, or by implementing new technological interfaces for design. However, a more profound change toward open architecture will occur when the discourse on the very ideas and notions of the profession are opened up. Pragmatic communication within the modern architectural



practice will only go so far.

Second, a new approach to the way in which the designer designs must be implemented. In order for an open architecture to exist, the architect must design a flexible framework that has the option of being modified by the inhabitants or the environment itself. A spatial operating system works on the idea that everyone is a designer, therefore, it is imperative that the architect not design an interface that controls the process omnisciently from above. Rather than dictating in this nature, the architect would only create the base upon which other co-designers build the rest. In this scenario, the design professional sets the stage for the actors to freely and openly perform their personal interplay.

However, just because everyone has the option to be a designer in an open source architecture, it does not mean that everyone would do so. The theory merely offers a system that is open enough to allow for anyone to participate in, but does not mean that everyone has to become a 'programmer'. Many people simply like the fact that something can be altered, or that its source code is available. Usually information that is open is more trust worthy; there is an innate aspect of distrust to something that is kept hidden. It really comes down to having access to the process- not that all people would necessarily know what to technically do with it. But it is significant that it is a personalized and communal system that is open to all. After all, as Mitch Kapor, inventor of the immensely popular Lotus

1-2-3 spreadsheet program and founder of the Electronic Frontier Foundation (EFF), a public interest group working for the civil liberties of people in information technologies, stated, "Architecture is politics" (Mau 91). And open source architecture is a democratic process that exists in space as well as time: an architecture that is designed by the user for their personal use.

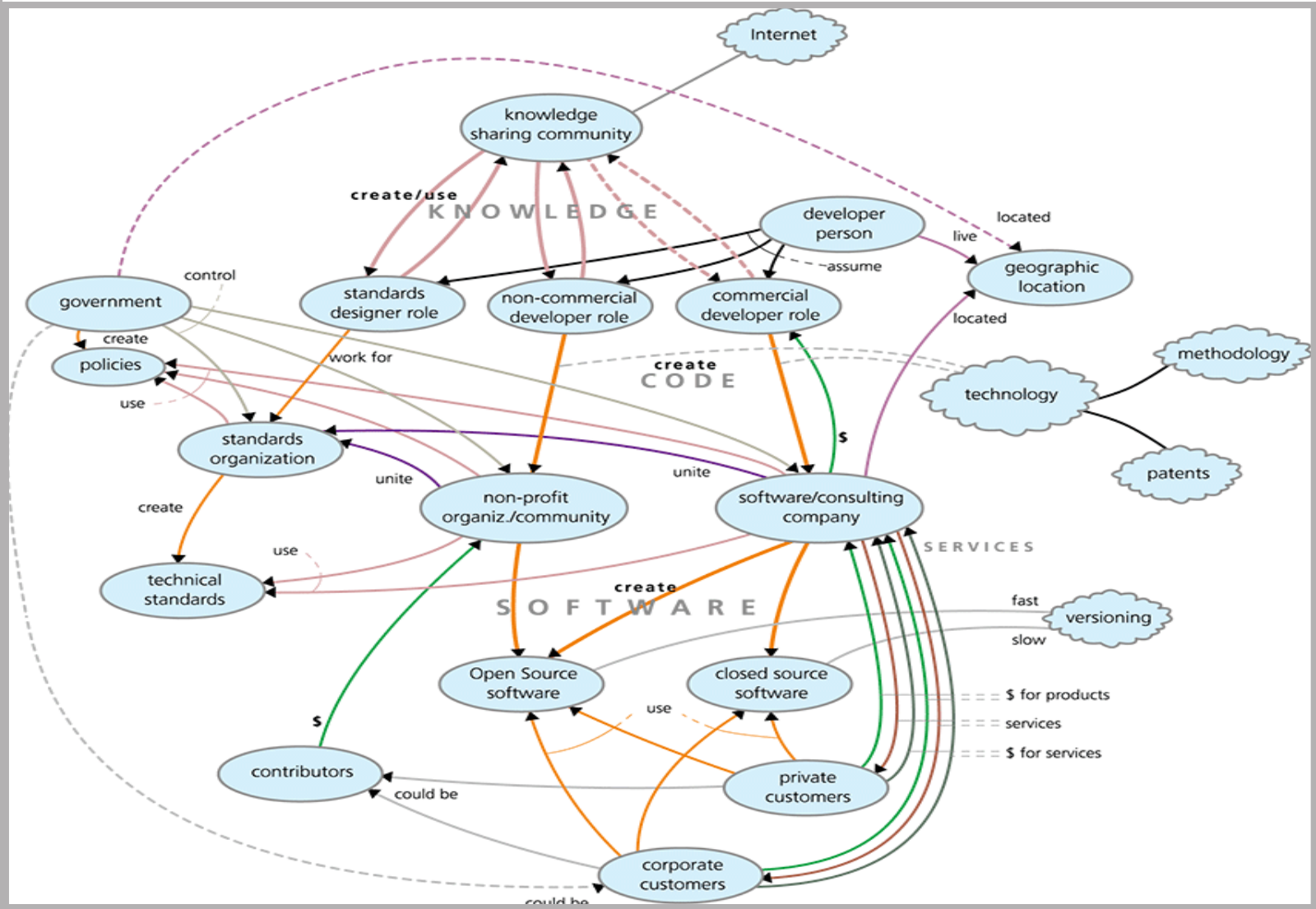


Fig.11. Open-source diagram

# SUSTAINABILITY

## SUSTAINABILITY

When engaged in playing a game, there has to be a set goal; in rugby, it is to score a tri. Without this desired outcome, the strategy of the game is impossible to define. William McDonough describes the endgame of sustainable practices as, "A delightfully diverse, safe, healthy, and just world, with clean water, air, soil, and power, that is economically, equitably, ecologically, and elegantly enjoyed"(23). He goes on to suggest that through the application of nature to human needs, we can create a model where waste equals food. Instead of disposing of waste, methods can be devised to use it as an input. McDonough's "Next Industrial Revolution" proposes that this process can be accomplished through industry and environment uniting in a synergetic and harmonious manner (24-30).

In 1962 Francis Crick, who is credited with the discovery of the double helix of deoxyribonucleic acid (DNA), put forward a similar concept in his writing about physiological vitality. His research indicated that

the three defining factors for something to be vital are that it must have a free form of energy, it must grow, and it must have an open matrix of chemicals. If we use the example of a flower, it has cells that grow and reproduce, it receives all of its energy in the form of solar radiation from the sun, and it has an open matrix of chemicals that work in the metabolism of the flower to benefit the plant, its reproduction, and its ecosystem. If we apply these principles to industry, human artifice and technology can be put in the same type of cycle. The outcome of this comparison is what can be referred to as "technical nutrients" (Mau 181).

Take aluminum for example. Humans have produced over 690 million tons of aluminum since 1888 and we still can account for over 450 million tons of it (Mau 181). Therefore, the idea is that there is the possibility of designing two different kinds of things. The first is products of consumption, which are literally biologically consumed and go back to the soil. The second is products

of service that we want to use, but not necessarily the molecular potential. With something like a microwave or a school bus or a carpet, the user is not a consumer but a customer. In these examples, at the end of the things lifespan, it should become technical and biological nutrition by returning back to the industry forever(Mau 190). This idea of an endless cycle of design and production promotes a major change in manufacturing from the wasteful traditions of the 19<sup>th</sup> and 20<sup>th</sup> centuries. The new sustainable strategy ensures a continuous construction/deconstruction process that circulates the product and its elemental matter- rather than recycling it- in a perpetual upcycle (Mau 181).

Since every year in the United States, 136 million tons of construction and demolition waste are tossed into landfills, amounting to more than half of all landfill waste, it is instrumental that methods are taken from the beginning to address waste. Additionally, architecture has a responsibility to be a leading entity in the support of sustainable energy collection and consumption. The United Nations Environment Programme (UNEP) Sustainable Construction and Building Initiative (SBCI) estimates the building sector consumes 30-40% of total global energy on an annual basis. A net-zero energy and waste protocol should be a mandatory requirement of any new architectural product (McDonough 33-37).

Fortunately, there are already numerous manufactures setting the precedent for the Next Industrial Revolution. Supply chain tools by Nike



Fig.12. Herman-Miller chair - a staple in the product world for upcycling and sustainable design (<http://www.hermanmiller.com/Products/Aeron-Chairs>)

monitor all the material in its total supply chain and inventory. The Herman Miller furniture company now has a no pvc, cradle-to-cradle, chair that can be used in making another chair indefinitely. BASF Chemicals, the worlds predominate chemical producer, is pioneering 'intelligent chemistry' with a line of polymer protocols designed for infinite recycling. In 1994, Steelcase Corporation its first textile that is clean enough to eat, and has since developed numerous similar products. The Instituto de Empresa in Spain, which according the *Wall Street Journal* is the top ranked business school in Europe, has begun offering new coursework in ecointelligent cradle-to-cradle management practices. And Ford Motors is developing the Model U to succeed the Model T, which is a car whose components can be returned either to the industry or the soil (Mau 187).

In an architecturel product market, where the architect is depending on the manufacture to produce sustainable solutions, there is extra amount of emphasis placed on company to exceed performance standards. The building industry, especially post economic recession, has to step up and take a moral stand on the grounds of sustainability. It would be professionally and consciously irresponsible to continue propropagating the old, excessively wasteful, practices of times past. In addition, the modern customer is becoming more ecologically savy and demanding these stratigies to be implemented. Taking que from other companies, like Hermin Miller and Steelcase, product manufactures have

to take the necessary measures to bring their products and services up to the stringent concepts presented by activists like William McDonough. An efficient and green building component ensures that the building starts in life from step-one as a environmentally conscious entity.

# PRECEDENT STUDIES

PRECEDENT STUDIES

## THE GALLERIA - SEOUL, SOUTH KOREA

Architect: UN Studio

Lighting designer: Rogier van der Heide, Arup

The Galleria was a boring concrete box prior to the façade renovations performed by UNStudio and Arup Lighting. It existed in a major metropolitan area of Seoul, but lacked the draw that the vendors needed. In an effort to prevent the building from permanently closing, the owners held an invitation only contest to renovate it. The winning design by UNStudio and Arup Lighting has transformed the featureless concrete box into vivid light wall that is capable of displaying patterns and messages.

The façade system that was designed for this building is composed primarily of acid etched glass



Fig.13. Galleria presentation board

disks. The 850mm diameter disks are structurally held by a self supporting steel framework that has been attached to the original concrete face. These disks are grouped into pods of three on a single steel strut, which is then suspended off a lattice of diagonal box section components. All of the lattice elements are protruded from the existing concrete walls by brackets fastened to I-section posts.

Arguably the most riveting aspect of the new façade is a highly advanced LED system. Each of the 4,340 disks has a controllable luminaire illumination mechanism. These luminaires are an innovative lighting solution, developed with Xilver Lighting in the Netherlands, which have the ability to output 16 million different colors of light with only four LEDs. In order to address the common pink and magenta hues that occur when trying to create pastel and white shades, each luminaire contains a LED set of two greens, a blue, and a red. The whole lighting system is mounted in a circular aluminum casting, a heat sink that allows for the dissipation of residual heat buildup.

When the system is operating each of the flat glass disks appear spherical because the luminaires project the light off center onto the surface. This angle, as well as numerous other factors, is controlled by a dedicated actuator mounted behind each pod of three disks. The control system was designed and supplied by E:cue of Germany, and is capable of operating 15,000

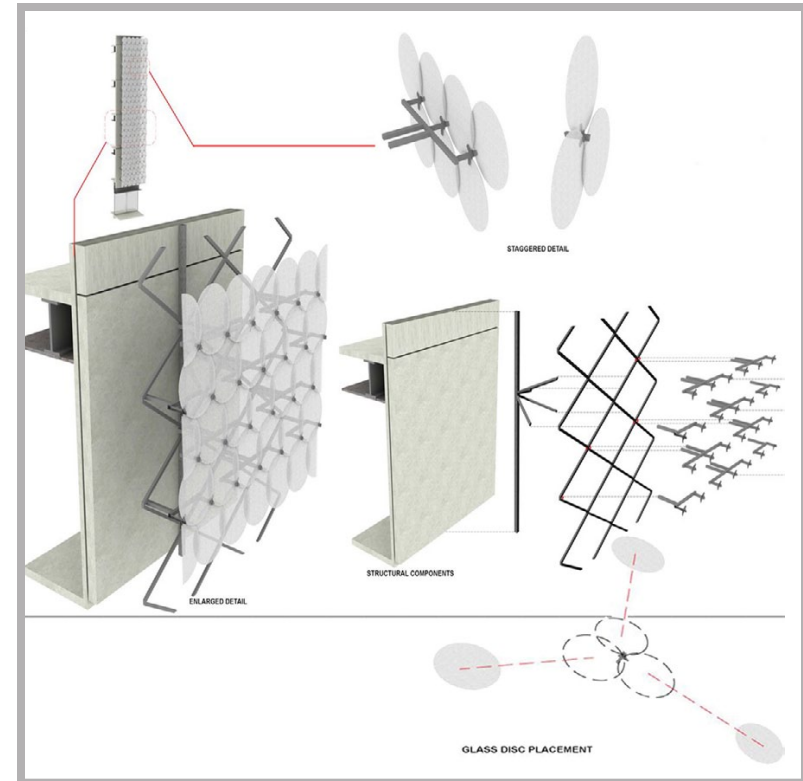


Fig.14. Galleria presentation board 2

different DMX channels simultaneously. The lighting configurations enabled by this system are some of the most elaborate ever conceived.

According to the lighting designer Rodier van der Heide, the modifications to the Galleria have been well liked by the occupants and viewers of the building. Overall sales and pedestrian foot traffic has grown exponentially, and the retail mall is no longer experiences financial trouble. The façade system has also become somewhat of a regional landmark and attraction, with people regularly stopping to look, take pictures, and enjoy the elaborate light shows (<http://bdonline.co.uk>).

## TRUtec

Barkow Leibinger Architects

Seoul, South Korea

11 story steel frame

“The rational building massing is very beautifully detailed and carefully developed,” commented the jury. “For a relatively modest building, it has an incredible street presence through a subtle manipulation of a

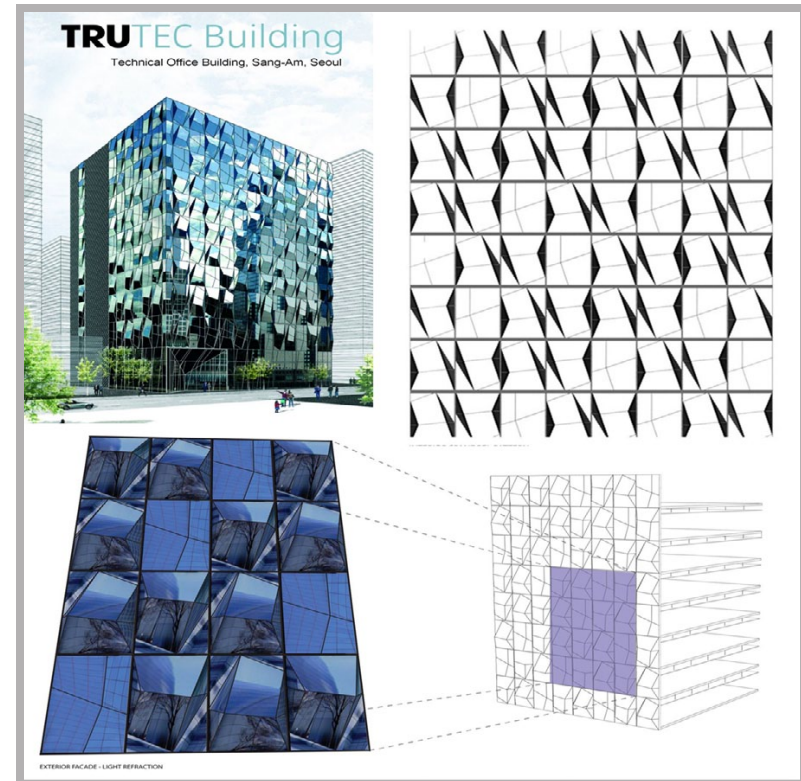


Fig.15. TruTEC presentation board



simple kit of parts” (<http://architectureweek.com>).

The Truete building features a unique and distinctive facade of projecting mirrored-glass bays. This custom building envelope was designed by Arup Facade Engineering, and consists of a patterned array of two window types — a 3D panel, used in two orientations, and a flat panel — creates fragmented reflections on the exterior and altered views from the interior. The face of the just over 55-metre-high cube is composed almost entirely of crystalline glass elements that, as well as mirroring the environmental aspects of the building, also refract them in kaleidoscopic way. This stunning visual is accomplished by way of storey high discs that are segmented into polygonal pieces. Each of these pieces measures 4.20 x 2.70 meters and add up to 20cm to the outside (<http://architectureweek.com>). The visual effect of this orientation of folded three-dimensional elements is an abstract breaking up of the buildings surface into pixel-like nodes.

At first glance, the Truete building appears to be a conglomeration of different elements that were assembled in a random pattern. However, there is a definite grid pattern that was utilized, partially in order to establish continuity with surrounding structures, that creates a logical matrix of modules. The molded design of the façade is actually just systematic variations on a single module. Through the execution of predefined algorithms the extrusions were precisely mapped prior to manifestation. The outcome is a building that retains

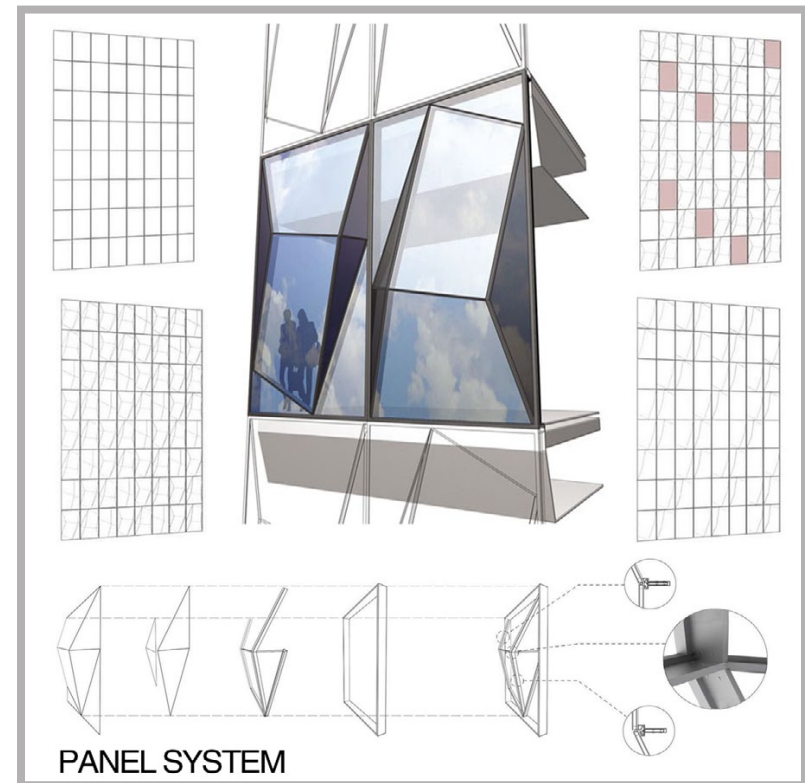


Fig.16. Truete presentation board 2 - panel system

its contextual character while acting as an optical filter that changes how both it and the world it gives are to be experienced.

#### PHARMACOLOGICAL RESEARCH LABORATORIES

Architect- Sauerbruch Hutton

Berlin, Germany

The relatively new Anglo-German partnership of Matthias Sauerbruch and Louisa Hutton is building reputation for projects that are marked by formal innovation, sustainability and an abundance of color. They take uninspiring architecture typologies, like factories, offices and research laboratories, and transform them into interesting and unique buildings. Projects such as the Pharmacological Research Laboratory in Berlin exhibit a resourceful response to site and program, demonstrating a structural polychromy that generates a multifaceted response. The firm only wants clients who desire a building with a strong visual identity, they are not for the lighthearted (<http://sauerbruchhutton.de/>).

The Pharmacological Research Laboratories looks like an inhabited Mondrian painting. This project is part of the research campus of Boehringer Ingelheim Pharma. The building is a long seven-storey structure

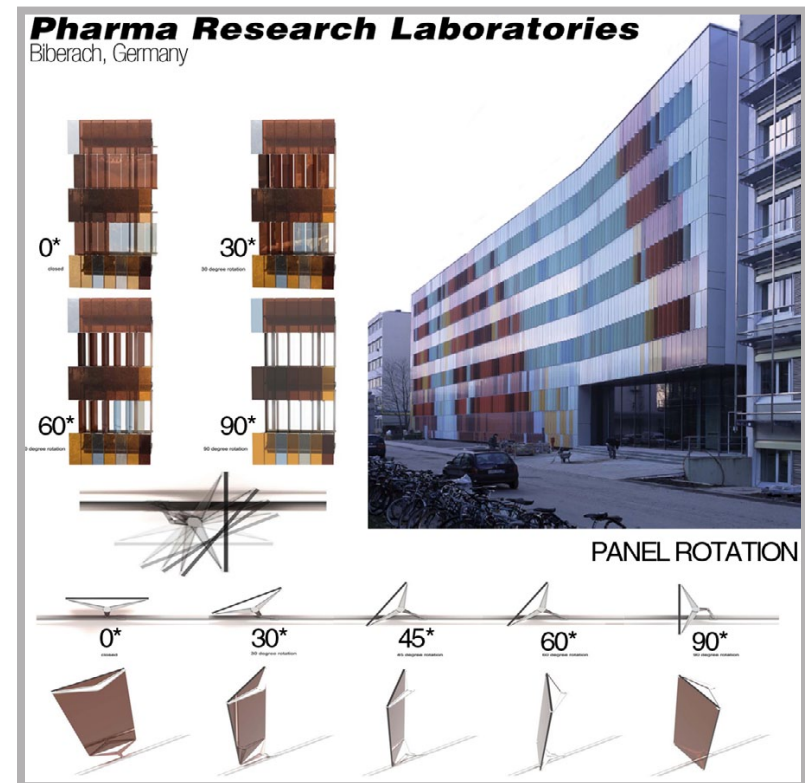


Fig.17. Pharmacological Research Laboratories presentation board

that mostly accommodates labs and offices. Its spacious ground floor foyer acts a unifying element, combining several paths that transverse the campus. The building consists of a simple volume with a glass skin, onto which a polychromatic pattern has been printed.

The pattern of glass panels was designed based on an enlargement of a microscopic image of one of the drugs produced by the pharmaceutical company. Each of these individual panels has been colored using a fritting pattern and the reverse of dots. There are a total of eight different solid color panels on the façade. As an architectural element, the matrix of panels unites the building's diverse parts into a unified whole; on a pragmatic level it operates as a sun shading device.

Each of the 2,892 panels acts as a means to control the amount of solar light and radiation that enters the building (Gray 11). While the colored fritting pattern appears stunning on the exterior of the building, on the interior the impact of these opaque colors is rather minimal. The light passes through the window through the transparent areas only, the spaces between the enameled frits, so that the inside spaces are not affected by the color of the panel. Additionally, each panel has the ability to independently move in relation to the angle of the sun. The effect of the panel system on the overall appearance of the façade is one of unification disrupted by individualism. Overall, the functionality of the façade is just as innovative and captivating as the aesthetic qualities.

