I, Ciara K Seymour, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture (Master of).

It is entitled:
Reciprocal Capacities and Adaptive Space

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Reciprocal Capacities and Adaptive Space

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by

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The socio-cultural context is rapidly changing, yet much of the resultant architecture has remained unchanged, in process and performance. More mutually enriched relationships between people, the space they inhabit, and the environment may be achieved through an architecture that responds to building occupants and environmental factors. In creative appropriation of technological advances, the space envelope—relative to a more responsive architecture—exceeds its meaning as mere element of enclosure and exclusion. The exterior wall is relieved of its nuanced label as boundary, of the dualistic positions of inside and outside, and moreover, becomes an interface between environments, which lie on both sides.

The thesis proposes an architecture that actively differentiates environmental conditions and socio-ecological context through morphological and material articulation. By identifying and relating the behavioral tendencies and performance capacities of material systems with environmental and social inflection the resulting provisions and opportunities for inhabitation approach an architecture that engenders emergent and intensively choice-driven patterns of social formation and occupation. Varied expression and spatiality can provide diverse spatial arrangements together with climatic intensities. The concept proposes a shift from mono-functional modularized building elements, based on linear task-solution concepts, to integral systems with non-linear, complex behavior and properties.
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Reciprocal Capacities and Adaptive Space

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As a transition between inside and outside—between the house and the urban space—the building skin plays an especially pivotal role. First and foremost it provides protection from the elements, demarcates private property, and creates privacy. However, the cultural function and aesthetic are just as valuable and continue to remain a distant second or third.

The ideas established by Modernism—which continues to exert its influence today, far beyond the heyday of the architectural style—stipulate that the external appearance of a building should reflect its internal life. Harmony should reign between form and function, inside and outside. As technical requirements grow ever more complex and insulation guidelines increasingly rigid, nearly every external skin has become a multi-layered system of surfaces that rarely give indication or insight into the interior life of the building. Similarly, the relationship of building users to the exterior (views, inhabitable outdoor space, and operable windows) is often compromised.

Functional Fixity: The Building Envelope

Functional Fixity: The Building Envelope

Gottfried Semper claims that the first instance of a wall and architectural space is the animal pen, a fence woven of branches and twigs. The timeline of human history and technology are mirrors of architectural development, and more specifically the wall, as it relates. The building skin, aforementioned as the animal pen, started as a purely functional necessity, in a formal sense, which successively broke free to individual taste and creativity, yielding ornament and decoration. Openings in the system had to be strategically placed and were not easily forged, resulting in an output indicative of the rudimentary means of production. Technological advancements gave way to new materials (first glass, then steel and iron, among others), which fostered a novel appreciation for light in buildings and porosity in walls. Gothic sacral buildings were amidst the first to incorporate glass into built design, and from the middle ages onward glazing was standard treatment for openings; however, it was not until the Industrial Revolution that the material became truly affordable in conventional construction. With this fundamental shift, functional and commercial demands were able to influence design decisions without previous limitations and concerns, thereby allowing for much of the same logic visible in façade systems today.

The word “wall” is usually taken to mean a firm, solid barrier placed to control the passage of people or animals, light, air, and the like; an object permanent in character, and partially subject to the will of the building occupants. The traditional wall formally encloses and divides space, meanwhile performing the equally vital function of supporting other walls, floors, and roof. The word “curtain” implies a somewhat flimsy barrier placed to control many of the same factors. As currently used, “curtain wall” has come to mean a wall that...
divides space, is controllable, and supports nothing but itself. Strong, flexible, light, thin, the curtain wall logically and somewhat tardily followed the development of the skeleton frame. With the introduction of steel and reinforced concrete framing, the ancient function of the wall as an integral part of the primary structural system was eliminated.

Curtain wall is relatively novel in semantics, yet conceptually existed, unnamed, for centuries. When the Greeks and Romans utilized post-and-lintel construction, filled in with brick, stone, or concrete for enclosure, they built curtain walls. The medieval cathedral with arches supported upon columns had curtain walls of stained glass. The Crystal Palace of James Paxton, the Bibliotheque Nationale, and the early skyscrapers utilizing skeleton construction had curtain walls of glass and either metal or masonry.

The curtain wall functions as a filter for the elements, fire, people, animals, sounds, odors, and anything else that might pass into or out of a building. The principal difficulty, in terms of construction, is with the elements that resist the passage of these items or, concurrently, allow their passage when desired. This problem is typically overcome through effectually assigning layers to perform specific jobs, in the most austere sense. For example, the traditional window is rarely a plain hole in the wall. It is nearly always one component in a spatially layered transitional zone. Curtains, blinds, folding shutters, window sills and flower boxes each fulfill a different task and create a "gentle" threshold from the outside to the interior. This has been the case and logic for the curtain wall since the onset of the style.