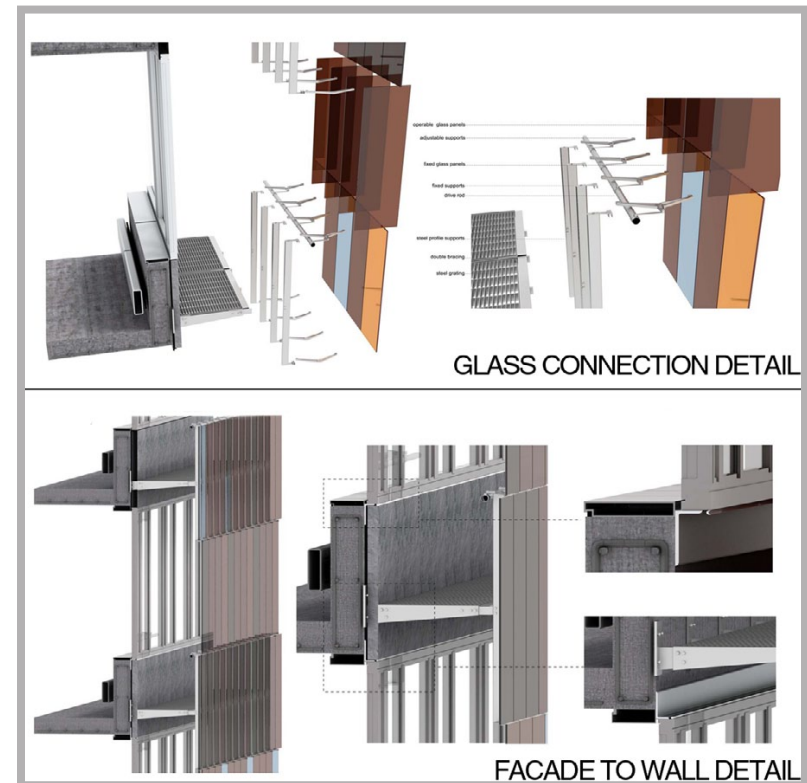


Fig.18. Pharmacological Research Laboratories presentation board 2 - facade to wall details and glass connection details

## LIVINGSHADE

Adam Lassy and Adi Marom

The Living Shade was exhibited at ITP Winter Show 2008. Students Adam Lassy and Adi Marom produced a kinetic shade device that regulates ambient light amounts within a space dependent on the brightness levels outside. The shading system is made from a group of units that can open and close independently. As each set of units transform, they can make a "living" shade system that "breathes" light into the room. The shade acts as an interactive dimmer, so that when it gets lighter outside the units open/close in a higher speed or different patterns.

While the matrix is indeed interesting, there are some fundamental flaws in the design. First and foremost, is the use of a rigid aluminum framing system. All of the units are adhered to a structural aluminum framing support system. While the frame is technically necessary for structural support, it severely confines the prospects of the project. From a monetary standpoint, the aluminum is the most expensive part of the project and adds unneeded expenditure. Secondly, the size and shape of the shading system is directly proportional to the configuration of the underlying aluminum frame. Therefore, a separate and custom aluminum frame must be built for each and every application of the shading device.

Also, the means of control of the system seem rather rudimentary. While it claims to be interactive, it is merely just reactive. The confines of responding to just the exterior ambient light levels is that the shading system only suits one specific demographic. What about the type of people that want to maximize the amount of solar radiation that enters a room in order to cut down on lighting expenses or increase thermal comfort. In addition, the LivingShade unit is only functional for a portion of the day. What happens at night when there are minimal exterior light levels? By definition of the system the units would be completely open. Personally, I think that night time is probably when most people desire privacy and would like most shades closed. There doesn't seem to be any fail-safes or customizable aspects in order to address these key concerns.

## PRECEDENT CONCLUSION

The three examples studied above demonstrate the importance that is placed upon the face of a building. In the noted cases, the façade is the distinguishing characteristic to an otherwise conventional structure. Through the use of various architectural methods (color, movement, lights, solar manipulation) the designers were able to create a totally unique experience for the inhabitants and spectators of the building. Similar to the common phrase “beauty is only skin deep”, much of the aesthetic considerations of architecture are placed on the skin of a building, where they can be viewed by the largest amount of viewers. Due to this widespread practice, most architecture is classified or identified by its outer appearance (at least arbitrarily), as is evident by the three case examples above that were extensively documented in concern to their exterior presence but had little mention of interior or spatial considerations.

It should be noted that two of the three case studies (Trutec and Pharma labs) had façade systems that go beyond the realm of visual stimulation to encompass functionality as well. In both buildings, there are integrated solar mitigation measures that enable the façade to have a direct impact on the quality of the interior spaces. This feature is important to note because it is an intrinsically interactive element incorporated into an otherwise static building. Although this interactive

aspect is rather elementary, only responding to a single set of input data and reacting in a predetermined manner, it is still an interesting example of how a piece of architecture can interact with its specific environment. Doing so is a sure method of contextually integrating a building into its natural surroundings in a sustainable and efficient manner.

The idea of contextual integration starting at the building exterior is a key concept in creating any façade system. However, the way in which it was accomplished in the Trutec and Pharma project differs in method then how it would occur with an architectural product, being that one is a custom application whereas the other is a generic product made to fit a certain set of criteria. The individual designed façade is made for a certain time and place, and is thus easily situated in its environment. However, the mass produced product is initially manufactured without consideration as to where it will be placed, and it is only through preconceived openness of manipulation that it can transcend into a unique manifestation. It is in the concept, therefore, and not in the means to produce the result, that these case studies can provide precedent to this thesis. Outside the conceptual, these projects are very different in the way in which the façade is designed, produced, constructed, and used. Whereas the custom applications of the case studies are unique to the specific project and are one-off facades, the product that this thesis is proposing would be a system that is inherently universal but has the programmatic flexibility to meet individual design objectives. It is a system that exhibits the aesthetic and functional aspects of the aforementioned facades but

in a manner that is mass producible, replicable, and customizable. Through the use of a programmable kit of parts and a structural module, the system has the ability to give any building the dynamic characteristics presented in these case studies, and so much more.

# SITE ANALYSIS

## SITE ANALYSIS

The site selection process for this project is not meant to indicate a specific location for installation. Rather, the purpose of this research is to analyze possible sets of generic conditions, which would be conducive to different aspects of an interactive façade system. Ideally, the final conception of the project will be a mass manufactured product that can be located in a multitude of contexts and regions. The desired goal is to create a set of design possibilities that allow for the system to be incorporated universally, yet also individually, at a global level.

The following five locations are areas or places that have the potential of being enhanced by finding of this thesis. Each location represents a set of contextual issues that can be addressed by part or all of an interactive and customizable facade system. While some features, and thus results, are shared among numerous site, each of the five sites noted also exhibit qualities of the system inherently unique to the specific place or situation.



Fig.19. Global graphic - the applications and potential for an interactive facade system are universal and globally applicable

## MADISON SQUARE PARK:

New York City, New York

- + Public Installation Detached from Building
- + Responsive to contextual issues
- + Temporary – Transient
- + Ability to cater to the site
- + Facilitate spontaneous interaction
- + Independent of any additional functions

Historic Madison Square Park is the cultural node of Manhattan's Flatiron District consisting of a combination of gardens, lawns and cultural programs for all ages. The park is roughly 6.2 acres located between 23rd and 26th streets and Fifth and Madison avenues.

In addition to the lush garden-like environment, the park also has a comprehensive art program. The Madison Square Arts is a free open air gallery that takes place throughout the park. Periodically, artist and performers are invited to exhibit their work in the no-walls gallery. The venue provide for one-on-one interaction with the art pieces as well as a constant stream of viewers. To date, numerous artists, sculptures, installationists, performers, and musicians have showcased their work in the park.



Fig.20. Madison Square Park presentation board



As a public installation detached from a building, Madison Square Park would act as an ideal venue for an interactive wall system. Since the system is a self-contained unit, there is no reason that it must be physically connected with anything, including a building. The module nature of the product enables it to cater to the specific site conditions by allowing for variations in the way it is pieced together. Depending on its configuration, it can be responsive to a range of different contextual issues. The module design of the wall also gives the system an innate transience which is ideal for a temporary art installation. Most importantly, the nature of the product, being interactive and reactive, has the ability to facilitate spontaneous conversation with park patrons. In a setting like Madison Square Park, this interactive element has the potential to be a unifier of the public.

## UNITED ARAB EMIRATES

Abu Dhabi, Dubai

- + Status Symbol – visual icon
- + Continually upgradable
- + Visually stimulating
- + Self promoting
- + Technologic significance
- + Indication of wealth

The United Arab Emirates (UAE) (Arabic: دولة الإمارات العربية المتحدة, Dawlat al-Imārāt al-'Arabīyah al-Muttaḥidah) is a federation of seven emirates situated in the southeast of the Arabian Peninsula in Southwest Asia on the Persian Gulf, bordering Oman and Saudi Arabia. The UAE consists of seven states, termed emirates, which are Abu Dhabi, Dubai, Sharjah, Ajman, Umm al-Quwain, Ras al-Khaimah and Fujairah. The capital and second largest city of the United Arab Emirates is Abu Dhabi.

There are various deviating estimates regarding the actual growth rate of the nation's GDP. However, all available statistics indicate that the UAE currently has one of the fastest growing economies in the world. In architectural terms, the surplus of capital available in the

UAE has led to the largest construction undertaking in recent history. During the years of 2002-2006, there were more construction workers in Abu Dhabi and Dubai than actual citizens. Already the area is home to the world's tallest tower (Burj Dubai), and has plans of

hosting an even taller structure of 1200 meters (30% taller than Burj Dubai). The magnitude of new construction is paralleled by a regional desire to outdo the previous structures. Innovation and experimentation are integral in every major construction project in the area.

In a building environment like what is present in the UAE, architecture becomes a status symbol. As the country establishes a name for themselves on the global platform, they look to their buildings as a means of demonstrating wealth and stature. The physical manifestation of their ideals through tangible objects is very much a part of their society. In this type of market, architecture that is visually stimulating is of utmost importance. Products like a kinetic façade system have an aesthetic significance that is key in what the demographic wants. Being flashy and attention grabbing is something that an interactive façade would provide in a relatively easy manner.

The ability of the façade product to be upgraded, both physically and software, is another appealing factor to the UAE market. Constantly seeking to be on the cutting edge is a trait that many of the projects in that area poses. Unfortunately, the majority of buildings are static structures that do not provide opportunity to be easily changed after completion. Having a façade system that is upgradable would allow the clients to continually have the newest and most technologically advance components. Overall, the United Arab Emirates signifies the type of client that would be interested in an interactive façade product for the superficial aspects, not so much the existential.



Fig.21. UAE presentation board

## MONTREAL METRO

Montreal, Canada

- + Public Transit
- + Station Identify
- + Responsive to train schedules
- + Opportunity for public interaction
- + Kinetic manifestation of train movement
- + Establish character of place

The Montreal Metro system is comprised of over fifty stations. The majority of these stations are decorated with over a hundred works of public art, such as sculptures, stained glass, and murals by noted artists worldwide. The city has encouraged the incorporation of public art since 1967, one year after the opening of the system. The design of the Metro was heavily influenced by Montreal's winter conditions. Unlike other cities' metros, nearly all station entrances in Montreal are completely enclosed: usually in small, separate buildings. Montreal's metro is renowned for its architecture and public art. Under the direction of Drapeau, a competition among Canadian architects was held to decide the design of each station, ensuring that every station was built in a different style by a

different architect. Several stations, such as Berri-UQAM are important examples of modernist architecture, and various system-wide design choices were informed by the International Style. Along with the Stockholm Metro, Montreal pioneered the installation of public art in the metro among capitalist countries, a practice that beforehand was mostly found in Socialist and Communist nations (the Moscow Metro being a case in point). More than fifty stations are decorated with over one hundred works of public art, such as sculpture, stained glass, and murals by noted Quebec artists, including members of the famous art movement, the Automatistes. Some of the most important works in the Metro include the stained-glass window at Champ-de-Mars station, the masterpiece of major Quebec artist Marcelle Ferron; and the Guimard entrance at Square (Laprise 22-34).

In the early years of the Montreal Metro's life, a unique mode of advertising was used. In some downtown tunnels, cartoons depicting an advertiser's product were inscribed on the walls of the tunnel at the level of the cars' windows. Today known as "tunnel movies" or "tunnel advertising," they have been installed in many cities' subways around the world in recent years (Laprise 78-81).

As these tunnel movies are inventive business strategies exploiting the trains innate property of movement, so to can a kinetic wall system act as a manifestation of locomotion. However, instead of acting in a passive manner, the wall system has the ability to actively inform the passengers about the motion of the

train. Interactively the wall could act as way finding mechanism, schedule indicator, condition response, and many other functions. The heavy foot traffic in a metro station would be insure that the wall is has the necessary exposure to be beneficial and utilized.

In a metro system that strive for individual station identity, the façade system provides the means to customize the features. Even if multiple walls were used in numerous stations, each one could be personalized to fit the context of its station. No two wall necessarily have to perform the same function or be configured formally in the same manner. However, each one could provide enough sensorial stimulation to give a unique and memorable character to its respective location.

In the public realm, interaction is a trademark feature of the wall system. The ability for the general metro patron to provide their input, whether physically or virtually, is a way that the individual can actively influence their environment. In addition, multi-user interaction is a trait of the system, enabling the conversation to go beyond the wall to include dialog between more than one passenger. Unlike Dubai, the metro example is less about the cursory features of the wall, and more about the aspects that can influence dynamic interactions between site and inhabitants.



Fig.22. Montreal Metro presentation board

## STADSHUIS CITY HALL

Schakelstede, Netherlands

- + Civic Center
- + Interaction with community
- + Content citizen controlled
- + Democracy incarnate
- + Platform between government and public
- + Iconic presence of community center

The 'Stadshuis', City Hall, of Nieuwegein is a mix of tradition civic spaces and non-typical function. Programmatically, the City Hall contains offices, court rooms, a library, a multi-cultural center, and commercial facilities. Due to the mix of uses, the building has become an essential part to the city's fabric and a part of everyday life for its citizens (3xn.du).

The city hall is the keystone in a plan to densify the city center, and will act as the central node to unite the complex context. Adjacent to the building is a large open-air public square that hosts a multitude of regional events. This space, along with the public areas of city hall and neighboring cafes, is the main gathering area of Nieuwegein. The new Stadshuis seeks to be

the focal point for public life and acts as the mediator between the citizen and government. As the architecture firm responsible for the design of the city hall, 3XN, states; "A public building provides the physical contact between citizen and state. This personal encounter in flesh and blood is the most important interface in a democratic society" (3xn.du).

As a means to strengthen this contact between citizen and state, the addition of a interactive façade system would facilitate one-to-one communication amongst all parties. While the current façade of the building is aesthetically pleasing, subjectively, it does not actively engage the public. Its static nature is purely architectural metaphor and function, acting a rain screen and building wall. The proposed interactive façade product has the ability to take make the face of city hall truly democratic. Through various mediums of communication, including the internet and physical contact, the citizens of Nieuwegein would be able to be the conductors of the iconic presence. Software integration could easily allow any number of people to submit visualizations to the government for display. The walls could change depending on season, event, purpose, or desired effect; the possibilities of use are nearly limitless. Any media, from text to complex video, could be a input for the actuator system of the façade. In the most basic sense, it could be democracy incarnate in architectural form.



Fig.23. Stadshuis City Hall presentation board

## PRADA FLAGSHIP STORE

Tokyo, Japan

- + Store Front
- + Owner Controlled
- + Upgrade to match current trends
- + Visual icon for a visual market
- + Responsive to viewers interior+exterior
- + Synchronize globally with other stores

In 1998 Prada initiated a campaign to change the shopping experience. A key concept in this new strategy is buildings designed by innovative architects. Prada Tokyo 'epicenter' in the Aoyama district is the company's second flagship store worldwide, following Rem Koolhaas' New York store. The high aesthetic building approach is very fitting for the area of Japan known for its prominent couture and street fashion.

Prada Tokyo is an extrinsic prism that sticks out, even in the chaotic Tokyo landscape. The experience of shopping within the building is a blend of retail and culture on a platform of kaleidoscopic structure. The designing architect, H&DM, created a tessellating rhombus

exoskeleton which acts as the main visual element as well as the primary support structure. In an region know for emphasizing appearance, and a client whose sole proprietary interests is visual appeal, the Prada store satisfies the expectations. Well, it satisfies the expectations for now.

The Prada Tokyo store is in an area where trends change at an overly accelerated pace, and made for a client whose whole business plan is based on being the first to deliver the newest style. What happens when the new building, which is hip and stylish now, becomes outdated and yesterdays news? The nature of the design makes the form completely integral to the structure. There is no plausible way in which the visual appearance of the building can be changed without serious renovation or demolition.

The façade system that this thesis is suggesting could solve these problems through the innovative use of the customizable module. Since the client ultimately has control over the system, they are in command of how it looks, what it does, and how it performs. If Prada wanted the store's appearance to match that of its newest product line, then the software of the system would enable them to do so. If all the Prada stores worldwide desired to be showing the same visuals at the same time, they could all easily network the individual facades together, enabling synchronized behaviors and performance. If the owner wanted the exterior of the building to mimic some special event happening inside

the structure, a system of controls and sensors could enable a dynamic inter-architecture dialog. And if the façade simply became outdated due to time, the actual hardware modules could be replaced or reconfigured to efficiently create a new exterior image for the building.

In an area of visual significance, for a client of visual prominence, the visual draw of the customer is of primary importance. In many cases the retail experience is about what happens before the customer enters the store. The window shopping expectations generally affect the nature of the actually shopping experience to the extent that it can solidify a sale. The era of the billboard is over, it is now time for the storefront to start addressing the viewer on a personal and interactive level.

# PROGRAM

PROGRAM

## ISSUES TO ADDRESS:

- How the exterior of a building interacts with the viewer, client, and surrounding space?
- How does technology effect/influence this interaction?
- How can an interactive display become integrated into the building's architecture and not be simply a billboard posted on a building?
- What if a building could be upgraded with the click of a mouse?
- In what way can the public play a proactive part in the appearance of architecture?
- The new generations of people are native to the digital age. What types of media do they create and use?
- How can the above answers influence the style of

modern architectural ornament?

## PROGRAMMING SCALES:

The goal for this project is to design a system of modules that can be programmed at different scales and in alternate ways to make customizable facades. Ideally, the façade should have the ability to be manipulated to match the conditions presented. This means that at every stage of its conceptions and implementation its must be able to change to meet the needs of the particular situation. Allowing for programming opportunities (both in the traditional sense and in a more progressive manner like open-source implications) is one of the prime ways that this will be accomplished.

The continuous programming approach is segmented into different scales of the façade from macro to micro and beyond:



1) The overall building face – At this scale the architect has the ability to design the macro appearance of the structure and its functions. By using a combination of modules performing different tasks, the façade can take on different aesthetic conditions and perform different functions. For example, say that there are three adaptable modules that a designer can choose from. If one designer wanted a building façade that performed a single function and had a monolithic appearance, a single module could be duplicated accordingly to fit the special requirements of the structure and deliver the anticipated result. However, if another designer wanted to address different aspects of the building with different functions or appearance, then they could use all three modules in a unique way (i.e. one module to address the needs of the building's ground floors, one to meet the demands of the middle body of the building, and one to exploit the conditions present at the top of the structure. The classical tripart approach).

2) The module – The next scale down would be the actual module itself. While certain features of the module would remain constant (connections, joints, size), other specific qualities could be adjusted to meet the needs of the designer or client. In this way, the product retains some of the features that make it universal while also supplying a means for customization. An example of this would be the way in which an opening could be addressed. Some may

want the module around a door to contain sensors that detect the presence of a person, while others may rather that module to contain an actuator in the place of the sensor instead.

3) The software – This area of programming uses the word in the classical computer engineering definition (contrary to how architects usually use it). Since a firm connection to an open-source software platform is integral to the concept, the façade will be able to be literally programmed to perform in alternate ways. This ability to continually be modified ensures that the end user can always change certain qualities of the building/space they inhabit. Sometimes a physical change of the building is not feasible or warranted. With a programmable interface to communicate with the system an individual can propagate change without any physical alteration.

#### TYPES OF INTERACTION

- Viewer + façade (video/motion sensing. Touch sensitive)
- Owner + façade (owner can cater facades performance to relate directly to the viewer they are trying to reach)

- Viewer + viewer (play games, send messages, display personal animations)
- Owner + viewer (owner can customize and program the façade to address their specific needs. Owner can change, upgrade, and control the system at any time)
- Façade + building (how does it affect the spaces inside the building? How is it structurally attached?)
- Façade + nature (collection of solar energy and water. Can it manipulate the light inside the building?)
- Façade + context (how does the façade fit into its environment? What contextual issues can it address)

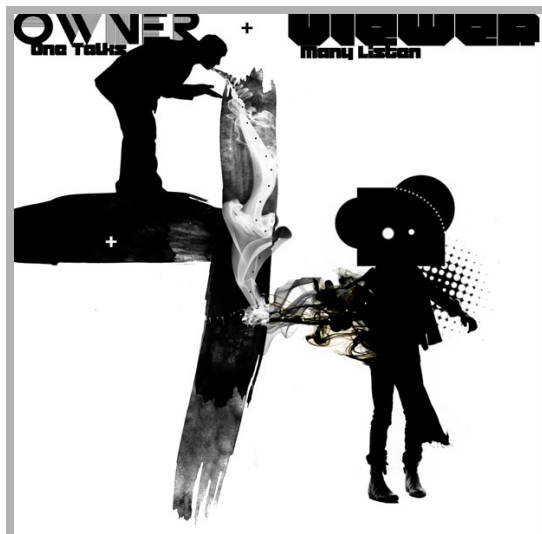


Fig.24. Interaction diagram - owner + viewer, one talks many listen

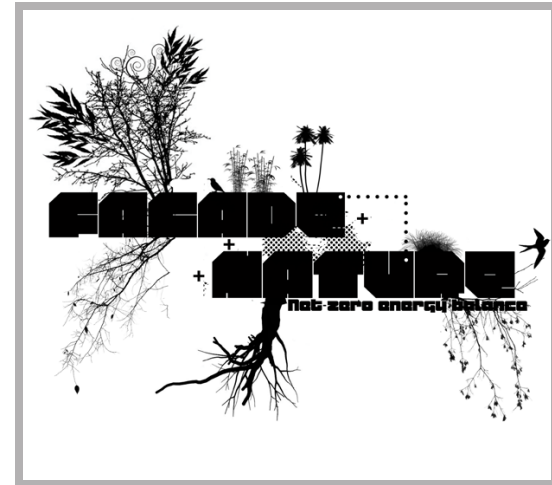


Fig.25. Interaction diagram - facade + nature

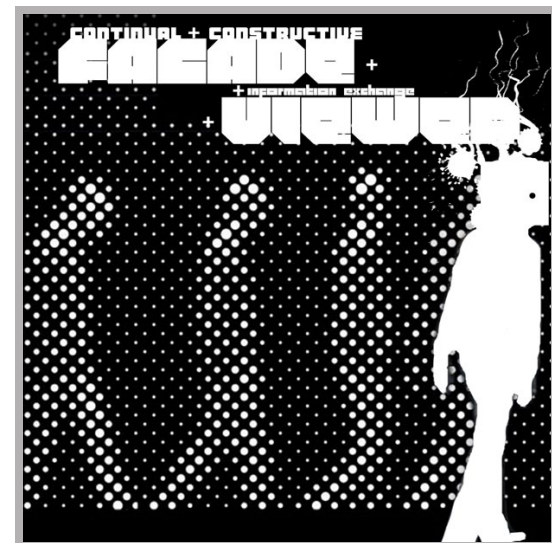


Fig.26. Interaction diagram - facade + viewer

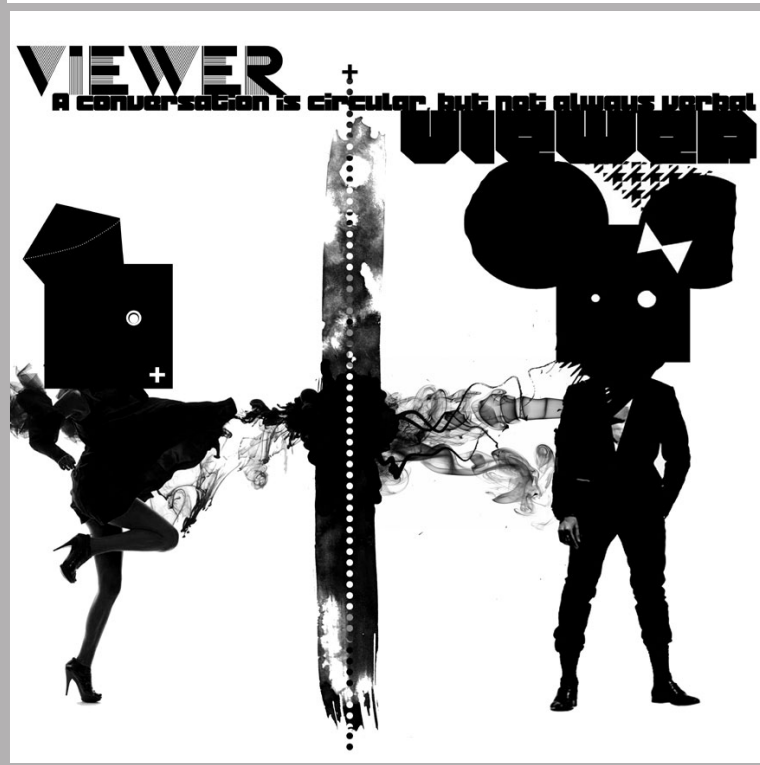


Fig.27. Interaction diagram- Viewer + Viewer, talking through the facade



Fig.28. Interaction diagram - facade + building, reciprocally active and fully intergrated

### DYNAMIC ELEMENTS

- Create time based interaction
- Use physical and visual movement as means to establish connection with viewer
- Has to be easily customized and changed
- Reacts to stimuli, i.e. the viewer, owner, weather, climate, light, ect.
- Each module controlled individually in the movement of the whole

### PRODUCTION

- Mass manufacturable
- Designed with the computer so that it can be built by the computer
- Inter-global/interconnected business model
- Collaboration with other technology leaders
- Minimize the amount of on-site construction time and labor

### SUSTAINABILITY

- System must have a net zero energy balance. Whatever energy the system expends, it must in turn produce
- Its ability to perform kinetically/visually is based on its ability to perform in obtaining energy
- Use of sustainable or recycled materials
- Minimize production and building waste
- Design to be upcycled

### COMPUTER INTEGRATION

The computer must play an integral part in the following areas:

- Design
- Manufacturing
- Assembly
- Diagnostics
- Interaction

- Client control
- Ordering/customer service

#### MODULE

- Set module size for smallest iteration
- Module can be repeated and assembled in an infinite amount of configurations and sizes
- Each module is easily attached and assembled to another module
- Complexity of interaction is based on complexity/ amount of modules
- Configuration and size is customized to clients specific needs
- “turn-key” product module. Each individual module contains everything that is required for it to work independent or as part of a group. Simple plug and play.

#### CUSTOMIZATION

- Both hardware and software are easily customizable

- Can be upgraded when future versions or new updates are released
- Can change from owner to owner
- Internet support community. Open source software that allows individual the opportunity to customize and make publically available. (i.e., if 10 façade units are installed worldwide with each generating 10 people who make their own interactions, that would yield a net of 100 shared applications)

#### MODERN ORNAMENT

- What is the modern conception of architectural ‘delight’? One of the objectives of this project is to answer this question and explore new ideas to make architecture appealing in a temporal sense. Since the face of a building has historically tended to portray the greatest concentration of ornament, it is fitting that this new façade system have inherent features that allow designers to shape aesthetics.

# SCHEMATIC DESIGN

## SCHEMATIC DESIGN

"It would be possible to describe everything scientifically, but it would make no sense; it would be without meaning, as if you described a Beethoven symphony as a variation of wave pressure. . . [which is why] imagination is more important than knowledge " -- Albert Einstein (9)

### DESIGN NARRATIVE:

I awaken. Opening my eyes on a new day I look out at the landscape before me and see my city. My city is my home; I am a creature in its habitat of steel and mortar. The giant sleeping sentinels I stare at on the horizon are the constant entities of this environment. Every day I venture out and move between, around,

and through them. Monolithic manifestations of man's inextinguishable striving and aptitude, they are the both the stage and the background of my existence. They play such a fundamental role in establishing my home and thus my life.

Yet, as I gaze upon them this morning, I feel that my influence on these frozen icons is limited to the minute and inconsequential. As a participant in a global culture of change, I live in a world of constant flux. The ability to alter everything from my eye color to the software on my phone is no more than a minute away. Change abides the flow of my life. Starting with the blog I edit over breakfast to the timer I set that turns off my lights at night, my life is continually being manipulated through my direct actions. But the matrix of built form that is my city remains the same, day in and day out, regardless of my personal concerns or actions.

As I step onto the subway car that will take me into the heart of my city, these feelings of inconsequentiality preside. I feel that, much like this ride, the relationship I

have with the dominate players of the built world is a one way path; with the architecture having a major influence on my life, but there being nothing I can reciprocally give back. The train speeds ahead, adhering rigidly to its tract, I sit passively and get carried along.

My destination is alive. Emerging from the darkened subway station I am greeted with a flurry of activity as people move with a velocious pace. Everywhere you look the built environment is aiding in the activities of the people. There is a constant and continual flow of individuals in and out of buildings with the sidewalk and road acting as the substrate that connects door to door. Some people sit on the stairs of a nearby entranceway while others eat lunch under its particularly large overhang. But in this scene of emanate use there is an evident juxtaposition of vibrant activity against a motionless backdrop. It is clear to me that in such an environment it is the architecture that is subservient to the people. There is no change in it demeanor or form whether someone sits to enjoy its shade or walks past without even giving it a second glance.

That is until something quickly flashes in my periphery. As I turn and see what it is, my mind is instantly drawn to its innately different qualities. Like a single color photograph in a sea of black & white, I am immediately enticed by its ability to stick out from the ordinary. Upon further investigation, my curiosity

for this foreign entity rises. It seems that I am looking at about 5 stories of the top a building, approximately three blocks away. There are other structures between me and the focus of my interest, so that only the top section of the building is visible. But from where I am standing it appears to be continually morphing, changing subtly in response to some unknown factor.

I stand there, now the frozen form, as the face of this new thing dances on the horizon. I feel connected to it. Even from a distance it seems that there is something about what it is doing that has a direct effect on the way I feel. No, wait, that is not it. The opposite is occurring, it is what I feel that is affecting this moving façade: the wind, the climate, the natural environment. As I feel the breeze touch my skin, I can see that it is touching the skin of the building. As my pours open and contract to the stimuli of the wind gently passing over the nerves, the façade is reacting. We are linked in this common experience of the world we both inhabit.

I need to know more, the visual draw has now turned into a physical desire to be in closer proximity to this thing. Each block I walk reveals more of the building, and with the ever expanding view comes a deeper fascination. Soon I notice that what I saw happening at the crown of the structure is different then what is going on at the base. Groups of people are walking up to viscerally interact with the façade on a one-to-one scale. The building is responding to these individuals is an equally dynamic and

personalized manner. The vibrancy that is apparent in the city is mirrored by the reactions of the building to its participants. In areas where people are actively engaging the façade, it is actively responding. In places where there are sedentary individuals, it is doing little or nothing at all. Directly and proportionally, the façade corresponds to a multitude of stimuli presented by the user.

I now feel the urge to participate in this ongoing spectacle. My skepticism of its authenticity must be abated. I approach the building from the street, and although I am a fair distance away, I notice that it has perceived my presence. Mutual perception is initiated; the dialog between object and user has begun.

I get close and reach out a hand as if to make a gesture of salutation. In direct, and immediate, response the building gestures back in its own means. Astonishment succeeds. Each body movement corresponds to a subsequent manipulation in the building face. It feels as if there is some sort of non-verbal communication between myself and this inanimate object (or at least classified as inanimate in the strictest sense of the word). As I react to it, it reacts to me, and the cycle is repeated in novel and curious ways.

This dialog, however, isn't limited to being between the building and myself. It seems that the more I delve into the robust possibilities of interaction the more opportunities arise. Where initially the

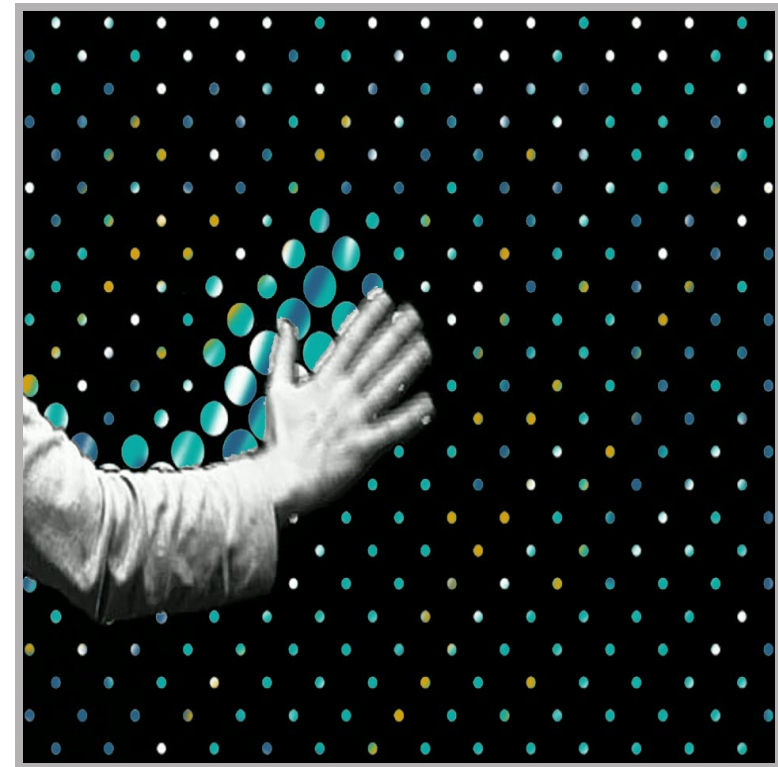


Fig.29. Computer graphic - interaction with facade in gestural manner



conversation was between me and the wall, now it has evolved to encompass several nearby users as well. We all are participating in shared communication with the wall acting as the mediator of connection. In a world where it is common to find a partner through a virtual medium like the internet, it does not feel strange to be holding a conversation on a building with a stranger. Actually, it seems refreshing in this city of nameless faces that the man-made realm can facilitate this type of interpersonal connection. And even this is only part of capabilities of this new façade system.

Moving around the perimeter of the structure, it is evident that this system is composed of multiple different interfacing platforms. Some areas seem to respond to touch, others to light and shadow, and some I cannot even tell how the input is being processed. All though seem to be working synchronically with each other in a holistic and haptic manner to create a unified, yet varied, experience for the user.

The most fundamental aspect of this system is that it changes in relation to time. However, this also means that time has passed since discovering this place and it is now time to depart. Although the building seems like it wants to follow me a little longer, and I notice that my footsteps on the ground adjacent to the façade are playing a role in the scheme as well. One last glance over my shoulder reveals that my spot against the wall has been taken by a new group of individuals in awe of what I have just witnessed; their presence generating

a new dialog with the building and its surroundings. Its brings a smile to my face to see the alternate way the interaction seems to be occurring with this group, mine seeming unique and specific to me.

Through this system I have had a veritable conversation with my city, with my home. On this little plot of land, I played a part in how the environment performed. Even if only for a moment, there was a connection, both physically and psychologically, between the actor and the stage. And the line that distinguishes the two was temporarily blurred.

Now, even as I walk away, my curiosity in this new found dictator of habitat is growing. How will this thing respond to my presence next time I encounter it? What are the other possibilities in form, performance, and application? Will it be the same tomorrow? Will it be the same next year?

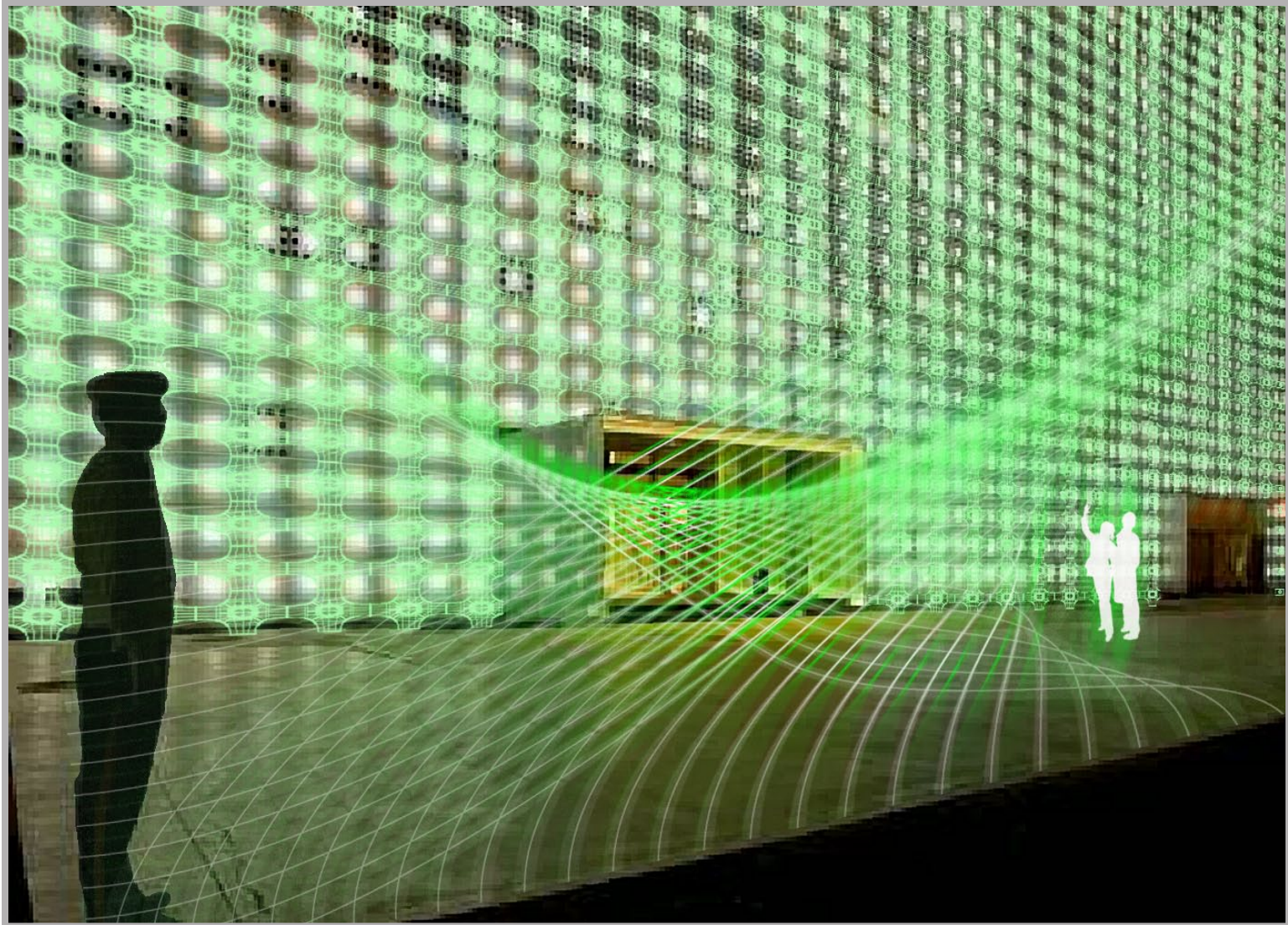


Fig.30. Computer graphic - conceptual rendering of interactive facade experience

## PROGRAMMING OPTIONS:

The goal for this project is to design a system of modules that can be programmed at different scales and in alternate ways to make customizable facades. Ideally, the façade should have the ability to be manipulated to match the conditions presented. This means that at every stage of its conceptions and implementation its must be able to change to meet the needs of the particular situation. Allowing for programming opportunities is one of the prime ways that this will be accomplished.

The continuous programming approach is segmented into different scales of the façade from macro to micro and beyond, and is meant to be employed by everyone with a design objective (from the product manufacturer to the architect and even the client).

At the largest scale the facade is programmed as a whole unit and the overall building face is devised. At this scale the architect has the ability to design the macro appearance of the structure and its functions. By using a combination of modules performing different tasks, the façade can take on different aesthetic conditions and perform different functions. For example, say that there are three adaptable modules that a designer can choose from. If one designer wanted a building façade

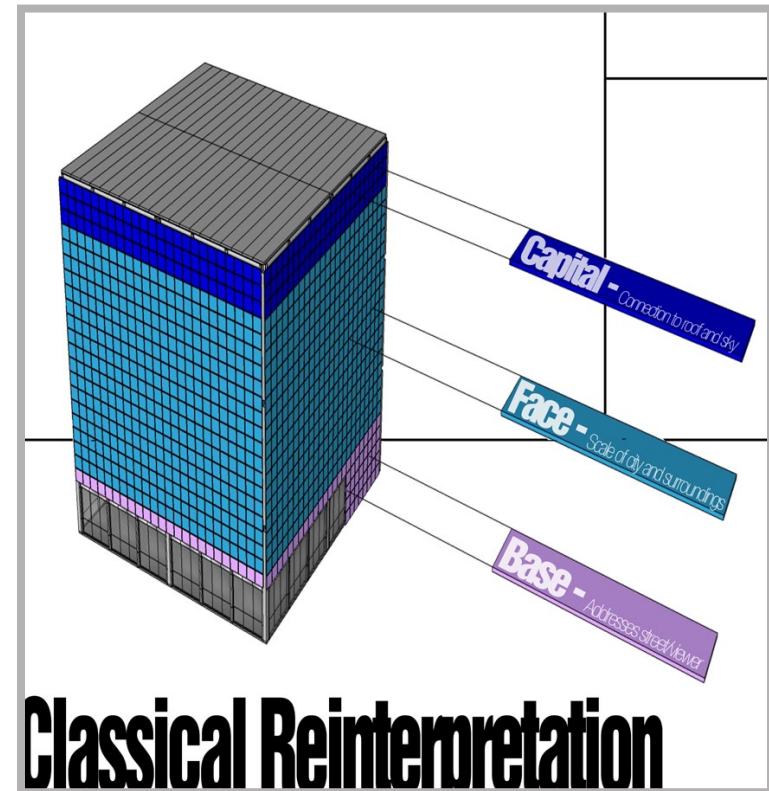


Fig.31. Diagram of programmatic opportunities - shows the possibilities of delegating different tasks to alternate areas

that performed a single function and had a monolithic appearance, a single module could be duplicated accordingly to fit the special requirements of the structure and deliver the anticipated result. However, if another designer wanted to address different aspects of the building with different functions or appearance, then they could use all three modules in a unique way (i.e. one module to address the needs of the building's ground floors, one to meet the demands of the middle body of the building, and one to exploit the conditions present at the top of the structure. The classical tripart approach).

#### MODULE:

In designing the module, it is key to begin by establishing a module size for smallest iteration. Schematically, it seems that a module size between 20cmx20cm and 50cmx50cm is the most efficient and usable. A small sizing, coupled with multiple connection possibilities, creates a module that can be repeated and assembled in an infinite amount of configurations and sizes. And because each module is easily attached and assembled to another module, they can be formed and reformed continuously.

Due to the nature of this design, complexity of interaction is based on complexity amount of modules.

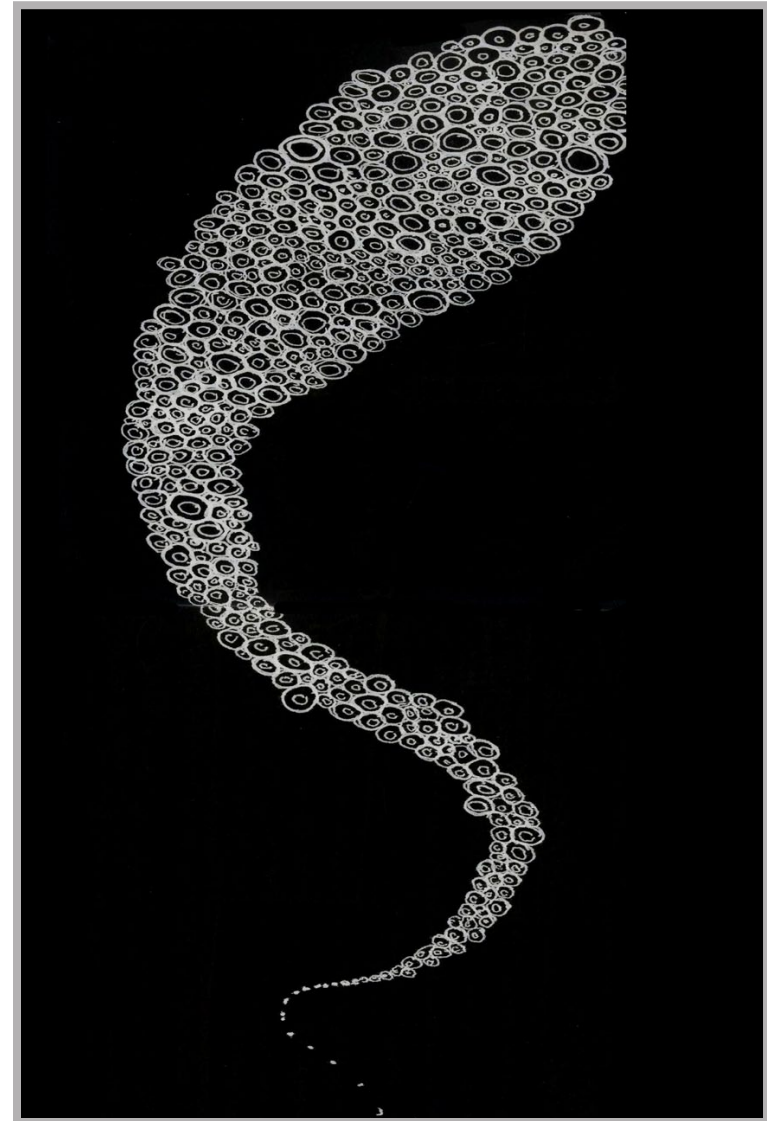


Fig.32. Conceptual modular sketch

The configuration and size of the application is customized to client's specific needs. It can be as small as a few modules put together to create a small installation, or as large as thousands to make a large building façade. In either case though, each individual module is a "turn-key" product. Each one contains everything that is required for it to work independent or as part of a group. Simply plug and play.

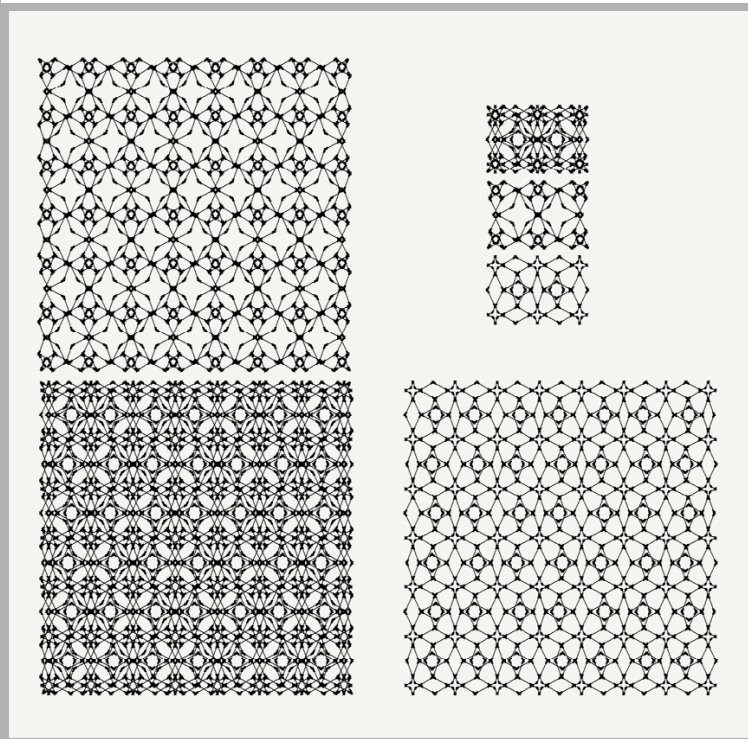


Fig.33. Computer graphic - modular studies - various different module orientations based around the same base module.