More recently the popularity of the building skin as a responsive system is being integrated, as one component of a more sustainable and low-energy solution, the curtain wall is moving beyond its traditional role. Simple folding and sliding shutters, moveable louvers and multi-layered glass facades equipped with a multitude of devices for shading and glare protection, light deflection, heat- and energy gain are some solutions for the newly inclusive system. In the face of diminishing raw materials and growing CO₂ emissions, this approach is increasingly salient.
The process of developing such a system inherently requires and allows for more comprehensive thought in the design process and product. The occupant/user provides contextual clues beyond the environment for how architecture may be developed, which again provides another element and/or layer for consideration in the amalgamation of thought. The dwelling of the nineteenth and early twentieth century suggested a largely static way of life linked to a specific place; today the act of dwelling increasingly acquires its space and time in the movement between the different poles of our existence. The flexible man organizes his life primarily according to the changing engagements of his professional career. Dwelling, therefore, increasingly becomes a practice of permanent moving, not only from one dwelling to another but also within the same dwelling. This restless way of life demands a non-permanent definition of architecture. To deal with the volatile nature of reality architecture must abandon a mechanistic concept of built-in flexibility in favor of an evolutionary flexibility: architecture that is priori incomplete, that can spatially adapt to changes in its internal and external surroundings, an architecture with a body of soft, pliable matter that, instead of imposing its definition upon context first acquires it there.

In *Animate Form*, Greg Lynn looks to the ‘performative envelope’ as a means of engaging the environment through forces that architecture and its surface are situated. As an example to illustrate this connection he points to the construction of the boat hull, which is based on an understanding of the external forces applied to the form as it moves through the water (flow, turbulence, viscosity and drag) and its necessity for accommodating multiple ‘vectors of motion’ simultaneously within its shape. The focus of the ‘performative envelope’ is its ability to hold within its shape...
multiple and latent responses to various external forces exerted upon it. However, a boat designed for the shallow waters of the Mediterranean would be ill-prepared for the open waters of the Atlantic, and neither of these boat hulls in dry dock would be anything more than a carcass. As Lynn states, ‘form is therefore shaped by collaboration between the envelope and the active context in which it is situated’.6

Architects have the resources to operate and design not solely on the basis of the needs of form relative to structure, force and envelope, but instead on the environmental criteria and conditions that facilitate organizations and actions within the places we inhabit. Investigations are allowed to be and are given the opportunity to no longer be just representations of forces that inform geometry, but rather simulations of the broader ecosystems and interconnected variables that make up ‘active context’. There is a kind of paradox in that, one could argue, a greater stability to something like painting, where aside from the developments of interpretation and practice, the form and program of any particular painting remain fixed forever in time, whereas in architecture, ever-changing demands and uses are either accommodated or resisted by the building. The very instability of the temporal inhabitation of buildings, per se, is a part of the force that drives the discipline as a whole to novelty, in that it is constantly being asked to address new and changing problems, and while such demands can never be finally addressed, they serve as a heuristic device to invention.7

Robert L. Davidson, a pioneer in the quest for the ‘ideal wall’, titled his article in October 1946 Architectural Record, “The Better Wall Is Coming.” In reality, 60 years later, it is still coming, however by embracing new technology, modes of action and forms of production a paradigm shift will occur, creating new “ecologies of practice” and forms of architectural production. Ecology, defined as the study of relationships and interaction between organisms and their environments; in the emerging ecologies of practice, relationships between cultural producers are reconfigured, extended, and amplified by new technologies.8
A Changing History: Temporal Technology

Architects have yet to fully engage the opportunities available today or speculate upon the implication that such research will have on spatial, formal, and social constructs. With open, forward thinking, and the availability of tools and technologies that permit execution, architects are now in a position to employ these opportunities with generative and projective research. Reyner Banham’s *The Architecture of the Well-Tempered Environment* is often understood as one of the inspirations for British High-Tech and certain aspects of ‘green’ architectural discourse, and is frequently referenced as historical material in technical courses on building systems. It is far less frequently placed in relation to the genealogical theories of material practices and responsive environments, where it belongs. The book is not simply a supplementary history but a projective theory of architecture that treats its technical aspects not as supporting representations of abstract concepts but as the conceptual material itself.

As with so many theories of architecture that are presented as a history of the discipline, Banham’s opening pages offer a ‘parable’ of origin. First he tells a story about the transformation of the human animal into a human subject:

*Mankind can exist, unassisted, on practically all those parts of the earth that are at present inhabited, except for the most arid and the most cold. The operative word is ‘exist’ ... in order to flourish ... mankind needs more ease and leisure ... A large part of that ease and leisure comes from the deployment of technical resources and social organizations, in order to control the immediate environment.*

Banham withholds the terms of architecture or city from this transformative moment. Compared to Aristotle’s origin where the city is a necessary condition for ‘culture’, or Heidegger’s emphasis upon dwelling, Banham suggests architecture and cities as merely manifestations of more general social-technical infrastructures.