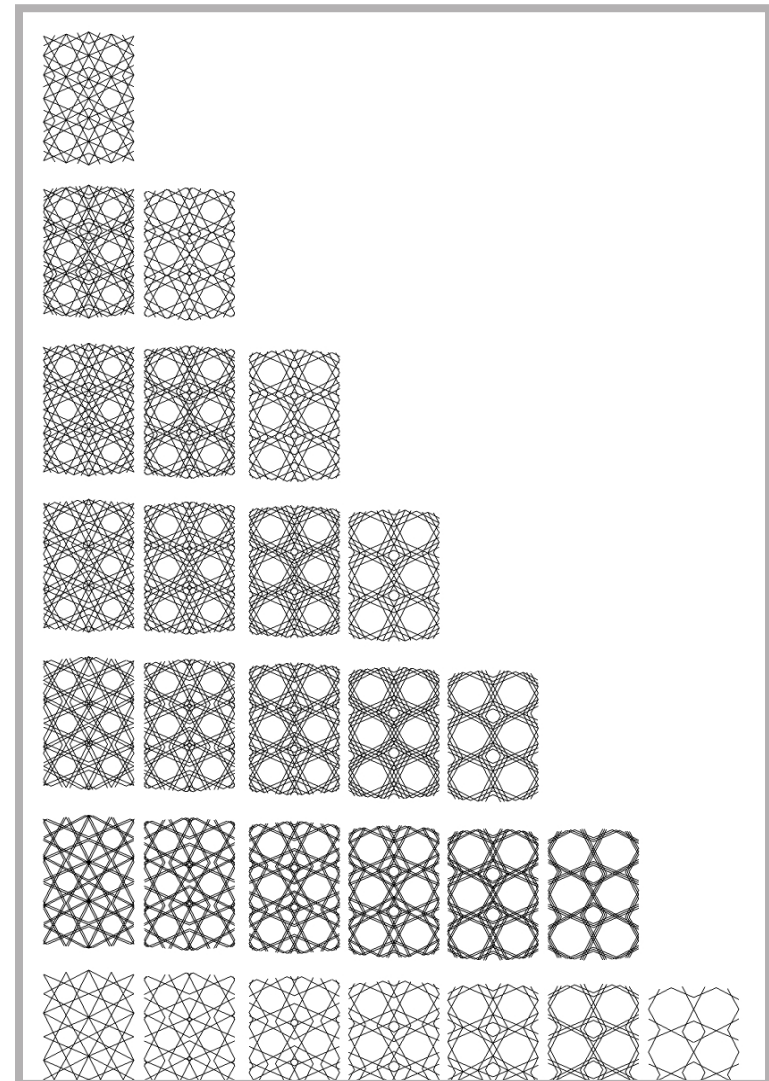


Fig.34. Computer graphic - modular studies 2 - various different module orientations based around the same base module.

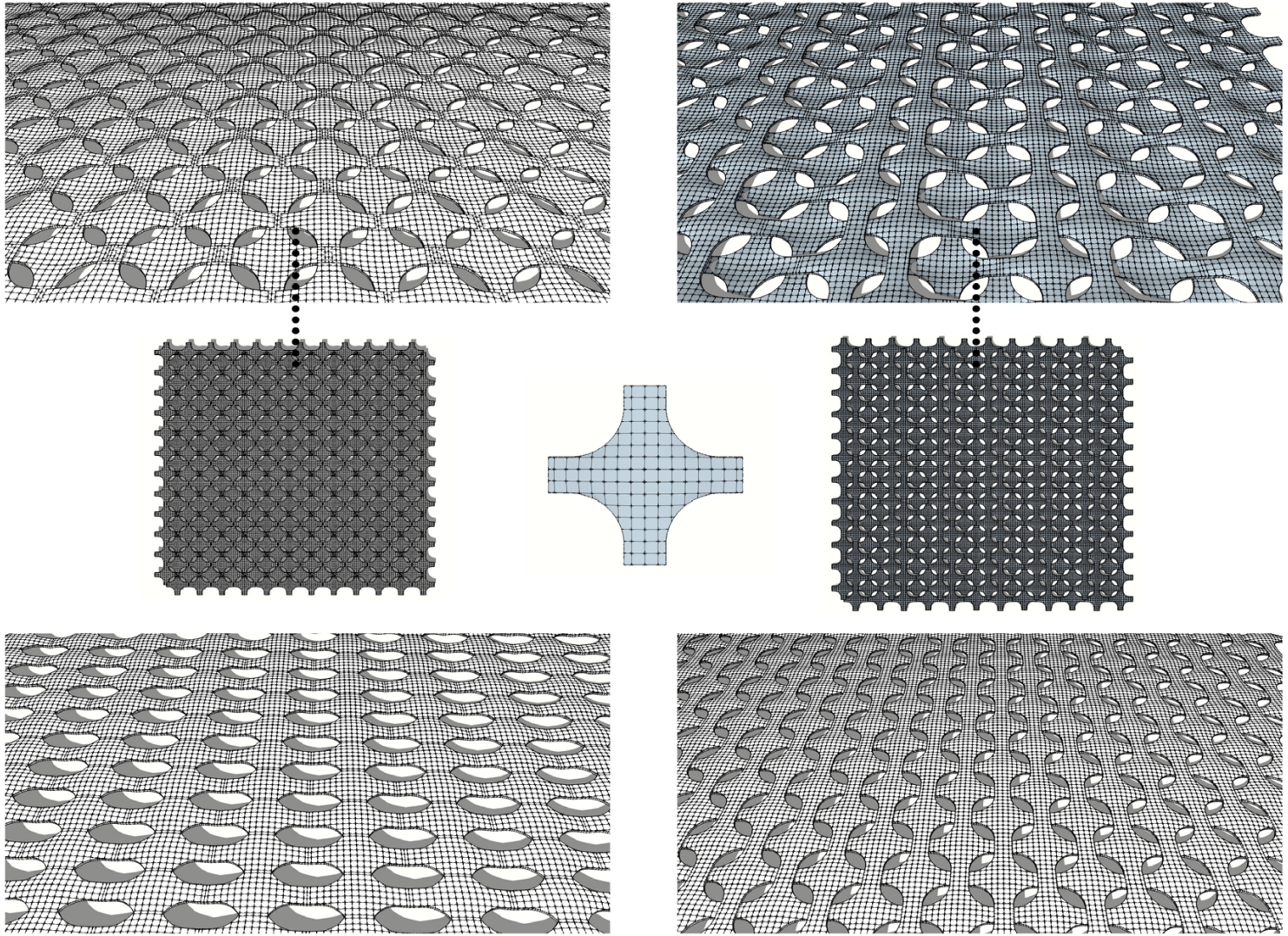


Fig.35. Connection drawings - various different module orientations based around the same base module.

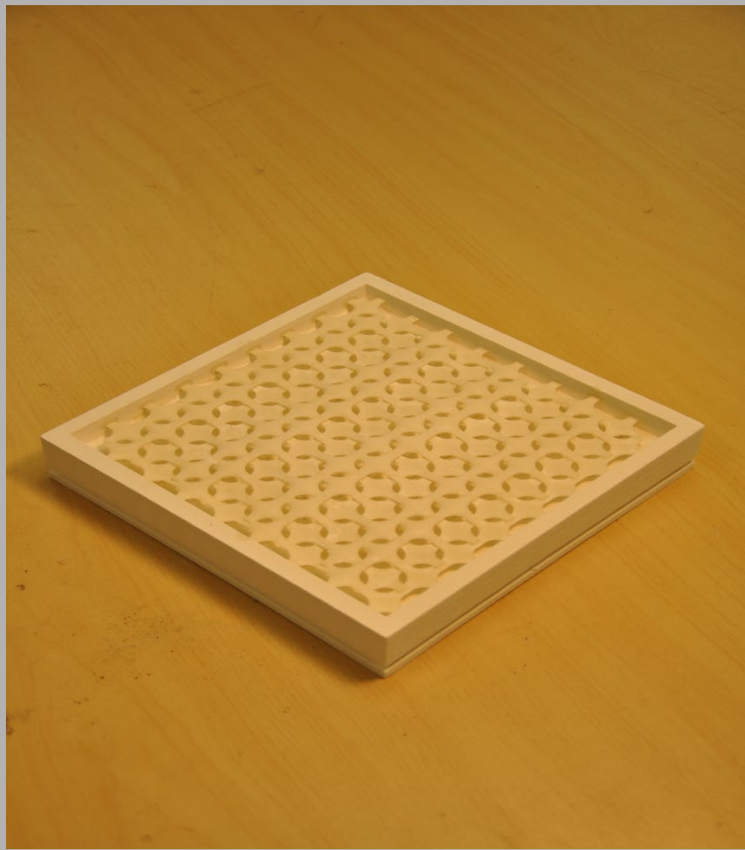


Fig.36. 3d print model of weaving module



Fig.37. Detail photo of 3d print model

## HUMAN/FAÇADE INTERACTION:

### Haptic interaction

At the human scale, the façade will have to be able to address the individual in a personal manner. In order to do this, direct response mechanisms must play a part in the design of the system. Drawing inspiration from the led light panels of Evil Mad Scientist, the following experiments use common infrared techniques to detect the presence of an object and control a set of output responses. In the construct, these output actuators are simple LEDs set to light in response to movement. While this setup with LEDs is not original, it demonstrates the possibilities for a similar approach. The actuator in this model has the potential to be anything, the use of LEDs was only due to monetary constraints at this stage of the project. Future iterations may contain a multitude of different outputs.

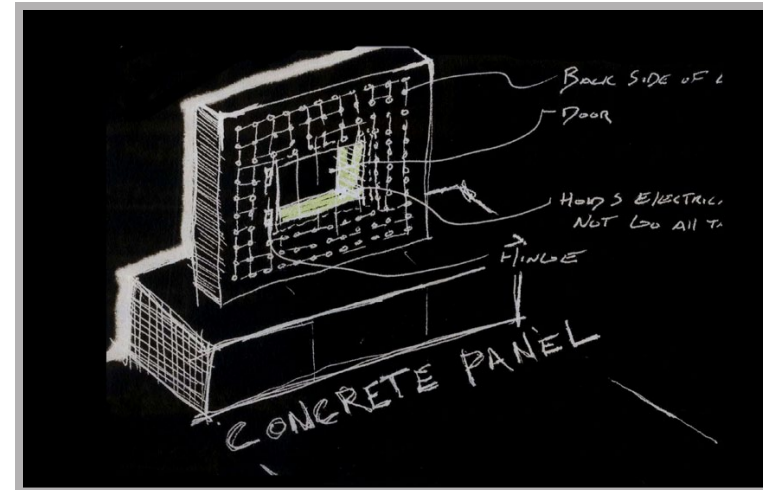


Fig.38. Initial concept sketch - it demonstrates that this idea can be incorporated in conventional building materials like concrete

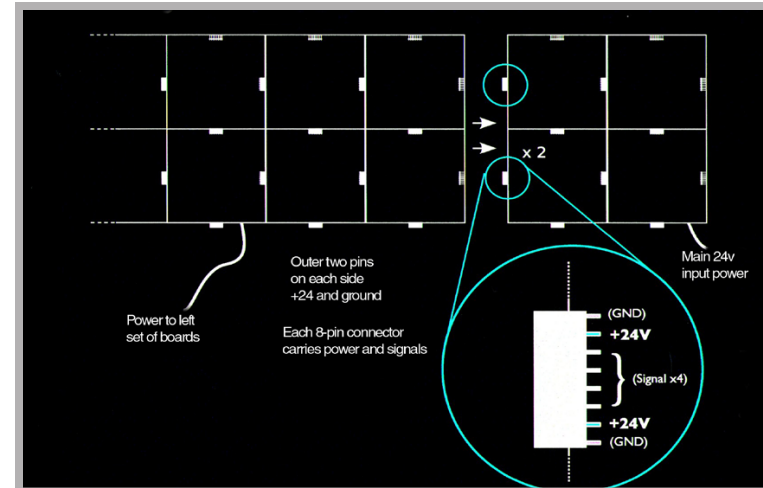


Fig.39. Detail schematic of touch construct - it has the ability to be connected in a multitude of orientations



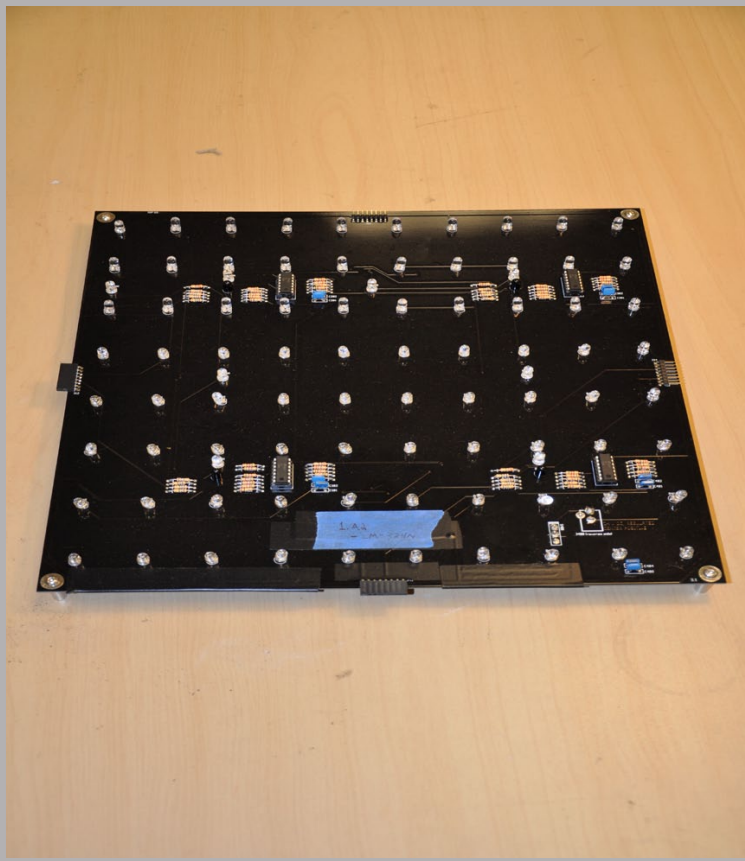


Fig.40. Touch construct in static state

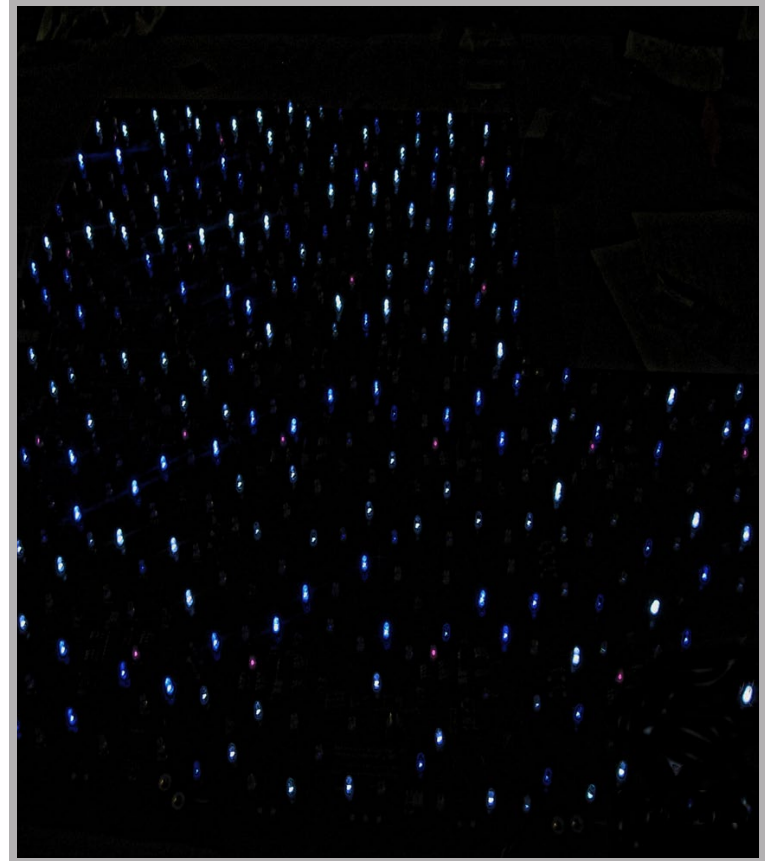


Fig.41. Touch construct in use

## PROGRAMMABLE RESPONSES:

Another scale and application for the façade system is in the macro control capabilities. Comparing the individual module to a pixel on a television, the system can be seen as a conglomeration of parts that make a whole. Each part has the ability to be individually controlled and manipulated. The resulting response is completely controllable through a centralized unit. This enables a wide range of users groups to actively dictate the performance of the building skin in specific and unique ways.

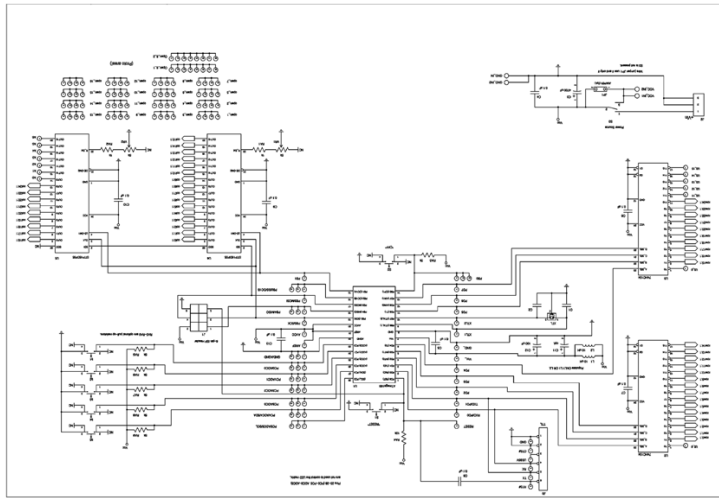


Fig.42. Detail schematic for led circuit

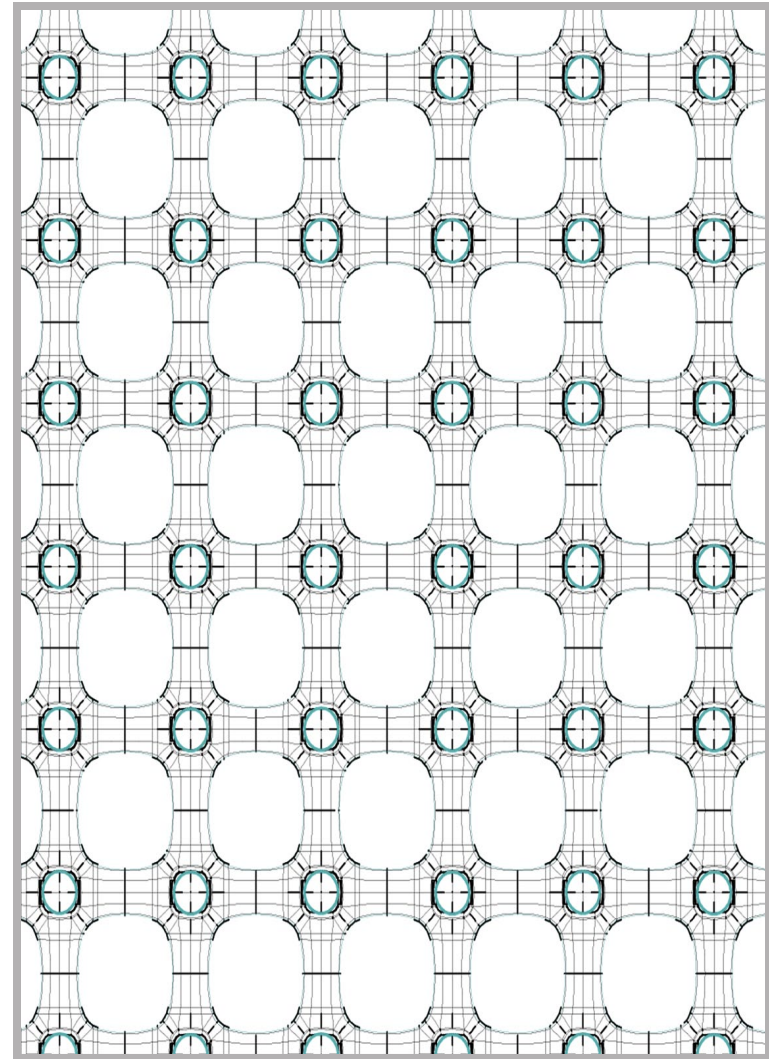


Fig.43. Detail drawing of led construct

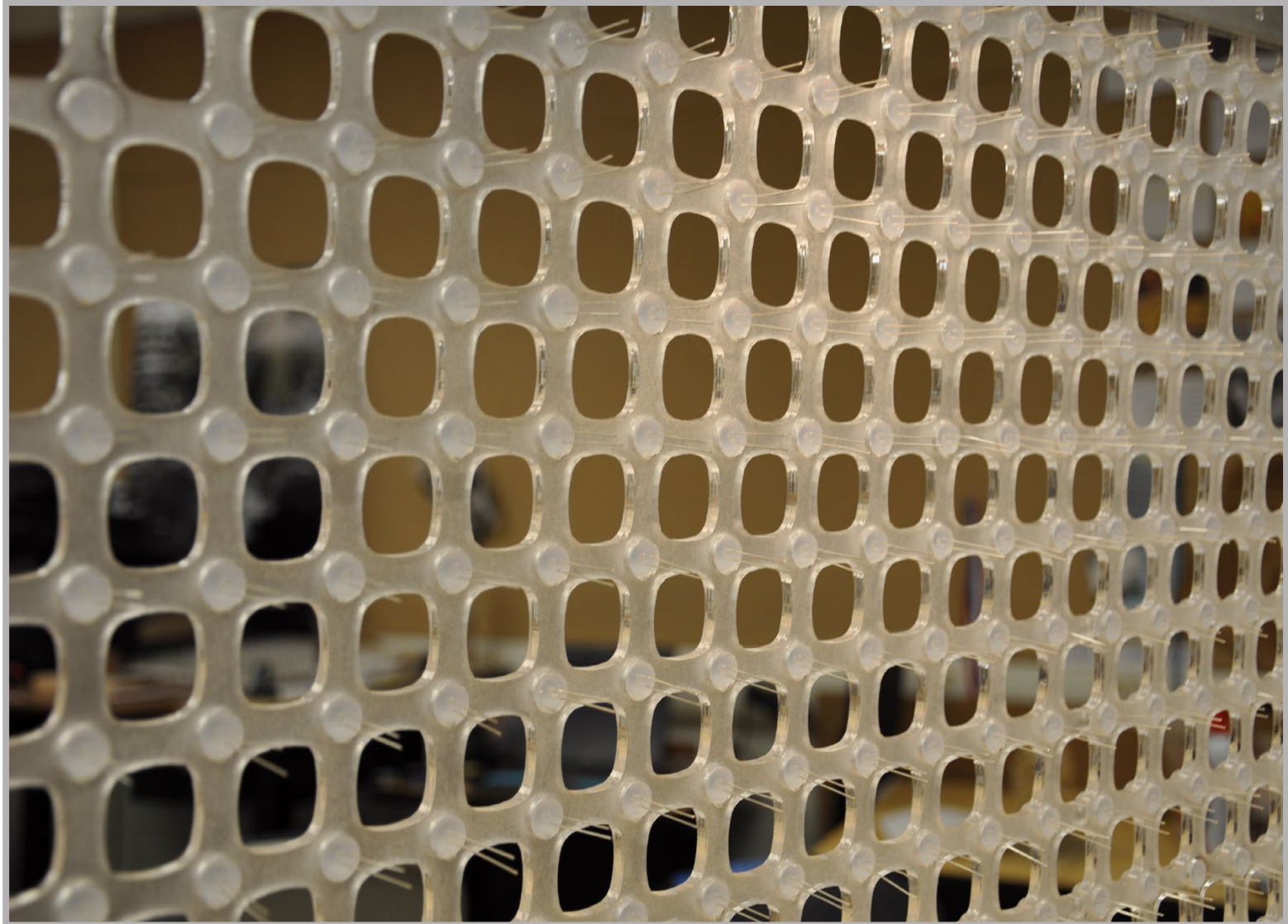


Fig.44. Led construct - built to demonstrate the capability of a micro-controller in manipulating specific pixels within a matrix

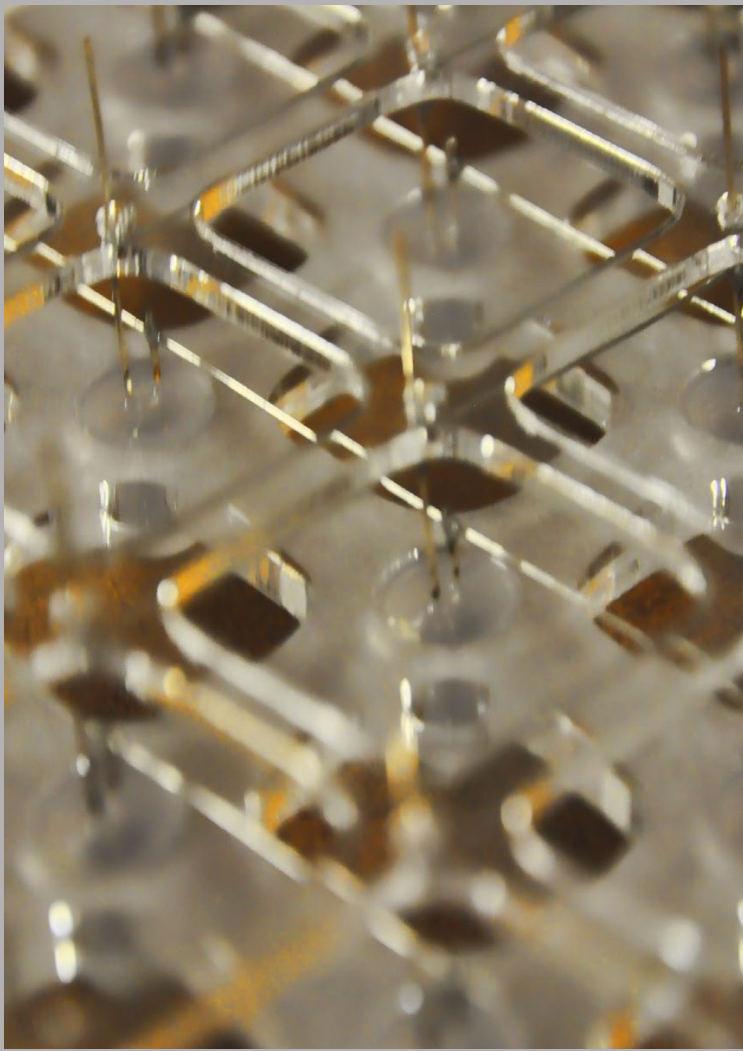


Fig.45. Detail of led panel - shows the multiple layers of lasercut plexiglass used to deliniate positive and negative connections

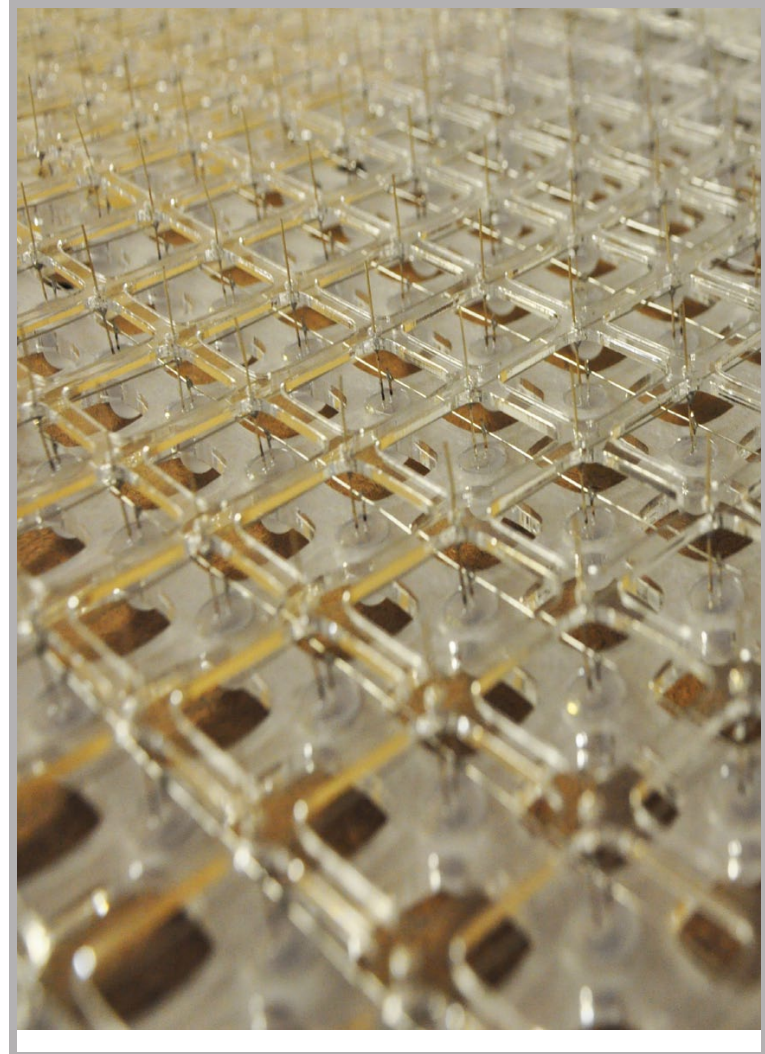


Fig.46. Detail of led construct

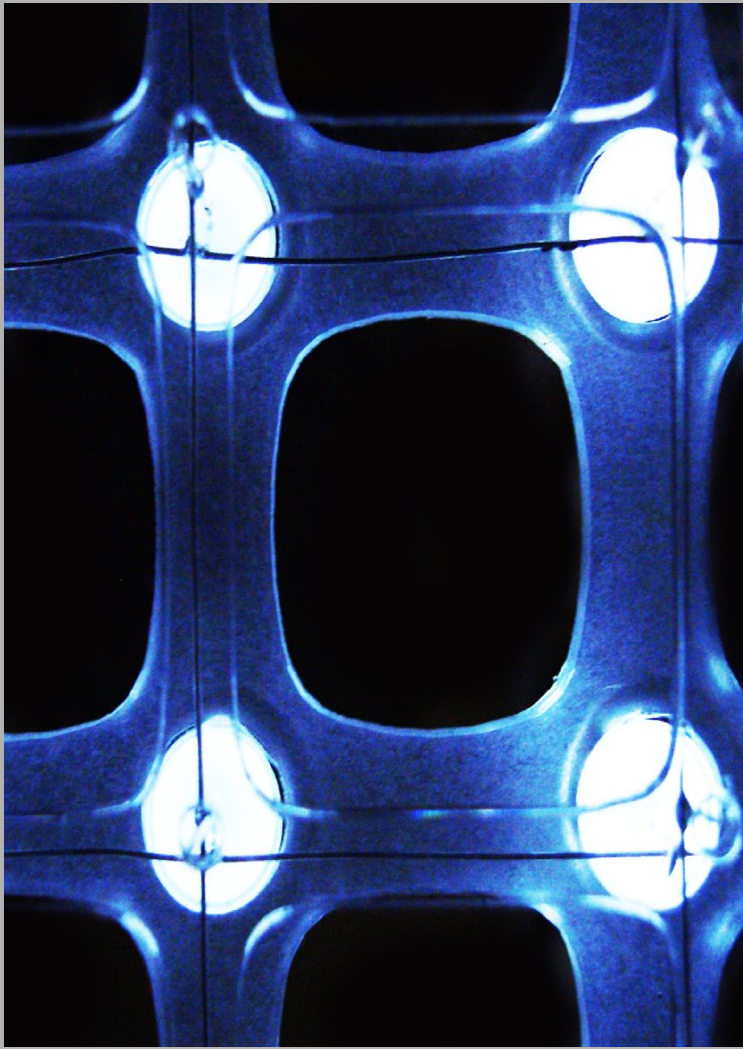


Fig.47. Panel during operation

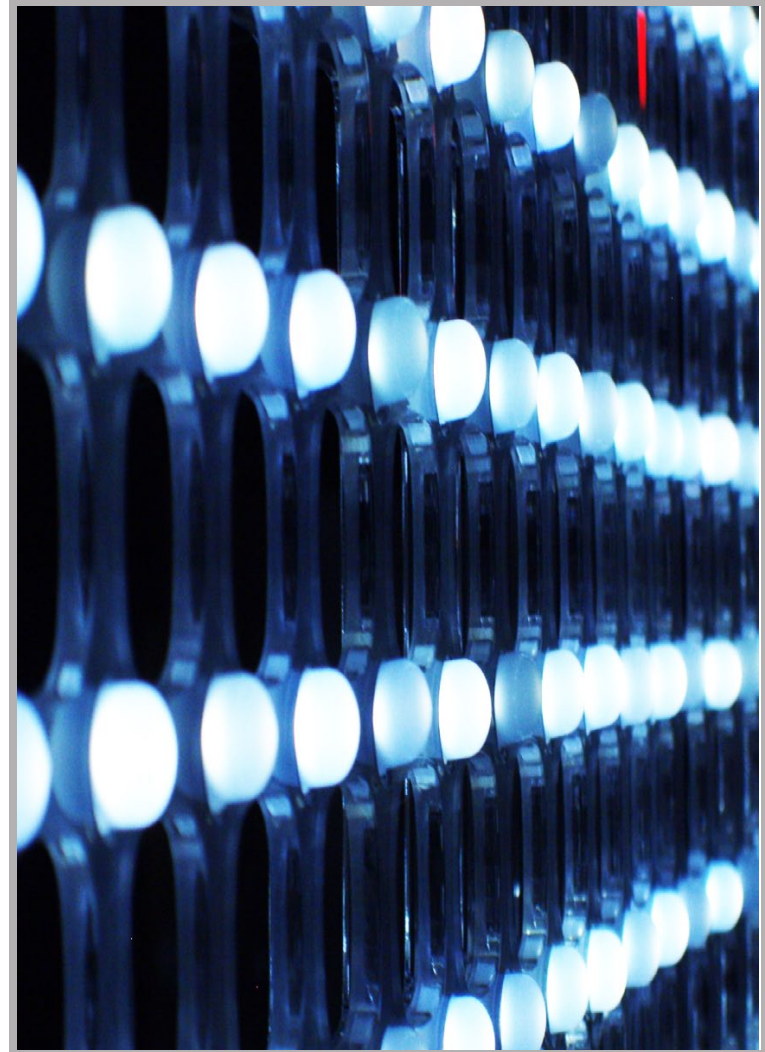


Fig.48. Panel during operation, side view



Fig.49. Conceptual rendering - showing the time-based visual change that can be achieved with an individually controlled modular system



Fig.50. Conceptual rendering 2 - showing the time-based visual change that can be achieved with an individually controlled modular system



Fig.51. Conceptual rendering 3 - showing the time-based visual change that can be achieved with an individually controlled modular system



Fig.52. Conceptual rendering 4 - showing the time-based visual change that can be achieved with an individually controlled modular system

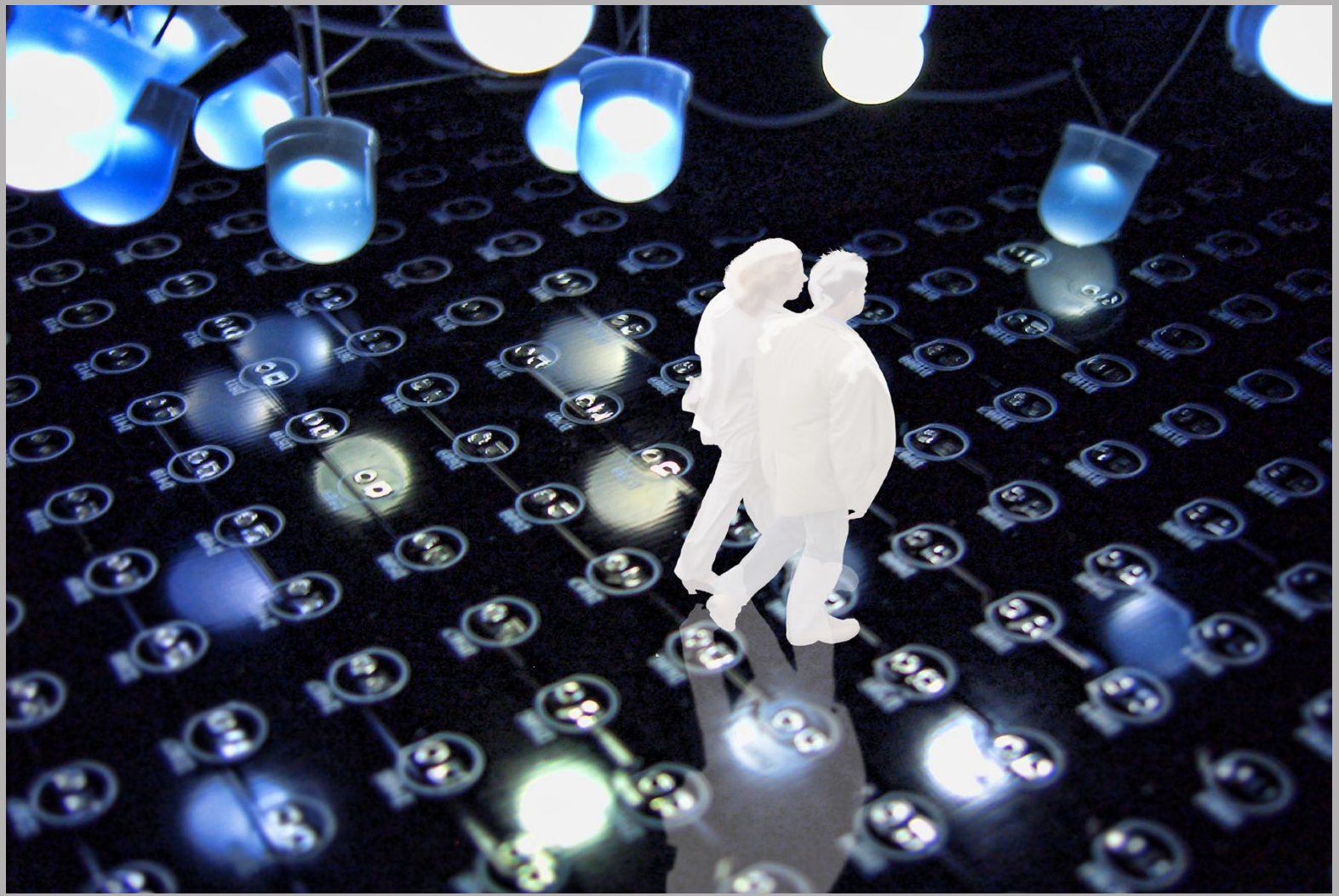


Fig.53. Construct manipulation graphic





Fig.54. Conceptual rendering - shows the possibilities of projection of the surface of a building and other non-physical visual elements



Fig.55. Conceptual rendering - shows the possibilities of projection of the surface of a building and other non-physical visual elements

### DYNAMIC ELEMENTS:

- Create time based interaction
- Use physical and visual movement as means to establish connection with viewer
- Has to be easily customized and changed
- Reacts to stimuli, i.e. the viewer, owner, weather, climate, light, ect.
- Each module controlled individually in the movement of the whole

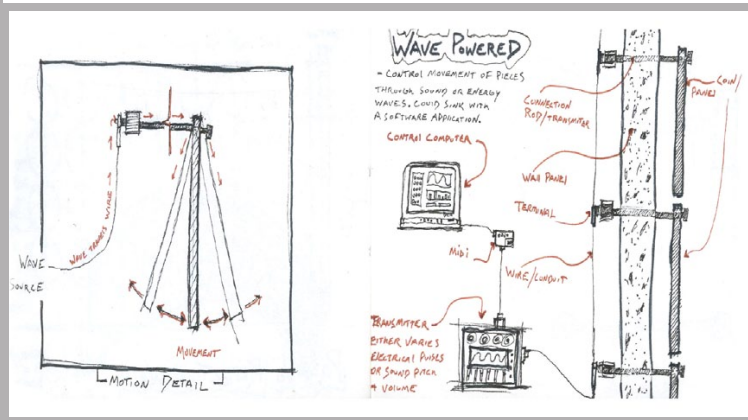


Fig.56. Conceptual sketches of a movement based wall system

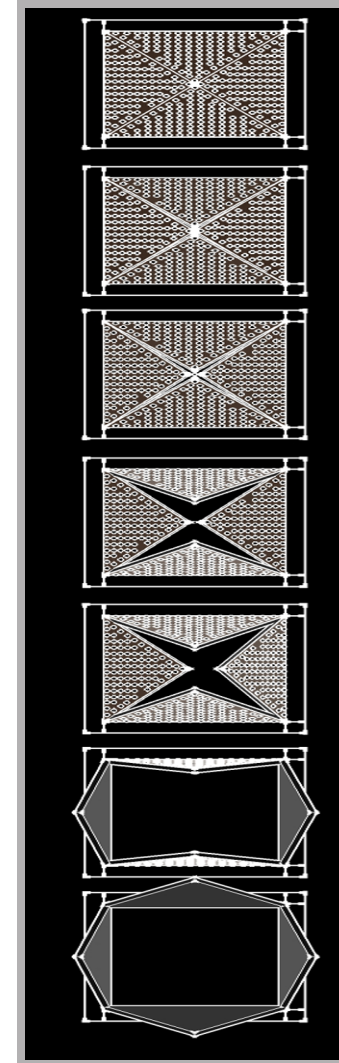


Fig.57. Initial dynamic idea graphic - based on a triangulated design that could open and close

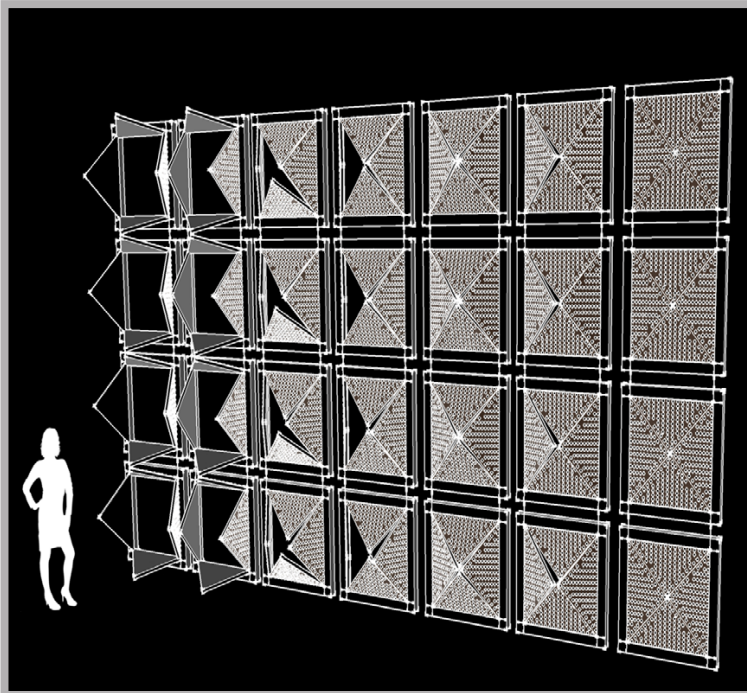


Fig.58. Initial dynamic idea - based on a triangulated design that could open and close

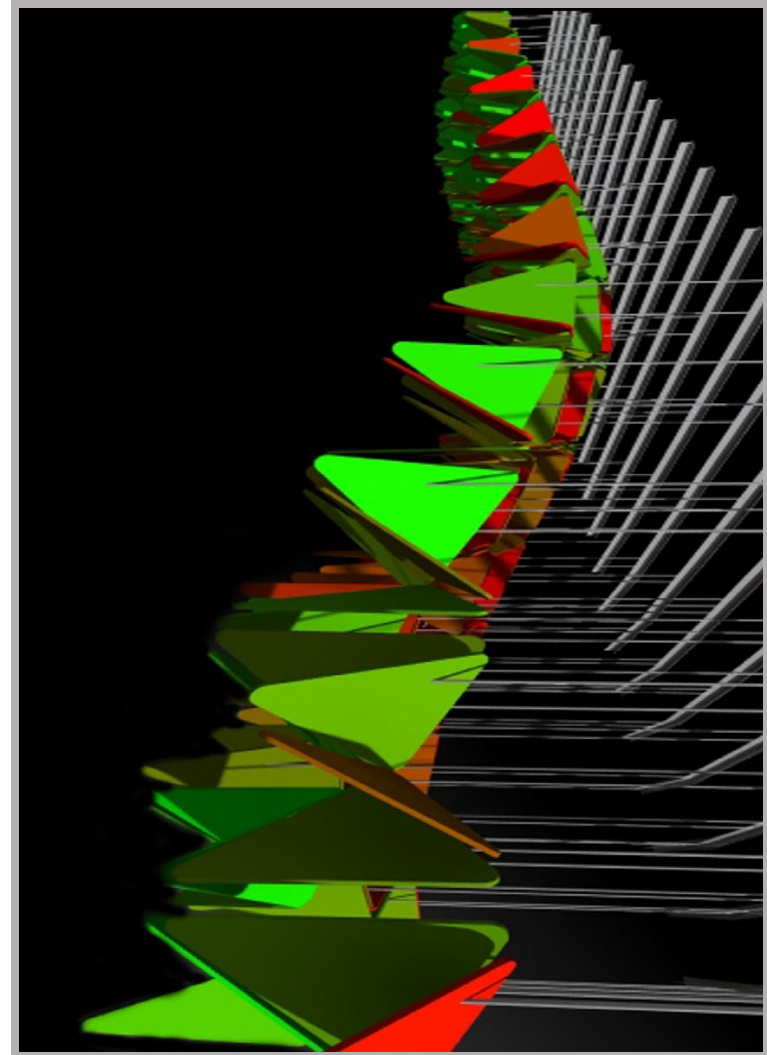


Fig.59. Conceptual rendering of dynamic system

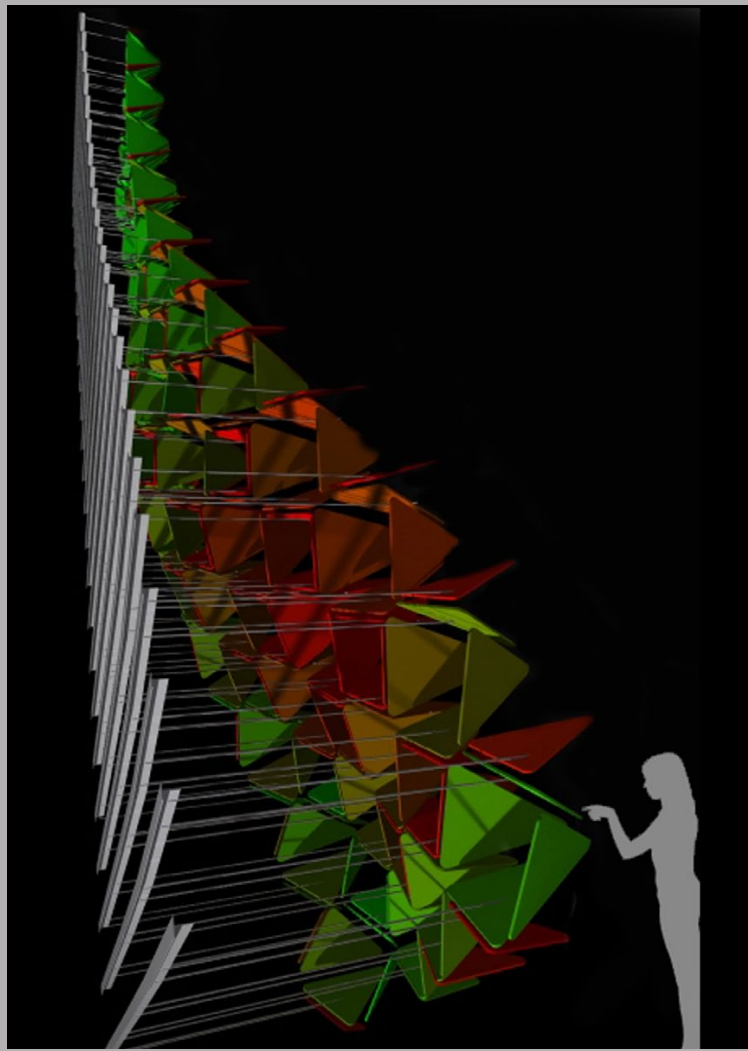


Fig.60. Conceptual rendering of dynamic system - responsive to touch and human interaction

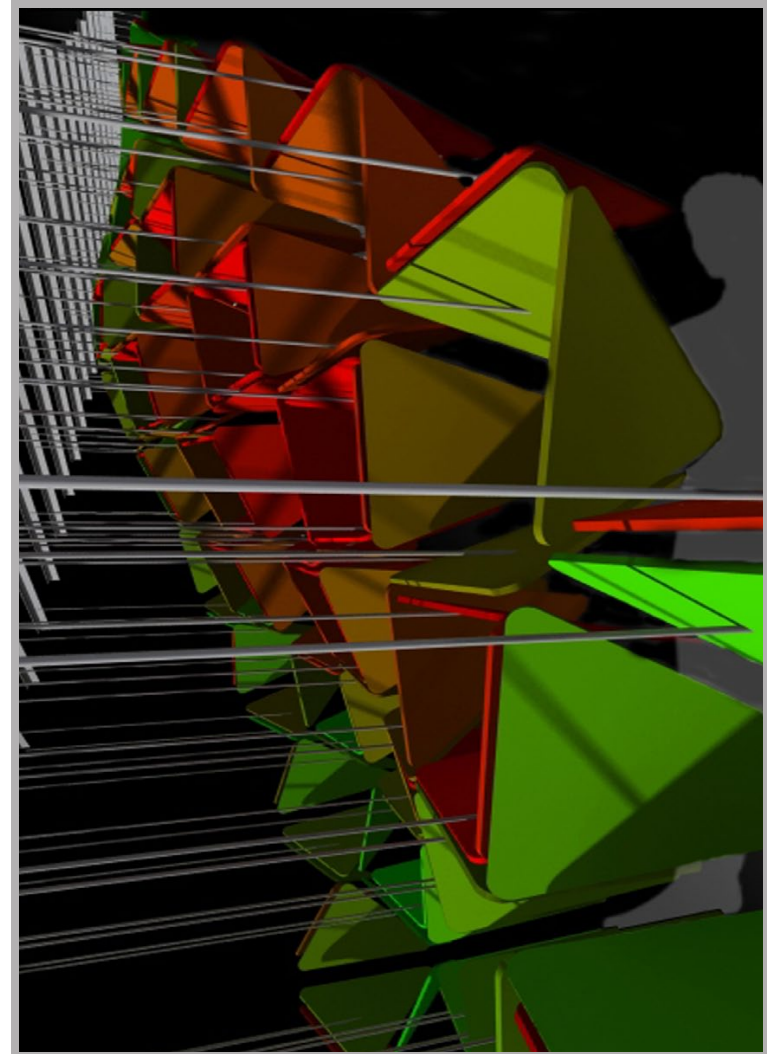


Fig.61. Conceptual rendering of dynamic system

#### BEYOND THE FACADE:

In order to better integrate the system into the context of the site and the interior of the building, several steps can be taken to expand its influence beyond the wall.