*The Well-Tempered Environment* provides the part of history Banham argues has been forgotten or ignored, presenting a themed but roughly chronological analysis of projects in regard to the infrastructure of modern buildings—air conditioning and ventilation, plumbing and so forth. For Banham, these were more than mere building services; they were motors to rethink practice, the architectural object, its subjects and social spaces. Banham was characteristically critical of modern architects’ response to this condition. Air conditioning and lighting were reshaping the relationship architecture shared with the environment, and indeed was making entirely new spaces and occupation available. To this end, Banham advocated a different relationship between aesthetic organization and technological function, one that is mediated through corporeal perception. While promoting the *biological function* of architecture in creating a world of forms that synchronize the human experience, he simultaneously supported the technological environment. Banham suggests a revised notion of architecture and its relationship to social ordering. He maintains the proposition that technical opportunities and problems can be the theoretical basis of architecture, and potentially more productive and challenging to our conventions than critical theoretical, phenomenological or deconstructionist-derived approaches of semiotics and representation that continue to dominate the discourse. This notion is even more pressing today, when architects need to convert ecology and environmental issues from technical problems with engineering solutions.
into engines for innovating and opening the discipline.

Rant on // for Technology

The virtual, in the mathematical and philosophical sense, comprises all that an object can be imagined to become. The virtual is a space of potentialities, unlike the actual, which can be measured quantitatively and therefore exists in metric space; the virtual is not metric and contains qualities—or aspects that cannot be quantified. The virtual, this space of potentialities, is what allows temporal techniques to be generative—in other words, to give rise to formal, spatial, and material innovations.12

There are a number of theories attempting to address technology, which tend to be associated with the disciplines of science and technology studies (STS) and communication studies, which can be categorized into social and group theories, further clarified through descriptive and critical theories. Descriptive theories attempt to address the definition and substance of technology, its emergence and change relative to the human/social sphere, while critical theories of technology often take a descriptive theory as their basis and articulate concerns and ways in which the relationship of technology to social structure and human practice might be changed. Two of which are most relevant responsive and/or reflexive architecture, and a spatial view of technology, the Structuration theory and the Actor-Network theory.13

The Structuration Theory defines structures as rules and resources organized as properties of social systems. The theory employs a recursive notion of actions constrained and enabled by structures, which are produced and reproduced, by that action. Consequently, in this theory technology is not rendered as an artifact, but instead examines how people, as they interact with a technology in their ongoing practices, enact structures which shape their emergent and situated use of that technology. It is an attempt to reconcile theoretical dichotomies of social systems such as agency/structure, subjective/object, and micro/macro perspectives. The approach does not focus on the individual actor or societal totality but social practices ordered across space and time.14 The theory suggests that all human action is at least partly predetermined based on the varying contextual rules under which it occurs, however with that, the structure and rules are not permanent and external, but sustained and modified by human action. To be clear, in this context, “agency” refers to the capacity of individuals to act independently and to make their own free choices, while “structure,” by contrast, refers to the recurrent patterned arrangements, which seem to influence or limit the choices and opportunities that individuals possess. The term “reflexivity” is commonly used by social scientists to refer to the ability of an agent to consciously alter
his or her place in the social structure.

Architecturally, reflexive does not take on an altogether dissimilar meaning: which describes an architecture that is highly responsive and intelligent, able to translate and connect to its contextual and environmental surroundings at a new level, while also operating in three or more spaces concurrently. The Actor-Network Theory (ANT), more technically described as a “material-semiotic” method, is the second of the two relevant theories aforementioned. The theory maps relations that are simultaneously material (between things) and “semiotic” (between concepts). It assumes that many relations are both material and semiotic. Actor-Network Theory tries to explain how material-semiotic networks come together to act as a whole, and in part looks at explicit strategies for relating different elements together into a network so that they form an apparently coherent whole.

The theory asserts that technology is as much of a social actor as a human. In this case, an actor is defined as “any element, which bends space around itself, and makes other elements dependent on it and translates their will into a language of its own.” Latour uses the example of an automatic door-closer (1988), which regulates human traffic patterns and allows only some sorts of access, to illustrate the idea of technology “bending space around itself.”

However, at this point technology should not be discussed in isolation, as Michel Callon argues: “The actor-network is reducible neither to an actor or a network. Like networks it is composed of a series of heterogeneous elements, animate and inanimate, that have been linked to one another...the entities it is composed of, whether natural or social, could at any moment redefine their identity and mutual relationships in some new way and bring new elements into the network.” Networks act by enlisting and translating other artifacts, other actors, into the network. The actor-network perspective stresses both the contingency of networks (i.e. not determined, permanent, or universal) and their emergent qualities. These networks are rarely stable for long, but are continually bringing in new elements and changing the relationships between the actors.

Temporal views of technology present genealogical models which argue that technology is what it is because of its history, notions largely rooted in Heidegger, however history is embodied and embedded
in relations of space (and relations in the network). Deleuze and Guattari argue that what makes humans human is a particular articulation of technology and language. The human stratum, as they call it, is composed by a double articulation. The first articulation is the Content to the Expression (Technology to Language), and the second is the articulation of form to substance within both Content and Expression. Therefore, technology is composed of the articulation of a particular form to a particular substance.

Any technology has both form and substance; substances concern territories, forms concern structures of codes. Forms are organized by what Deleuze and Guattari call a differentiating machine. The differentiating machine is an abstract logic that arranges the aggregate of substances or artifacts according to its function. It grids or structures the network, establishing relations of difference and negativity.