- Interior partitions can be used to bring certain aspects of the façade into the interior of the building.
- Walkways and paths can be part of the input mechanisms.
- The building face can wrap around the structure to address the sky through the means of roof.
- Certain functions of the system can follow the user as they approach or leave the site in order to provide continuity and flow of response.

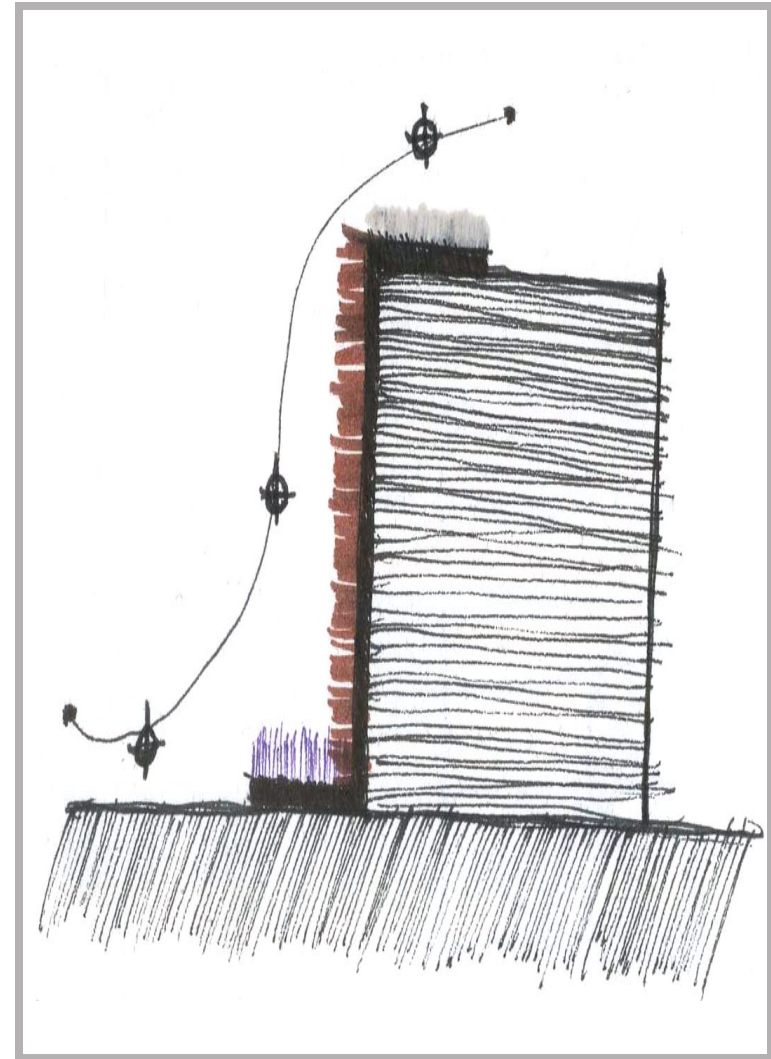


Fig.62. Diagram depicting the alternate functionality of the facade system

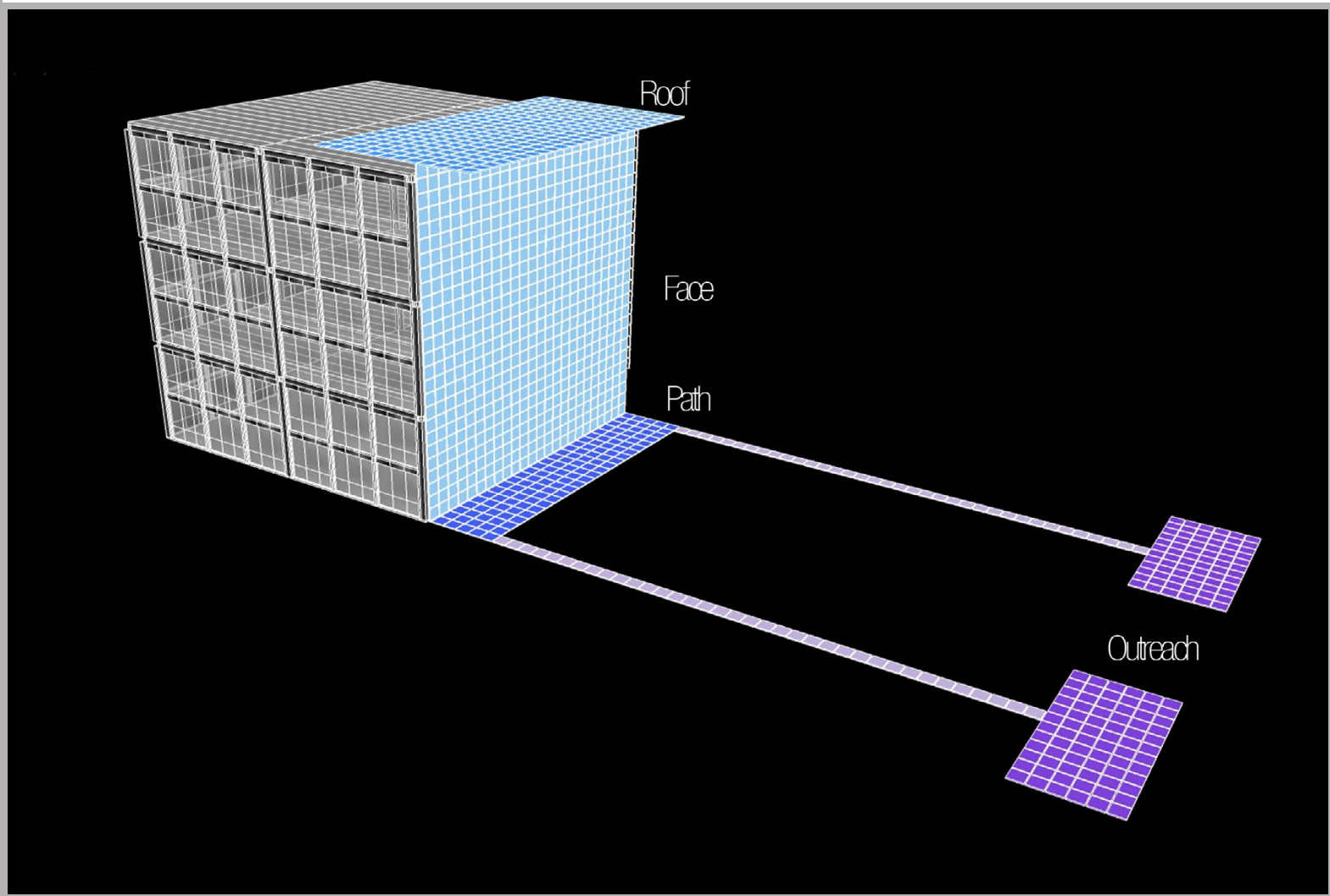


Fig.63. Diagram of outreach possibilities of the system - it can begin to percolate other areas of the site and building

# FINAL DESIGN

FINAL DESIGN

## DYNAMIC LIGHT

The final iteration of this project has manifested itself in the form of DynamicLight. Taking for the previous case studies, experiments, and schematic designs, the DynamicLight façade system is a modular interactive wall treatment. It is comprised of 9"x9" self-sufficient units that can be arranged in a multitude of configuration and function types.

As an individual unit, each module contains the same basic components and performs the same functions. As a conglomeration of units, the wall has the ability to act in an infinite amount of ways and perform any number of tasks. Similar to the led construct, each unit can be controlled independent of the others. This in effect enables a networked set of inexpensive micro-controllers to communicate through serial ports and become a living whole comprised of pieces. Each



Fig.64. Day and night. The facade system has the ability to portray different things depending on its environment

piece being like a pixel on the led construct that can be controlled by any number of inputs and react in various degrees of designated output.

For the DynamicLight façade, the output, or function, of the individual unit is two-fold. First, each unit has an integrated servo motor system that operated a mechanical lever device which opens and closes the six panels per module. The movement of the panels is used to regulate solar radiation entering the building as well as capture solar energy through photovoltaic mesh. Each servo system can efficiently open and close the panels from a complete closed position (less than 2% solar transmittance) to a fully open position (88% solar transmittance compared to clear glazing). Simply opening and closing these panels to the absolute maximums has the ability to aid in the mitigation of solar radiation. However, the dynamic aspect of the design is that each panel can be controlled to a 1/16<sup>th</sup> of a degree, which enables the wall to constantly adjust the amount that each panel is opened to maximize the occupant's thermal/visual comfort. And because each unit is also controllable in a custom manner they can all be performing in a different manner dependent on the specific needs of the controller. This means that some units may be tracking the sun with ambient light sensors and constantly adjusting their panel operation dependant on sun angles, while other units are responding to ping sensors and opening as people walk by, while even others are performing a set sequence of



Fig.65. Text graphic - haptic qualities of the facade system



Fig.66. Text graphic - sensorial qualities of the facade system



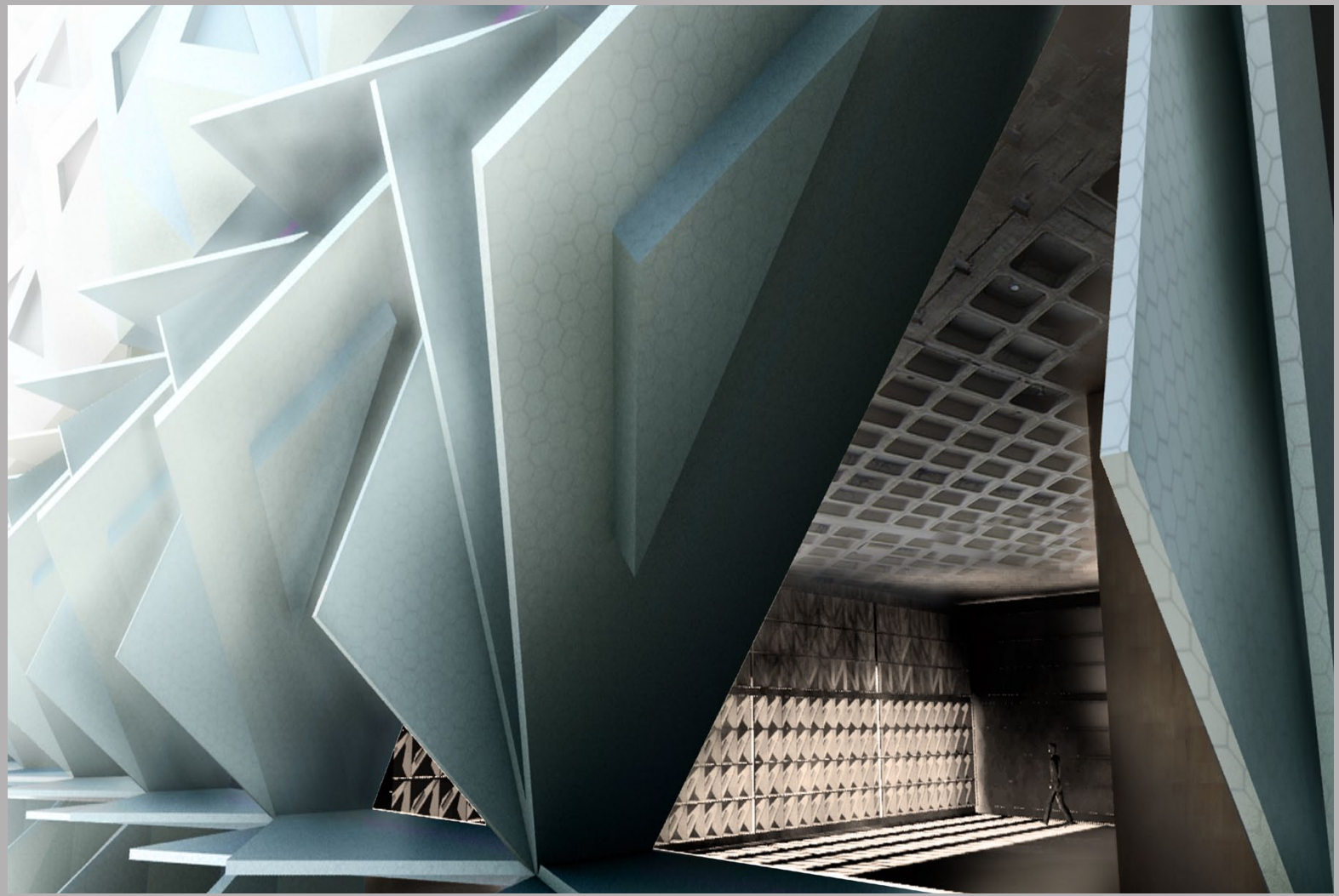


Fig.67. Computer rendering - shows a detailed view of the facade system from the outside looking in

activity that was custom programmed by the building's occupants.

The second output of the DynamicLight wall occurs after the sun goes down and the use for solar mitigation is no longer pertinent. At night, the façade system has the ability to display complex visualizations through an integrated array of led lights. From solid color changes to warping myriads of rainbows, each module performs as an ambient glowing pixel. Emitting the light inside each unit is a red, blue, green, and white led luminare, producing a possible color combination range of over 1 million colors. Depending on the amount of units connected together, the potential visualizations that can occur range from the simple to the very complex. Similar to a television screen or computer monitor, the more units that are used in a façade will directly relate to the resolution, and thus complexity, of the possible light manipulations and visuals.

Like the movement of the panels, the output of the led lights can be controlled through various different sensors, controls, programs, and input devices. It can be an interactive endeavor like the led touch construct that responded to movement, or it can be programmed through a computer program like Processing, and every other imaginable user interface in-between. The greatest strength of the design is its versatility and open-source nature. It is made to be hacked, coded, chopped, and customized by the user. Ultimately, it is through the user's customization that the product

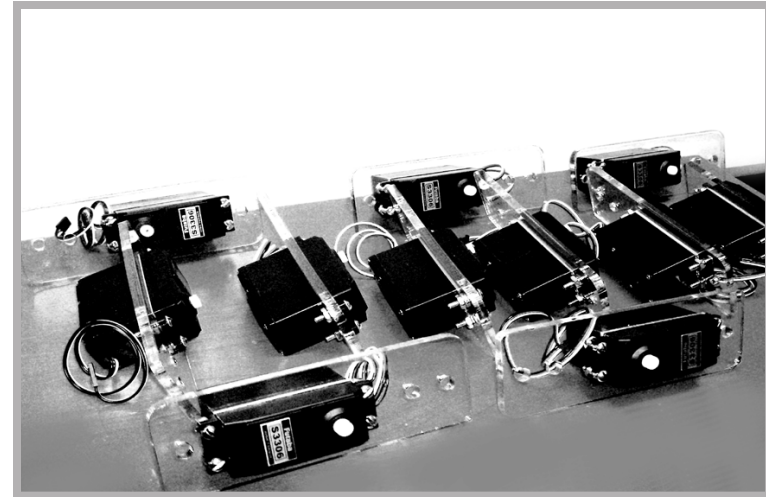


Fig.68. Servo motors - Futaba S3306 servos mounted to plexi

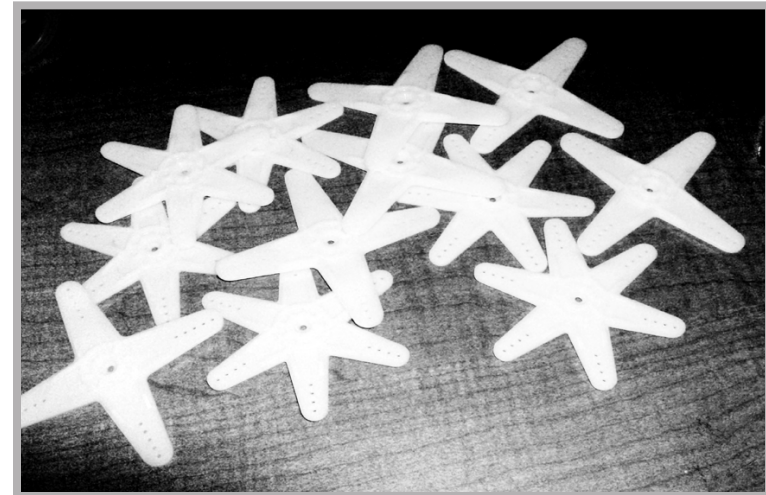


Fig.69. Servo drive arms - 16mm

becomes successful. Since it is impossible to design a mass producible product that fits multiple different applications and specifications, it is the openness of the design that allows the individual to make it unique and appropriate to its installation. Hence the 'dynamic' aspect of the product lies not only in its function but more so in its innate propensity to change in order to meet alternating requirements.

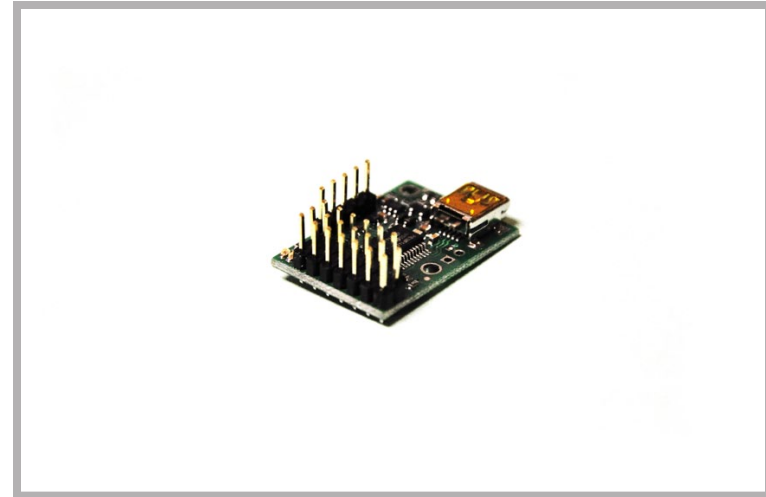


Fig.70. Servo control board - supplies ground, power, and control signals to six servo motors

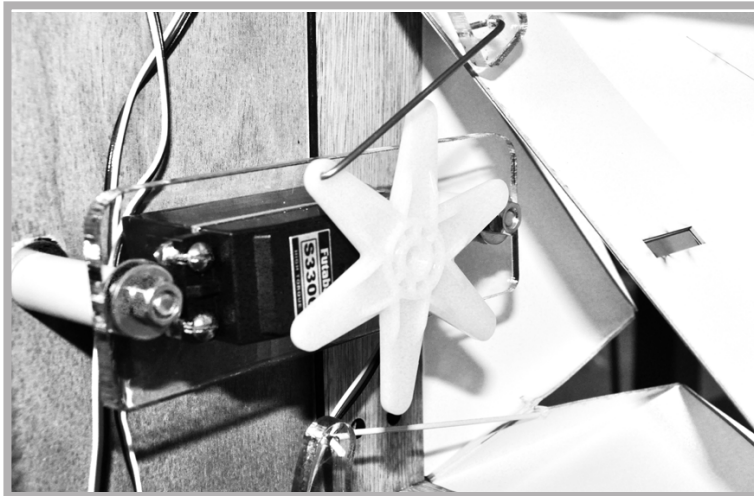


Fig.72. Servo motor mounted - servo is mounted in a lasercut piece of plexiglass and attached with 1/4 bolts and steel spacers



Fig.71. Individual servo motor - Futuba S3306 can provide 26Kg/ square inch of torque on 6v power



Fig.73. Exterior conceptual rendering - facade system closed



Fig.75. Exterior conceptual rendering 2 - facade system in action, checkered pattern



Fig.74. Exterior conceptual rendering 3 - facade system in action, diangle pattern



Fig.76. Exterior conceptual rendering 3 - facade system in action, strip pattern

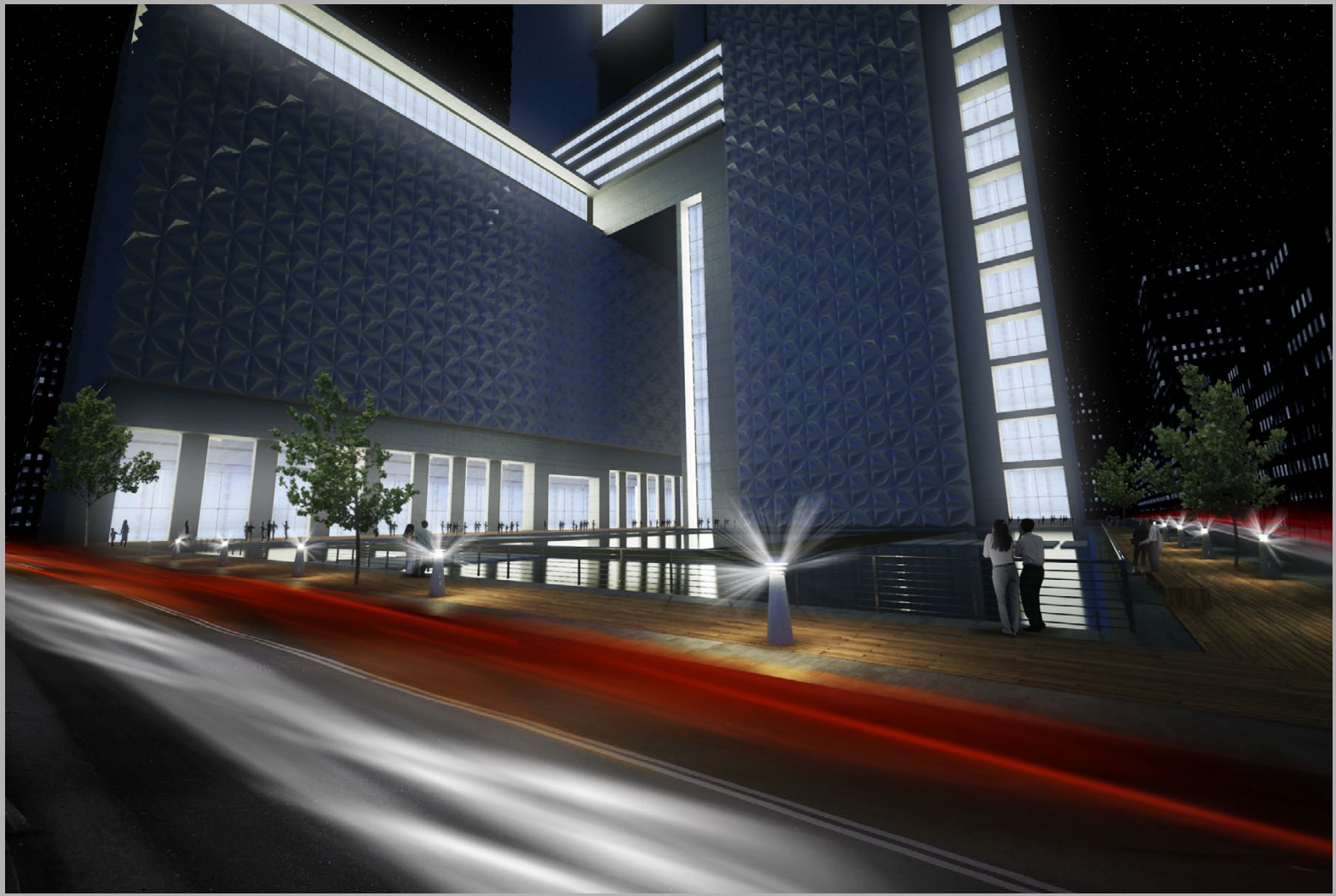


Fig.77. Conceptual night rendering

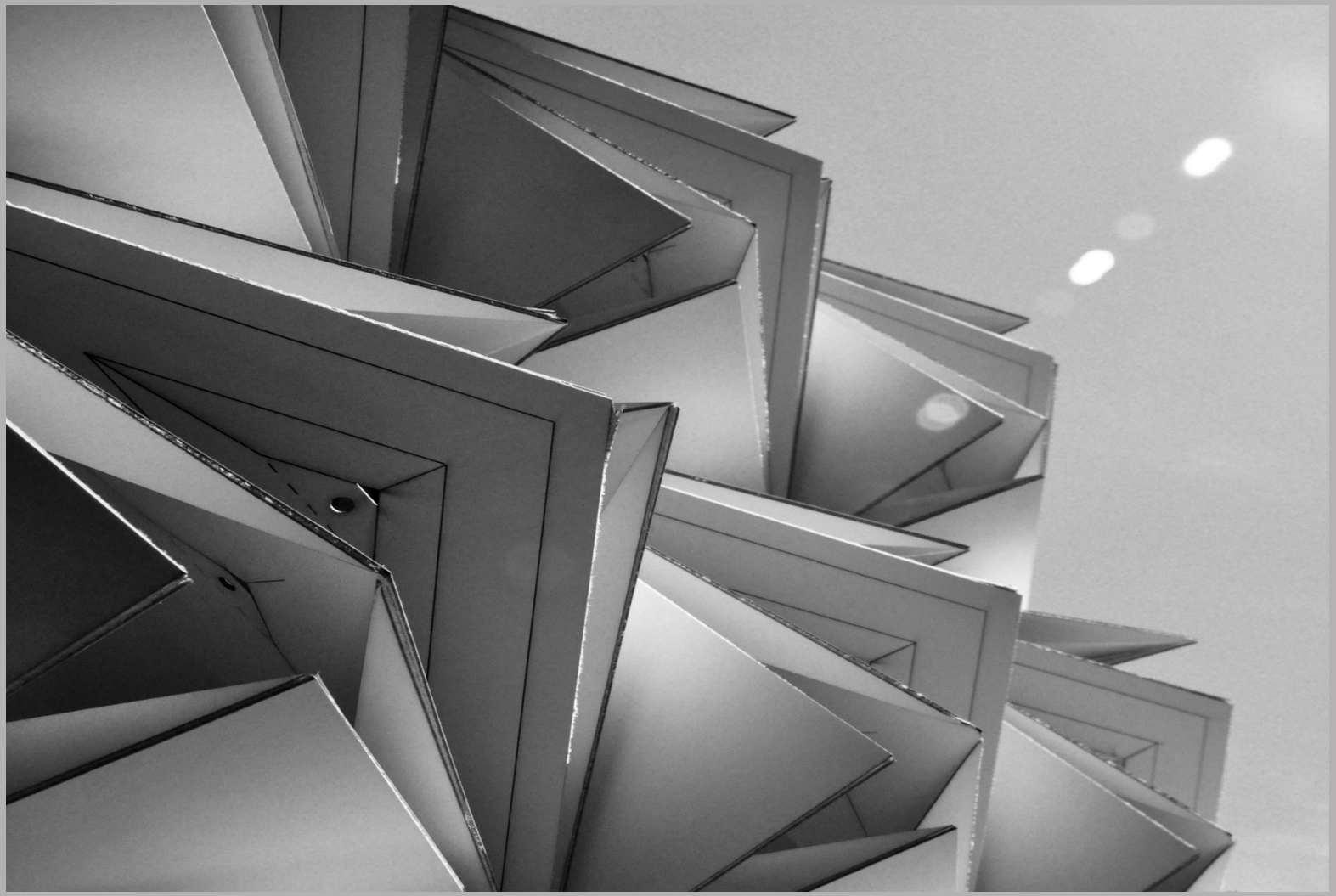


Fig.78. Dynamic light qualities of facade - photograph shows how the angles of the opening and closing units catch sunlight in different ways

## FLAT-PACKED DESIGN

In order to promote an easy and inexpensive factory-to-completion process, the desired method of undertaking relies heavily on maximizing the materials and simplifying the assembly process. Drawing on the incite of such great innovators as Swedish furniture designers Gillis Lundgren and Baron DuMuff, the notion of flat-pack economy and practicality became the solution of choice. The flat pack furniture designed by the aforementioned individuals was designed to be rapidly and easily assembled. These furniture pieces were fabricated in flat parts so that when all of the pieces were put together to be shipped they could easily be stacked on top of each other and took up as little packing space as possible. The manufacturer benefits from the product being exceptionally space efficient by saving substantial amounts of money in shipping and storage costs. Savings can then be passed along to the consumer whom gets a better product at a lower then market average cost.

Along with all of the pieces being designed with the notion of economical packing in mind, each component is pre-drilled, cut, and scored to aid in assembly. Ideally, the design of the whole unit is such that the inexperienced construction worker may put the

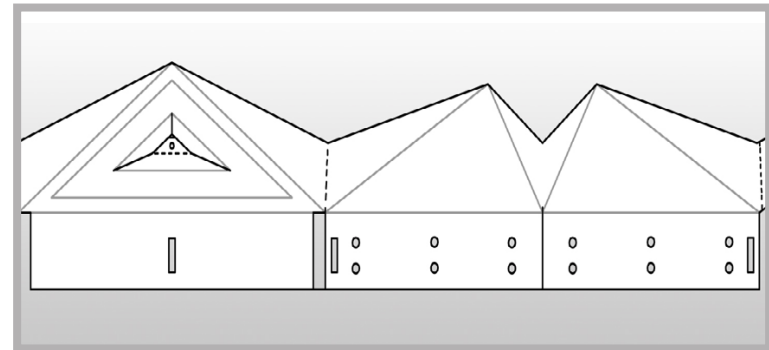


Fig.79. Autocad drawing of single module - shows the score and cut marks that are utilized to make the flat lasercut piece 3d

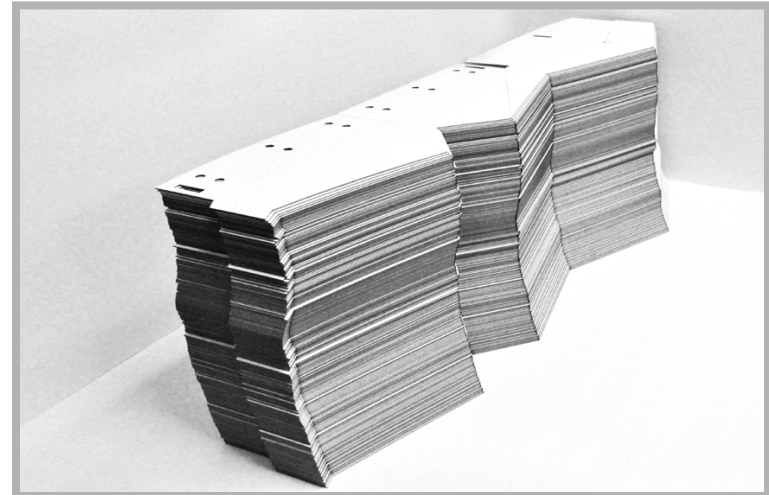


Fig.80. Lasercut mat board - the stacked 112 cut out pieces of mat board prior to folding, stacked in a flat-pack manner

whole thing together with little to no problem. Since all of the accurate and complex parts of the piece are fabricated under the stringent conditions of the factory and all of the proper hardware is packaged along with the pieces, the assembly that the construction worker has to do is lies easily within his/her expertise of simple building processes. In addition, there are no specialty tools that are required in order to put the individual façade units together. Everything that is needed and not shipped with the other parts is assumed to be in the common tool collection of the average construction company.

Another advantage to a flat pack design approach is that the very nature of the design abets a mass producible product. And mass producing a product assures that the consumer ultimately saves even more money compared to other viable alternatives. It also assures a certain degree of uniformity to the module and hence the product. Lastly, mass production techniques allow for the total production line to be efficiently tuned in order to reduce the amount of waste produced.



Fig.81. Lasercut chip board - the stacked cut out pieces of chip board prior to folding, stacked in a flat-pack manner



Fig.82. Multiple stacks of chip board - the stacked cut out pieces of chip board prior to folding, stacked in a flat-pack manner



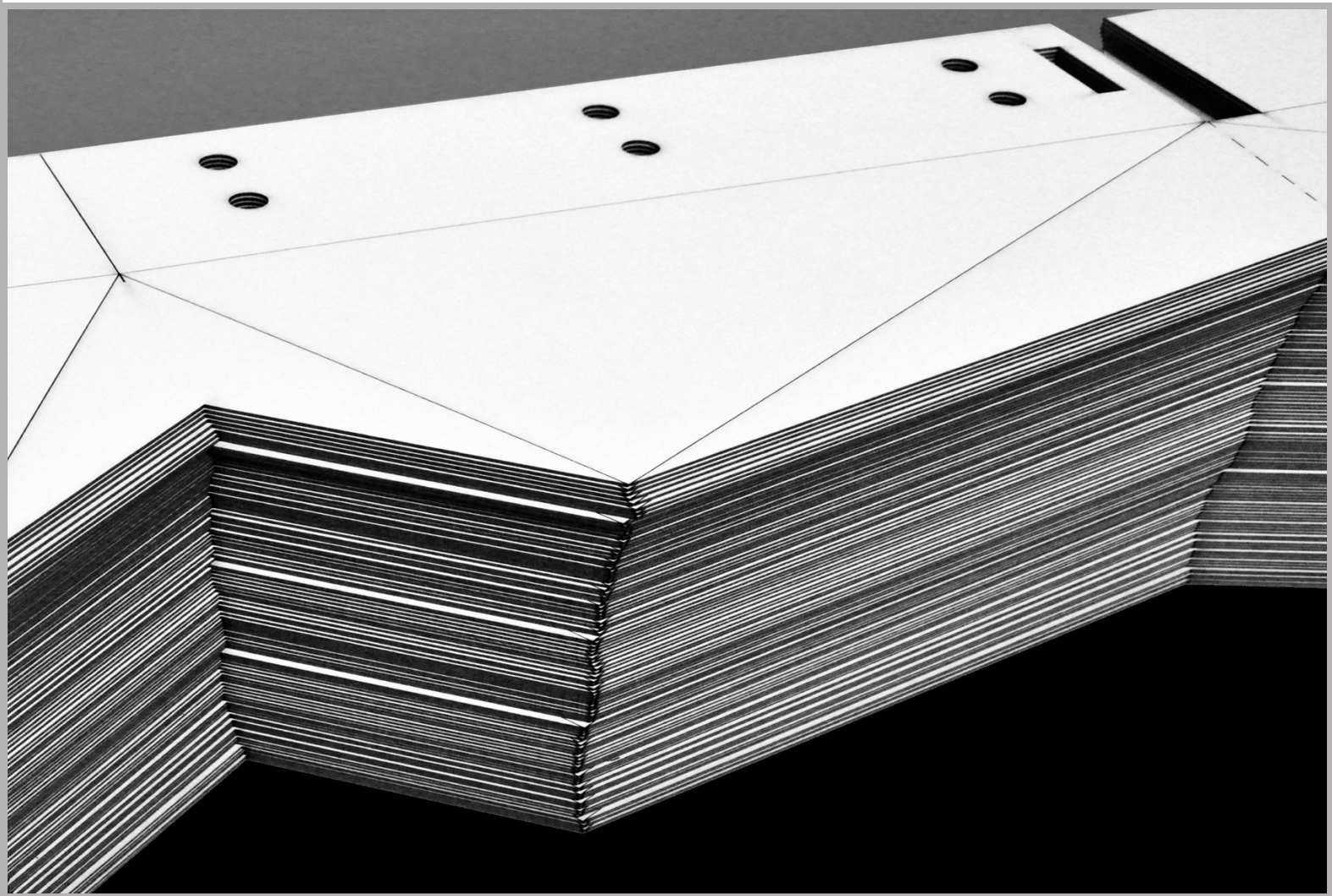


Fig.83. Detail photograph of mat board - the stacked cut out pieces of mat board prior to folding, stacked in a flat-pack manner. The score marks necessary for folding can be seen

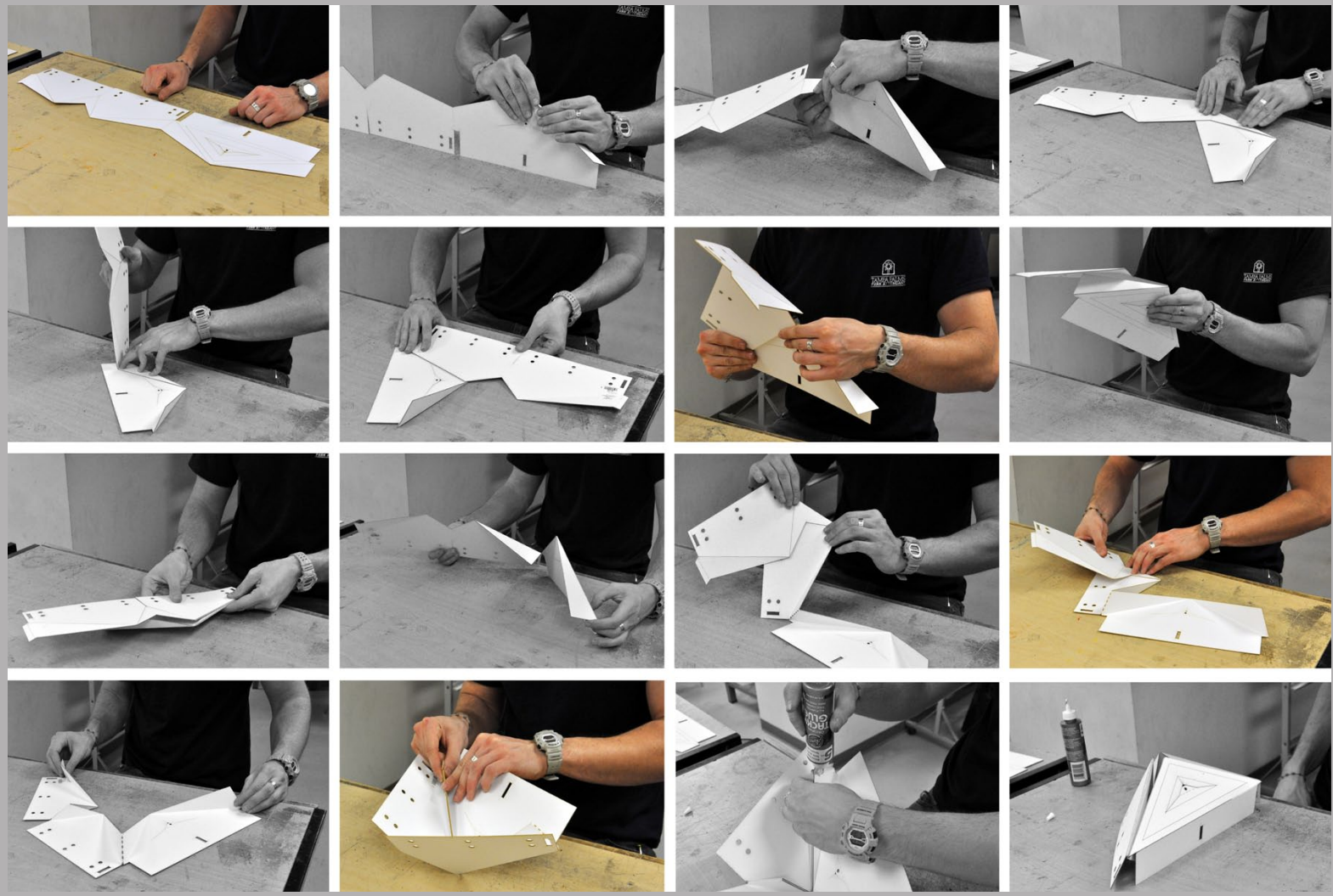


Fig.84. Folding sequece - the sequece of photos shows the manner in which one piece of mat board is folded to create half of one unit



Fig.85. Folded units - units that have been folded prior to receiving the structural frame

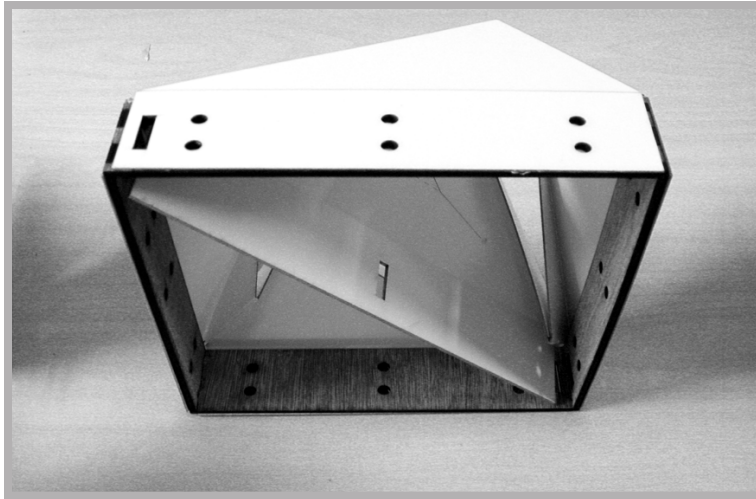


Fig.86. Module unit - back

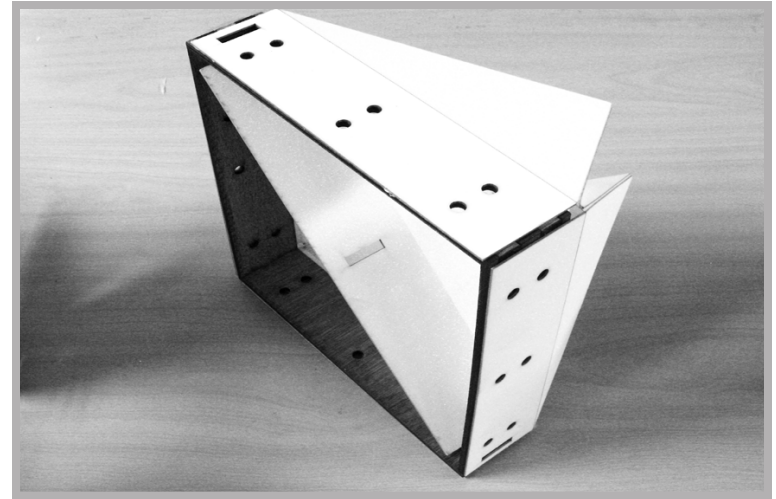


Fig.88. Module unit - left side

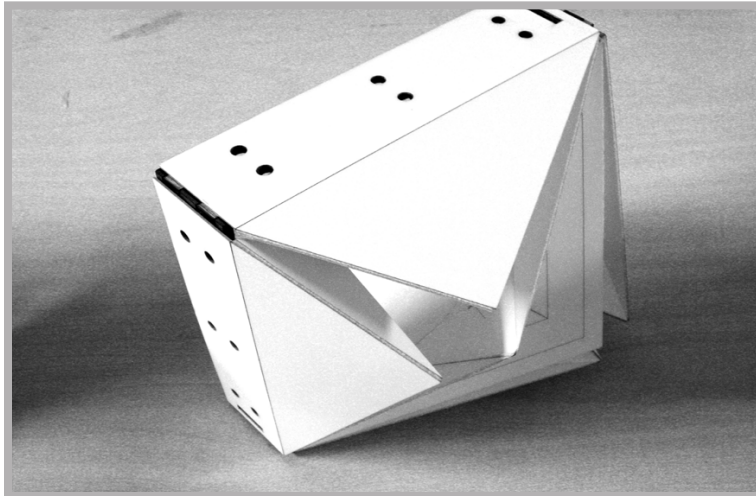


Fig.87. Module unit - right side

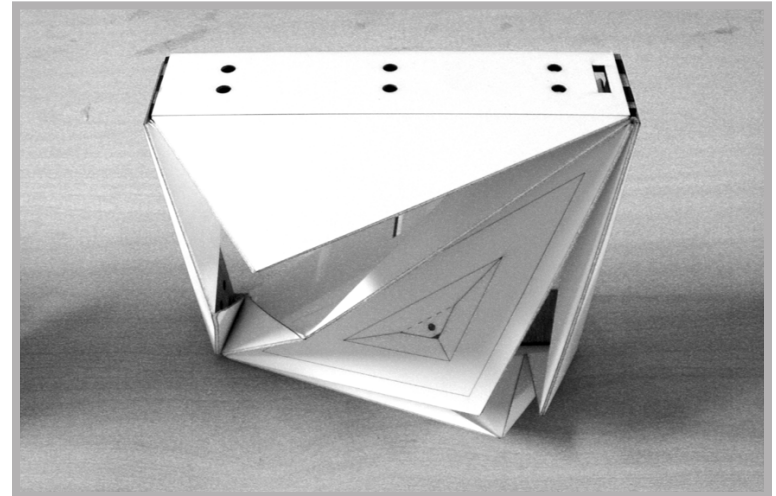


Fig.89. Module unit - front

## SOLAR COLLECTION

Solar collection is a key aspect of the DynamicLight system. Since a carbon zero energy balance is desired, the whole façade must collect or mitigate and equal amount of energy to that which it consumes. To accomplish this goal a network of photovoltaic solar cell, in the form of a semi-transparent mesh, are integrated into each modular unit. The PV cells are contained in a mesh layer between the structural substrate and the outer ETFE layers. As the unit panels move during the day each PV panels is optimizing solar collection as it is simultaneously blocking solar gain into the building. Therefore, each unit is performing two sustainable energy functions at once; collection of electricity through harnessing solar energy, and lowering the load on the buildings mechanical system by controlling

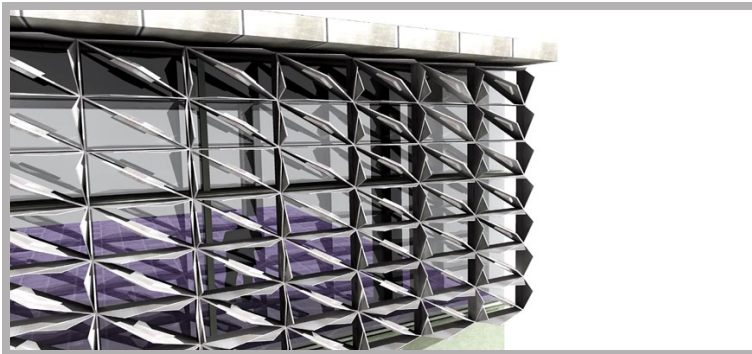


Fig.90. Rendering of DynamicLight facade - all units open

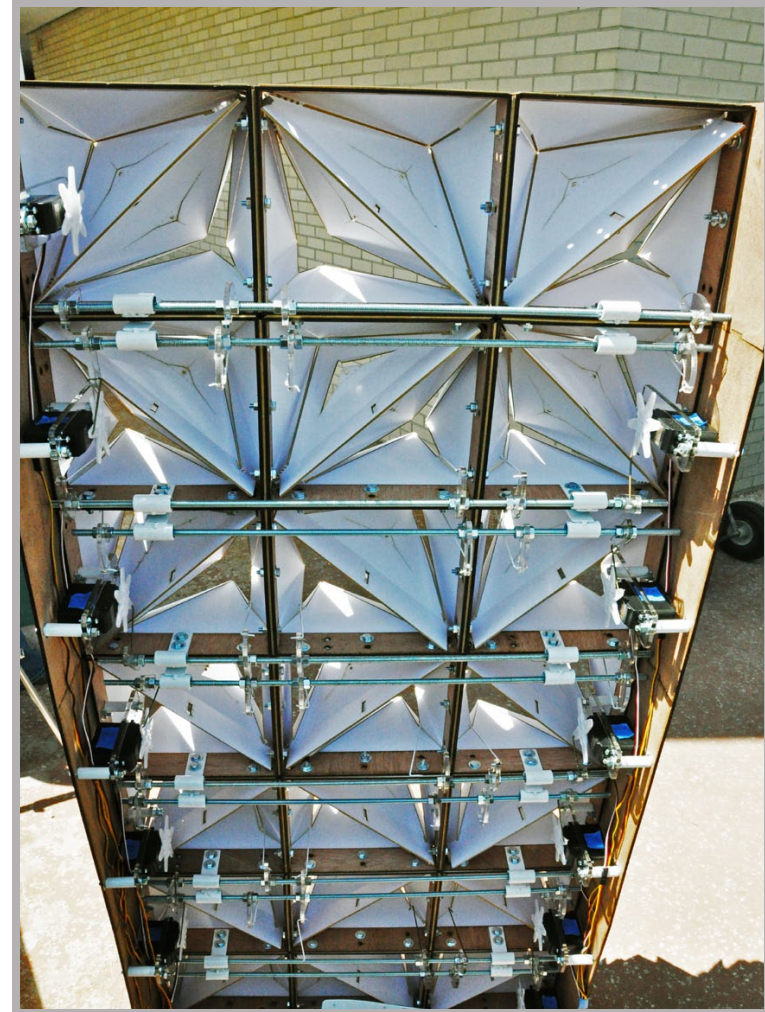


Fig.91. Final wall mock-up - back side showing mechanical components

the amount of sunlight, and thus heat, that enters the interior space.