Technology is a plane of content, and as such it can also act as a plane of expression to another plane of content, and so on. For example, the computer microchip is content to a certain expression (program speed, memory space), but at the same time the microchip is the expression of another content (material elements such as silicon, and/or social elements such as military and industrial needs, etc.). In this way, any technology is necessarily part of a system of technologies, a system with both technical and human actors. A technology services or supports other technologies and is similarly serviced and supported. The form of a technology will have resonance with similar forms of other technologies and technological systems. To use the previous example, a microchip will have qualities similar to other microchips as well as circuit boards, logic diagrams, etc. Also the form of a technology will be in accord with the forms of the technologies it supports (i.e. the computer into which the chip is placed).

So, to expound upon the temporal view of technology mentioned above, a technology takes on its current state through formal resonances established between other technologies, technical systems, strata (biological or chemical), and/or social, political, conceptual and/or other needs or structures. According to Wolfgang Schivelbusch, in the early 1800s the first class railway passenger cars were modeled closely after traditional coaches, whereas the third class cars more closely resembled open wagons or cars. The first class carriages were the result of the coach being brought into a formal resonance with the constraints of the rails, as well as the need to comfort and familiarize rail travel for the bourgeoisie. The third class carriage was then the result of both economic necessity and the lack of a need to articulate their travel with types of travel they experienced previously. In America the railway car evolved differently. The form of the train was not brought into resonance with that of the coach or carriage but rather with the riverboat or steamship. American railway cars tended to be longer and more open than the compartmentalized European train. There is no necessary evolution between coach and train or steamship and train; rather it is the matter or the articulation of forms, formal resonance.

The spatial view of technology formed here, argues that a technology is an aggregate of disparate substances, shaped by blocks of resonance, which are the mutual becoming of disparate forms, distributed by particular abstract logics, and articulated to an equally complex and varied plane of language. Technologies are social actors, which interact in networks of power relations, which produce,
repair, and maintain social space.

It should be evident at this point that the term technology has a general meaning and that it can stand for practically anything related to some temporal process, if qualified by, technology not becoming “technology” except because of the user, who is observing it; submitted necessarily to a temporal process: life. No technology, or “machine,” to hone the semantics to be more architecturally relevant, can be imagined without “containing” an intelligent observer. Thusly hardware is not machine, nor is hardware + software machine, as “machine” is only and exclusively a system containing “the machine and me.”

This logic then gives way to the typical architectural paradigm, as it stands today, labeled as “paternalist,” by Yona Friedman. In paternalist organization, it is the translator (designer, expert, or computer) who establishes his own preferences and judgments, in the interest of a particular future user, after a learning period during which the translator studies the peculiar particularities of this future user. Thus the translator would make some decisions for the future user, “with paternal benevolence,” leaving the entire risk of potential errors for the future user. The second way, which Friedman refers to as “nonpaternalist,” the translator makes no judgments or decisions and thus needs no learning period. It functions only as a sort of “speedwriter” denoting the tentative decisions of the future user and emitting a “warning” about expectable reactions of the real world upon each decision. In this case the learning period exists as well, but the future user does the learning, and it concerns the structural characteristics of the real world alone. Simply stated, in the paternalist scheme the translator is associated with the future user, whereas in the nonpaternalist one it is a part of the real world, the latter being “structurable.”

The investigation of the paternalist-nonpaternalist scheme, in other words, whether or not a machine (in the abstract sense) could be conceived wherein both the intelligent observer (the future user) and the real world (the object of the design) would mutually learn about each other, is relevant in the sense of creating a feedback system. In the thermodynamic paradigm of the Well Tempered Environment, the distinction between software and hardware becomes less important than architecture’s role as a secondary osmotic membrane of information / energy, one that creates the opportunity for new spatial-social organizations. This homeostatic second skin is a model for the new sort of responsive information architecture that could catalyze new and higher forms of social organization and subjectivities.
Nicholas Negroponte, in Soft Architecture Machines, suggests an architecture that refines and extends the discipline by improving the energy performance of buildings with responsive technologies (sensors / control systems / actuators) while also producing buildings that reflect the technological and cultural conditions of our time. The typical introduction to responsive architecture is made with the thermostat; however in the pursuit of evolutionary improvement the example is inadequate. The thermostat analogy leads to the objectionable process-control model for architecture, a decode-interpret-translate decision structure with old-fashioned feedback loops evidenced in the most common oil burner. Similarly, space capsules, cockpits, and any environment that consists solely of complex instrumentation are not the correct metaphors. The type of responsive environment sought after is one that includes what Gordon Pask has titled the you-sensor, to which Negroponte provides the following example:

When I return at night and ask my wife to put the whatchamacallit youknowwhere, she most surely knows exactly what I mean and where I mean. She knows because she knows me in terms of all the models and models of models previously discussed and because she can use this information in the context of my facial expressions, the weather outside, and whether we are going out to dinner at night. At the same time, her response is in the context of her own intentions, and her level of commitment to one behavior versus another is achieved by our participating in the same events with the same objects.26

Transposing a similar responsiveness to the physical environment suggests that it, too, must have purpose and intentions, and it must have all the paraphernalia required to build the necessary models of the user and to use them in context. In brief, it is not a regulatory control system; it is an intelligent system.

With that, Negroponte categorizes the type of behaviors that the physical environment can exhibit: reflexive and simulated. The first is motor, visual, olfactory, auditory responses that take place as a part of space, reflecting a purpose. Electric doors, rotating stages, and motorized partitions are not good examples because they are activated by yes-no, overt commands; thus they are no more interactive than the turning on of a vacuum cleaner. The second kind of response, what is referred to as “simulated,” is easier to envisage. One can imagine a living room that can simulate beaches and mountains, or fantasize experiencing the chills of Mt. Everest and the heat of the Congo with a simulatorium. One of the reasons that simulated responses may appear easier, more wholesome, and less troublesome than reflexive ones is that they are naturally relegated to play and entertainment and most probably will not intrude into the pragmatic, serious activities that are the cornerstones of our daily lives.

At this point, two other forms of response warrant elaboration: operational and information. They are not exhibited through architectural gestures and transformations; however, at present they afford the most convincing examples of computers at home. For instance, operationally, the home of the future might have surrogate butlers and maids embedded in all walls and floors or clunking about in bodies of plastic or steel. They would make beds (when it was recognized that you were not returning to bed), and do other activities of the like. Unlike the household robot, the machine would know the user on a more abstract and individual level. Consider any information terminal or wall surface to
which verbally posed questions on subjects ranging from the weather, to the stock market, to the likelihood of a political turn of events, would appear.\textsuperscript{27} Putting all these responses together begins to reveal a picture, however unclear it may be. The result yields a dramatically different relationship between ourselves and the spaces we inhabit, one characterized by intimate interaction.

Greg Lynn, in Animate Form, further expounds upon the idea of architecture of change, responsive to both the environment (context) and human interaction, more specifically through animation. Animation differs from motion as it implies the evolution of a form and its shaping form; it suggests animalism, animism, growth, actuation, vitality and virtuality. There is however an innate difference in these references, from the aforementioned Negroponte citations, in Lynn does not necessarily suggest that the architecture move. Dynamically conceived architecture may be shaped in association with virtual motion and force, but this does not mandate the architecture change shape. Actual movement often involves a mechanical paradigm of multiple discrete positions; where as virtual movement allows form to occupy a multiplicity of possible positions continuously with the same form. This methodology is not all that dissimilar to the previously mentioned as the logic remains for creating a new architectural model based on a multiplicity of factors.

Architectural form is conventionally conceived in a dimensional space of idealized stasis, defined by Cartesian fixed-point coordinates. An object defined as a vector whose trajectory is relative to other objects, forces, fields, and flows, defines form within an active space of force and motion. Force is an initial condition; the cause of both motion and shape of a form is defined by multiple interacting vectors that unfold in time perpetually and openly. With these techniques, entities are given vectorial properties before they are released into a space differentiated by gradients of force. Instead of a neutral abstract space for design, the context for design becomes an active abstract space that directs form within a current of forces that can be stored as information in the shape of form.\textsuperscript{28} Rather than being represented as a frame through which time and space pass, architecture can be modeled as a participant immersed within dynamic flows. Previous architectural experiments in capturing motion have involved the superimposition of simultaneous instances. The superimposition of a sequence of frames produces memory in the form of spatio-temporal simultaneity.

This shift from a passive space of static coordinates to an active space of interactions implies a move from autonomous purity to contextual specificity. Because of its dedication to permanence, architecture is one
of the last modes of thought based on the inert. More than even its traditional role of providing shelter, architects are expected to provide culture with stasis. This desire for timelessness is intimately linked with interests in formal purity and autonomy. Stasis is a concept which has been intimately linked with architecture in at least five important ways, including 1) permanence, 2) usefulness, 3) typology, 4) procession, and 5) verticality. Each of these assumptions can be transformed once the virtual space in which architecture is conceptualized is mobilized with both time and force. With the example of permanence, the dominant cultural expectation is that buildings must be built for eternity when in fact most buildings are built to persist for only a short time. Rather than designing for permanence, techniques for obsolescence, dismantling, ruination, recycling and abandonment through time warrant exploration.

Another characteristic of static models is that of functional fixity. Buildings are often assumed to have a particular and fixed relationship to their programs, whether they are intersected, combined or even flexibly programmed. Typological fixity, of the kind promoted by Colin Rowe for instance, depends on a closed static order to underlie a family of continuous variations.