The harnessed energy from the integrated PV mesh is stored in individual batteries that are part of each individual unit. During the operation of the unit (i.e. to run the servo motors or power the led lights) the battery provides the initial power. In the unlikely case that the system needs additional power, or if the batteries are insufficient, the whole array can be connected to the main building's electrical grid. However, the probability of the system needing to draw electricity from the main grid is highly unlikely. What probably will occur is the opposite; the PV mesh will collect an abundance of energy and the excess can be sold back to the main power grid for a profit.

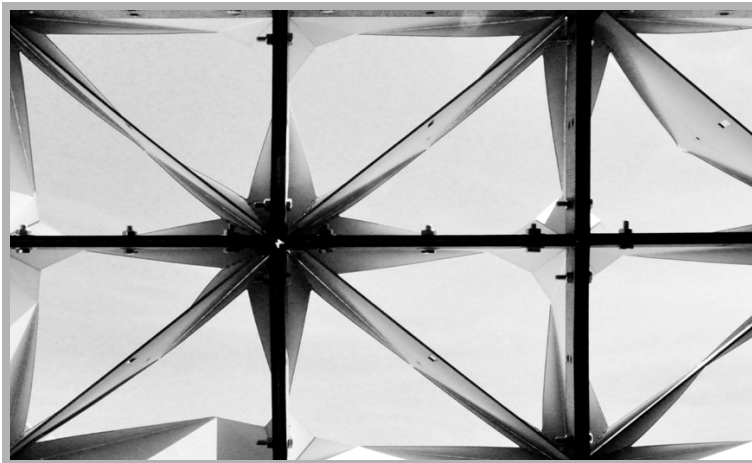


Fig.92. Final wall section - photo of units in alternating configuration and fully open

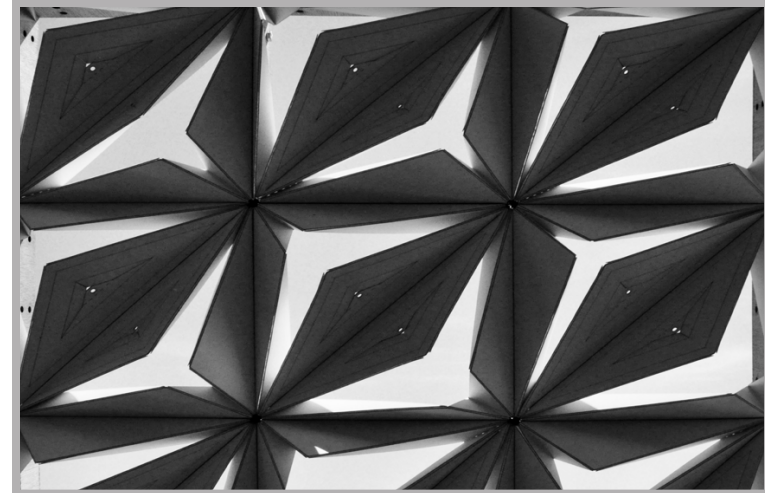


Fig.93. Final wall section - photo of units in matching configuration and closed



Fig.94. Modular units - efficiently organized taking up minimal space waiting assembly

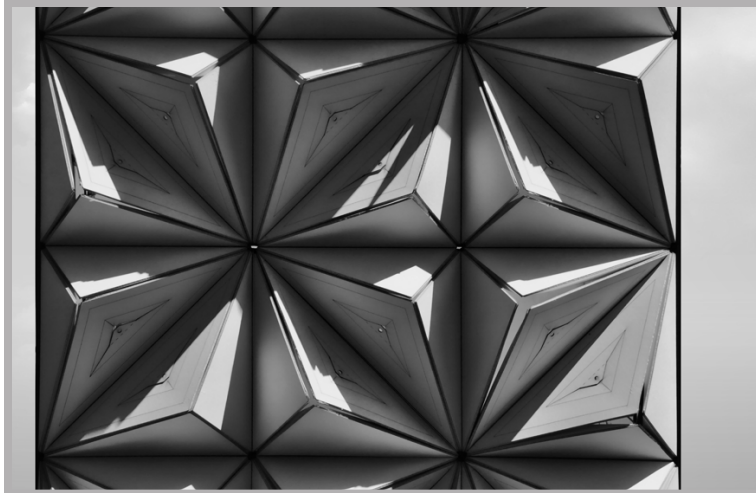


Fig.95. Final wall mock-up - front view units closed, no sun transmittance

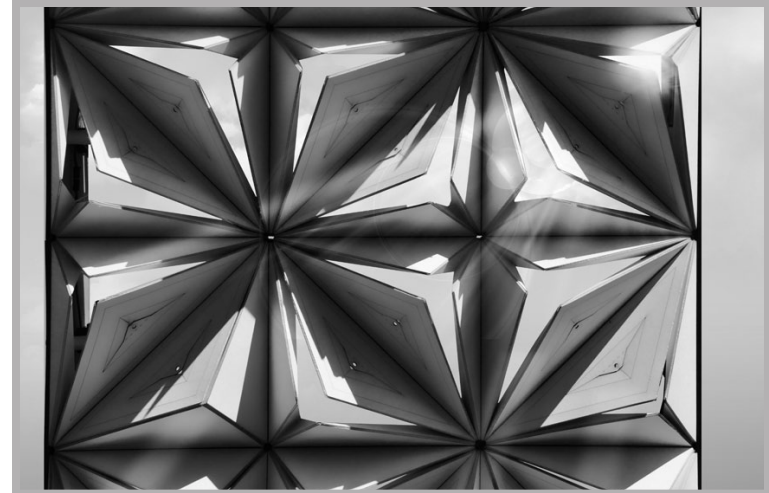


Fig.97. Final wall mock-up - front view units 30% open, partial sun transmittance

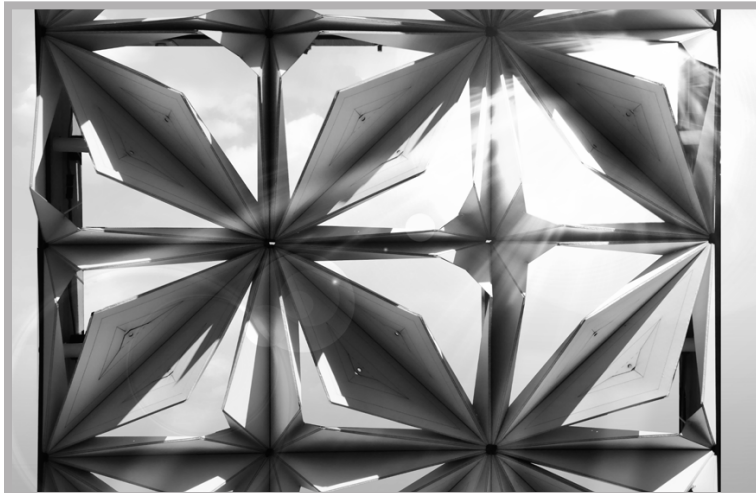


Fig.96. Final wall mock-up - front view units 60% open, moderate sun transmittance

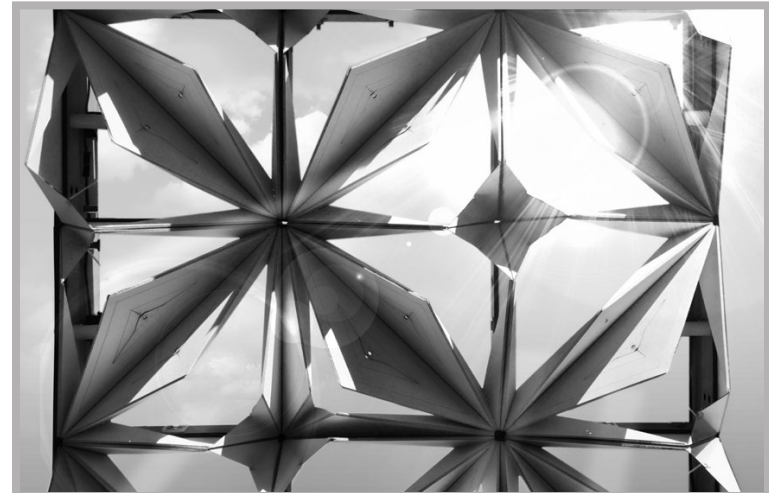


Fig.98. Final wall mock-up - front view units 90% open, full sun transmittance



Fig.99. Final wall section



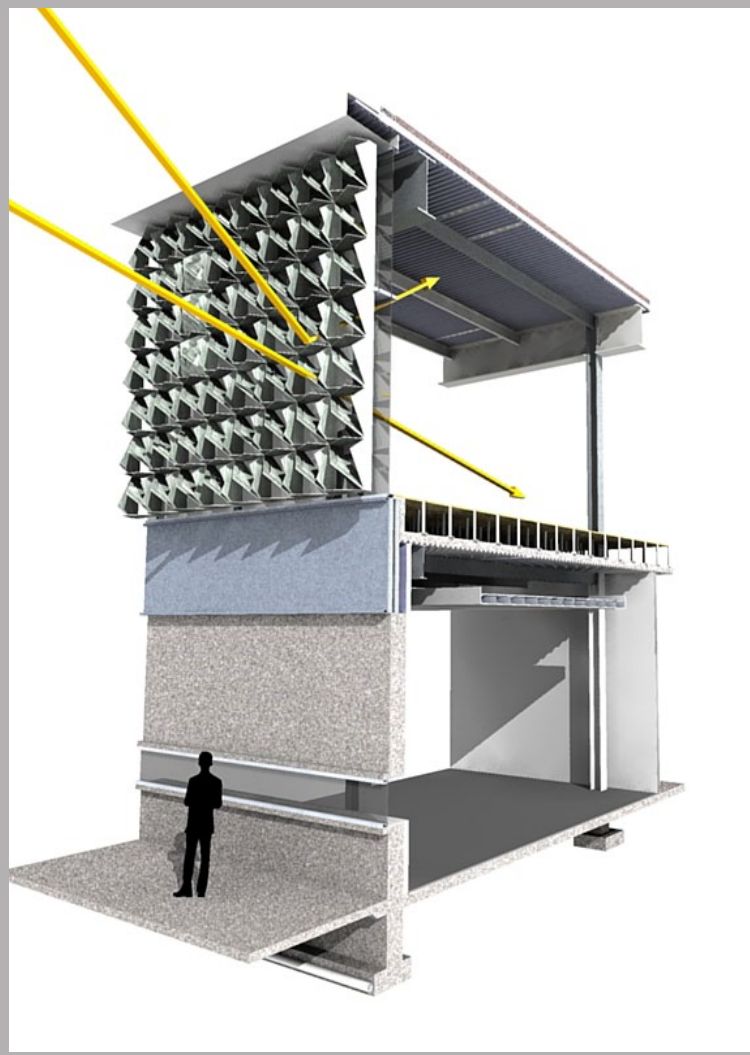


Fig.100. Diagram of facade operation - units open and solar light entering interior space

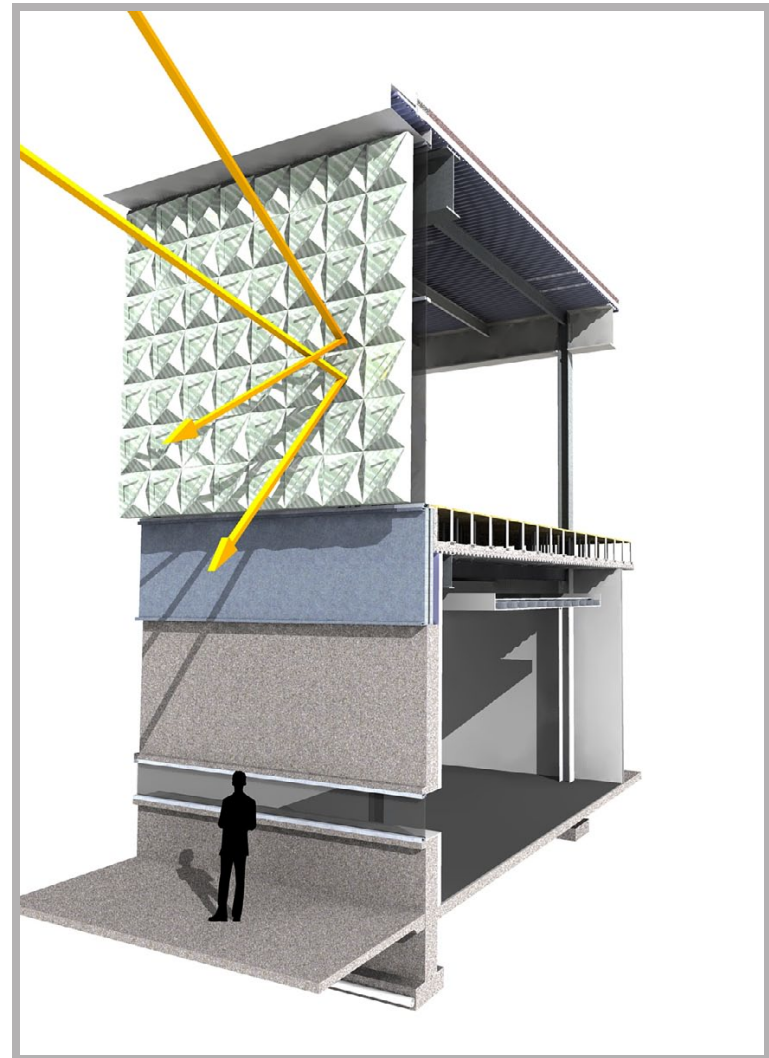


Fig.101. Diagram of facade operation - units closed and solar light being blocked from entering interior space

## CONCLUSION

In all honesty, I feel that a conclusion at this stage is premature. In my eyes, there is much more potential for this project outside these printed pages. The future of this kinetic façade system hopefully lies in the development of the abstract into the reality. If my assumptions about the demand for a product like DynamicLight are correct, then there is a market for the production of such a façade system. Hopefully, in the near future the concept presented in the preceding pages will become an actual wall somewhere in the world. Now, it is time for the true 'real world' rigor of testing and fabrication. I can only hope that the future iterations of this project are as fun and enjoyable as creating the conceptual underpinning have been.

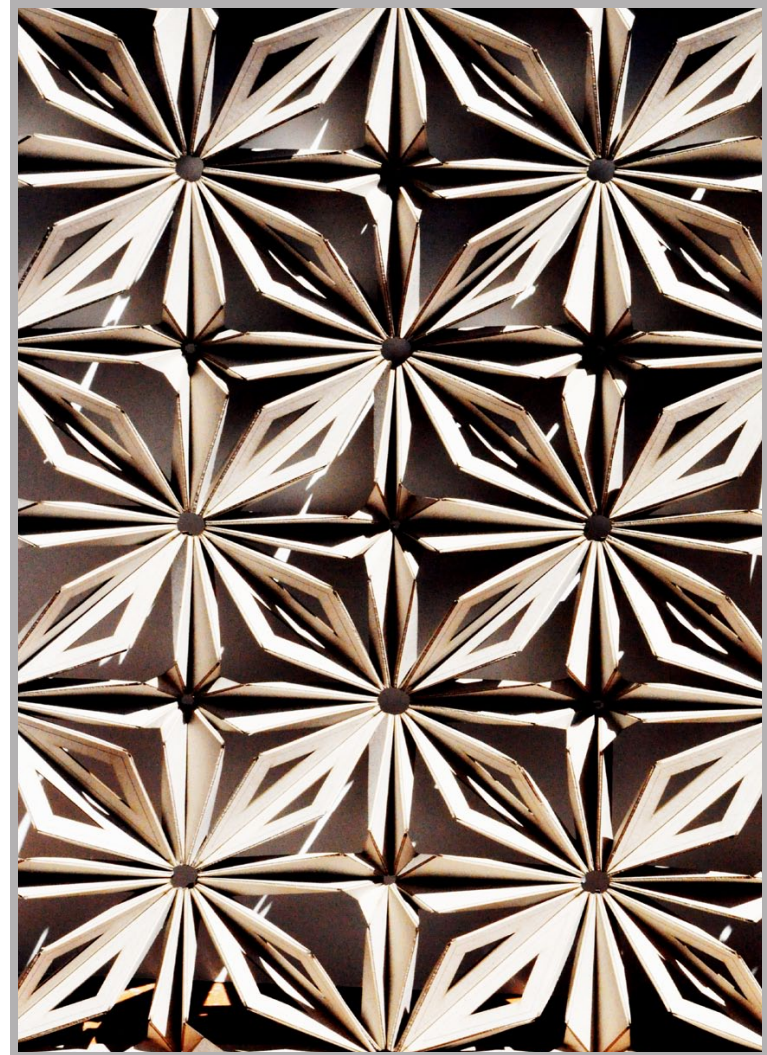


Fig.102. Final wall section - one of the many ways that DynamicLight units can be configured

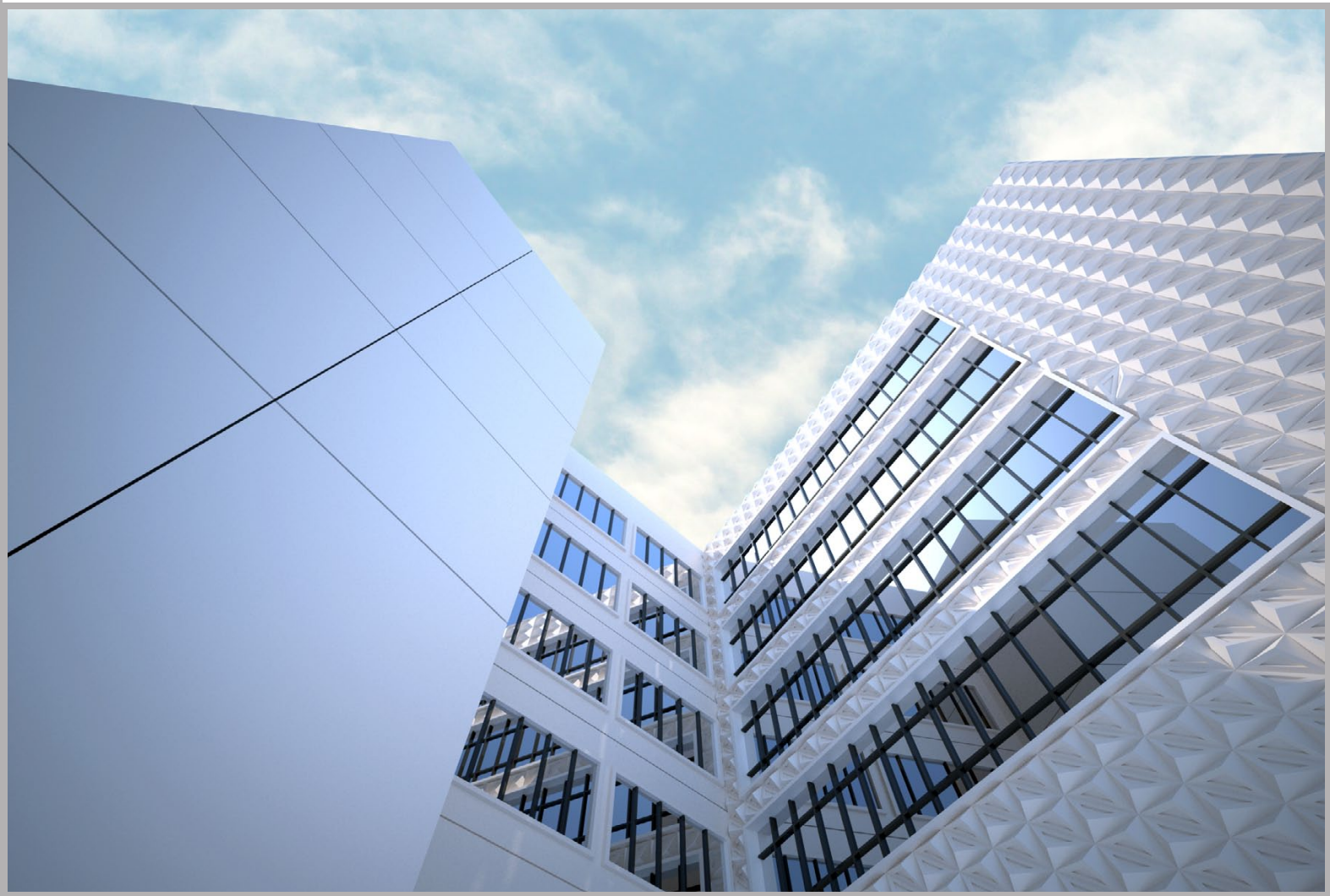



Fig.103. Conceptual rendering - the sky is the limit and the possibilities of DynamicLight kinetic facade system are limitless

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