Form should be shaped by collaboration between envelope and the active context in which it is situated, broader ecosystems, and interconnected variables to produce and influence an active context. The evolution of machines from assistive tools to actual livable environments has everything to do with the coalescing of computational processes with the material substrate of building systems. This has come to pass as we are witnessing a pervasiveness of computing technologies in our built environment. Distributed electronic sensors are used to mine for information, computing processors deliberate and formulate responses that mechanical and display devices execute in lived spaces. Computers have left the desktop and are now embedded or mobile all around us. The potential for this development is that our architecture can become more responsive to its context and adaptable to the way in which we use it. This will have ramifications for the way it conserves energy, provides more amenable environments for human health and comfort, and fosters more fulfilling social and aesthetic interactions.
Material Culture

In some sense, today’s research and development in the field of “building technology” is still no more than a similar, direct outgrowth of the ways of the industrial revolution, a way of thinking that has long been superseded in most other disciplines by a cybernetic, information, computational revolution. The industrial revolution brought sameness through repetition, amortization through duplication. In contrast, information technologies—soft machines—afford the opportunity for custom made, personalized artifacts. Nevertheless, there are some researchers (for example: Allen, 1974, Lynn, 1999, Diller + Scofidio, 2008) who see the chance for custom-made environments more reflective of personal needs, implemented with techniques of industrialization, augmented by computing systems.

As proposed by Negroponte, there seem to be two types of construction in the infancy of invention that lend themselves to physical responsiveness, which he refers to as “softs” and “cyclics.” The “softs” are an important vehicle to responsiveness, but they must be studied with great caution, as they may be considered an obvious material of “responsive architecture.” Soft materials, like inflatable plastics, are presently the most natural material for responsive architecture, because they exhibit motor reflexes through simple controls, and more importantly memory. Form is memory in this case. “Cyclics” consider “architectural” responses in a coarser time grain, relegating the moment-to-moment responsiveness to informational and operational features. The underlying assumption is that we can develop a continuous construction and destruction process. This idea is not in reference to “Kleenex architecture” that can be disposed of and readily replaced, but more so in reference to an ever-continuing building process.

Contemporary architectural design characteristically deploys hard material thresholds to define spatial arrangements and areas for predetermined use of space. Within this context, building performance is seen to relate to structural and environmental conditions, an area thought to be characteristic of engineering and thereby often perceived and treated as some kind of post-design optimization. There is, however, an alternative approach to performance driven architectural design based on a spatial paradigm that correlates material and gradient environmental thresholds and their capacity for mutual modulation. In this context, notions of both ‘structure’ and ‘environment’ need to be understood in a more broad sense, beyond the singular function of load-bearing and mechanical ventilation, air conditioning and heating. ‘Structure’ herein is defined as
the interrelation or arrangement of parts in a complex entity with particular spatial, formal and behavioral attributes and characteristics, the latter of which are indivisible from environmental performance. ‘Environmental performance’ is defined as the multitude of interactions between interrelated material and climatic constituents of the human habitat.  

Given this insight, architecture in accordance actively differentiates environmental conditions by means of its morphological and material articulation. It does so by linking behavioral tendencies and performative capacities of material systems with environmental modulation and the resulting provisions and opportunities for inhabitation. This method engenders emergent and intensively choice-driven patterns of inhabitation and social formation, and approaches a new paradigm for social and environmental sustainability relative to the built environment.

Conventional materials such as rubber, concrete, plastic, and wood, with this logic, can and should be re-imagined and sensitized to the ephemeral and dynamic qualities of the environments in which they are fabricated and eventually deployed. Materials are processed in a manner to efficiently maximize their latent strengths. This fact has resulted in the production of innumerable building products that are presently used in construction. Primarily engineered to resist radical shifts in performance relative to changing conditions in the environment, the application for these traditional materials has remained unchanged through the years; however, by exploring the material substrate and identifying its unique behaviors in response to specific external factors the potential for a more inclusive sophistication presents itself.

Le Ricolais suggests that matter, material, constructional systems, structural configurations, space, and place comprise a continuous spectrum rather than isolated domains. Such an understanding provides a model for organizing forces and their effects that is communicative, reverberating across scales and regimes.

The studies of column failure performed by Le Ricolais are a specific instance of this model in operation. He was specifically interested in the new geometries that arise as a consequence of the column’s deformation on the way to failure, transcending the purely geometric generation of a structure. Thus, material behavior takes an active role in the genesis of new structural forms, and moreover, the forces that act on the component model behave diagrammatically.

The implication of this scalability of material behaviors has far-reaching corollaries for architecture. The channel for change in this instance is the diagram, which provides an abstract model of materiality. Such a diagram can be derived from any dynamic system at any scale. Monitoring and mapping certain effects (temperature, pressure, wind speed, etc) as a gradient field will produce a schema of relationships that once abstracted from origin and material sources, provide an elastic yet precise diagram awaiting a new scale and materiality.
Cells

Cells are the basic elements of all systems in living nature. The process of cellular differentiation underlies most natural systems’ capacity for functional integration and adaptation. The field of cellular solids is remarkable as it is emblematic for a paradigm shift in material science. Until recently material research was conducted in a material-specific manner. For example, metallurgists studied metals and polymer scientists studied plastics. By nature, this material-specific approach did not investigate more general properties that traverse a particular material category and are shared by a wide range of different materials. Cells, of course, boast a long history in science, yet the rigorous investigation and classification of cell characteristics across different materials is a relatively recent phenomenon known as cellular solids.27

In the most basic definition cellular solids can be described as assemblies of cells being made up of an interconnected network of solid struts or faces. These struts or faces are understood as the edges and faces of cells. A simple cellular solid is a two-dimensional array of packed polygons filling a plane. These cell assemblies closely resemble the hexagonal patterns produced by bees.

The MA dissertation of Andrew Kudless focused on the development of cellular solids systems. The research aimed at providing an architecture-specific background to the geometric, mechanical, and morphological properties and processes of honeycomb cellular solids with the ambition of developing a novel honeycomb structure made from readily available stock material in which each cell can be different in size, shape and orientation. Until recently, manufacturing constraints prevent the production of an irregular cell pattern. The ability to differentiate the honeycomb morphology brings it much closer to the remarkable versatility found in natural systems, in which irregularity is the key to functional integration and adaptation while regularity is just a highly unlikely anomaly.28

As a consequence this research is based on the hypothesis that a differentiated honeycomb cellular solid provides the material and technological innovation required for a higher-level integration of multiple-performance criteria as observed in natural cellular solid systems. The opportunity for form, growth and behavior integration is exhibited naturally in these systems, however for architects to exploit this level of integration new design and production methods need to be developed. The first critical step is abstracting the geometric and material properties of cellular solids into industrial manufacturing logics.

As a starting point for investigation,
existing man-made cellular solids and their accompanying fabrication processes were studied. One of the most widely used industrial cellular solids is honeycomb sandwich panels. They are used in the aerospace industry, where high strength to weight ratio is of critical importance, but also in architecture, for example as the core of façade panels or lightweight wall partitions. Because of the fabrication processes of these panels, they have relatively stringent constraints relating to the amount and type of curvature that can be achieved. Furthermore, the amount of variability in cell sizes, depth and orientation across any one panel is limited, producing a relatively homogeneous performance capacity across the entire system despite potentially heterogeneous requirements. Through the investigation of design and production processes not typically associated with honeycomb structures, it became possible to expand the amount of morphological differentiation and related performance capacity.

4.3: Self-shading and shading pattern analysis of one specific double-curved surface configuration at five different times on 21 June relative to a specific location.
Emergent Structures, Invention

Organizational principles that promote communication across scales, in which the particular is able to affect the general and vice versa are of primary concern. This requires a methodology that involves both top-down and bottom-up logics operating in a feedback loops. (Thus, hierarchy, in this case, has nothing to do with power structures and everything to do with material organization.) This methodology, in contrast to the reductive models of modernism, enables the emergence of new organizations and new architectural effects out of wholes that are not reducible to their parts. This emergent organization becomes legible not as parts to a whole but as whole-whole relationships.

Variation can be deployed at any scale, but there is a range outside of which the system becomes invisible. At micro scales they merely act as decorative texture; conversely, at an extreme macro scale such a difference becomes imperceptible and thereby, meaningless. It would, for example, be absurd to suggest continuous variation in the joints of superhighways. It is at the middle to large scale—the space of mass reception—that there seems to be both an economy and need for variation.

When architecture addresses evolving demands there is a break in the norm of perpetuating the classical model to unveil a novelty of thought. This issue of the norm, in some sense, is related to the issue of difference, as for example when a normative model is so elaborated upon it departs so much from the model from which it was derived that it shifts from being a difference in degree to a difference in kind. Extreme elaboration can produce demands that never existed before. Thus, inventions may lay fallow for a time, until they are pulled in to the social field when a receptive context for them comes about. In this way, invention actually forms a norm.40

The notion need not be developed within the featureless space of ideality but conceived as enmeshed within a universe of difference. In this model, quantitative and qualitative difference is an inherent attribute of matter and space, with the two being inextricably linked, allowing for the consideration of many levels of order at once within a coherent system. The proposed paradigm for design can be approached very broadly – its meaning spans multiple realms, from spatial, social and cultural to purely technical (structural, thermal, acoustic, etc.), conditionally generalized as working in between the fixity of historical codification and the variability of materials and forces.
Involving Generative Scaffold

The thesis is the iterative process of exploring the negotiation of a boundary condition (building envelope) in pursuit of creating a more interactive and conversational architecture. This communicative interface between the user, environment (interior and exterior), and the resultant space is an investigation into an architectural ecology that fosters social scenarios through spatio-temporal-assemblages. The designed material becomes an active interface between people and the built environment.

The concept of autopoiesis, in which a system/organism/entity is produced from within itself and in turn constructs a reality based on its internal organization, provides a loose frame for experimentation. An architecture defined by degrees of enclosure, privacy and separation, impregnated with a concern for the environmental, actualizes latent potential rather than simply responding to or representing existing possibilities. The work focuses on the spatial boundary as the sole site for design operations, a playground to alter threshold and visibility conditions between users, reconfiguring the social as well as physical boundaries of the varying programmatic elements.

A matrix of genotypes and phenotypes is used to maintain a structure and organization for the thesis. The genotype, control group, is internally coded, inheritable information. The functions of the wall at the most basic level fall into this category. The phenotype is the outward physical manifestation of the organism, anything that is part of the observable structure, function or behavior of the organism. Shaped by pressures and inputs, these are considered additions to the most basic genotype, relative to people, activities and some elevated environmental response.

Within the developmental process is another layer of complexity borrowed from the logic evident in the work of R&Sie(n). Architectural choices are negotiated within an indeterminate environment, and vice versa. The opposition between the sponge and the grid, where the first is the outcome of a self-organized process and the second a simple act of top-down planning illustrates an issue not merely tied to tools and representation (organic vs geometric). A grid (generic) can work as the framework for very indeterminate behaviors, while a sponge (articulated) can trigger very specific local answers. By taking a fractal point of view, with alternating layers (natural/artificial; Euclidean/non-Euclidean; controlled/self-organized) that depend on time, scale, 2-D/3-D shifts the process, and in turn product, go beyond Villard and Filippo. The first was inside the process and the second designed the object; this proposal calls for an amalgamation, where the process is designed. The “scenario”, a method often used at R&Sie(n) as a pithy introduction to each project, is employed to join interpretation and project, places and processes of transformation, together in a system open to mutation, to the proliferation of stories and their continuous falsification.

What if the building façade is a reactive fluctuating barrier that tells and embodies stories?
Contextual Sustenance

The story is envisaged in Soho, New York City at the south east corner of the cross streets, Broadway and Broome. This orientation beckons sun shading, so in the most general sense, requires horizontal louvers along the longer south facing façade, and vertical deeper louvers along the east. Admittedly, this response lacks depth, but nevertheless provides a point of departure for developing phenotypes relative to the environment.

The New York City area averages 234 days of sunshine annually. Winters are cold and damp, yet the Atlantic and the partial shielding of the Appalachians keep the city warmer in winter than inland North American cities located at similar or lesser latitudes. Spring and autumn are unpredictable, and can range from chilly to warm, although they are usually mild with low humidity. Summers are typically hot and humid with a July average of 76.5 °F and nighttime conditions are often exacerbated by the urban heat island phenomenon.

The city receives an average of 49.7 inches of precipitation annually, which is fairly spread throughout the year, and an average winter snowfall of about 22 inches for the last fifteen years; however this usually varies considerably from year to year.

The humid subtropical climate of New York City is inherently an active player in the design process. Some conjectures are edited at the onset of the experiment as they are not suitable for the environment, while others that remain must be considered in regard to these constraints. Ventilation raises questions of orientation, the kinetics of open vs closed states, and aperture size; also, involved amongst environmental affairs are passive solar heating, if possible, and cooling. These, as with all the elements in the scenario, are replaceable and interchangeable, testament to the thesis emphasis on the continuous process rather than final result. Simultaneously of note, each element is necessary and influential.

Soho has a rich history that spans from early 19th century farms and rolling hills to a present day shining archetypal example of inner-city regeneration and gentrification, encompassing socio-economic, cultural, political and architectural developments. The area was once an industrialized part of Manhattan, that was nearly abandoned save for the artist population who saw promise in the large spaces and windows admitting natural light and cheap rent. Soho is now a commercialized eclectic mix of boutiques, posh restaurants, artist’s lofts and galleries; an area more affluent in nature yet the artist’s population remains due to laws enacted in favor of maintaining this culture.

While this history is abbreviated, it provides sufficient contextual background, as the primary focus of the thesis exploration is...

7.1 Site conditions considered
with the active context. The questions being asked of the system are those that deal with program, the user(s) as they relate, and the environment.

To further set the scene, the six story corner lot is programmed with businesses that compliment and cater to the bustling atmosphere Soho exudes. By developing a matrix with parameters primarily focusing on environment, porosity and materiality as each relates to proposed programmatic structures, the optimal fit for the site and experiment is determined. Optimal, in this sense, means an organization that will purportedly produce dynamic results so as to aptly test the overall investigation, keeping in mind the scenario that is being attempted.

At street level a boutique clothing store and hair salon share the space, the second, third, and fourth levels are occupied by a startup software company and the fifth and sixth are loft apartments. This sequence integrated with elements previously illustrated as part of the “scenario” allow for the first set of explorations to occur.
Analysis || Synthesis

Contemporary architecture design characteristically deploys hard material thresholds to define spatial arrangements and areas for predetermined use of space. With this logic, building performance is often considered an optimization addendum to the initial design process. A spatial paradigm that correlates material and gradient environmental thresholds and their capacity for mutual modulation is a step toward reconciling the discontinuity.

The thesis seeks to propose an architecture that actively differentiates environmental conditions by means of morphological and material articulation. By linking the behavioral tendencies and performative capacities of material systems with environmental inflection the resulting provisions and opportunities for inhabitation approach an architecture that engenders emergent and intensively choice-driven patterns of social formation and occupation.

This idea, paused for process and investigation, fosters an architecture that fractures the traditional static model in search of a reflexive evaluation that evolves and responds. Grounded in a material study of the elasticity of rubber and its possibility as a building material, the experiment elucidates a curtain wall brise soleil that reacts, at the hand of the inhabitant, to change space and simultaneously shade. The inherent flexibility of the material allows for a double curved self-shading surface and pattern, and a network of rods connects the shading system to the interior providing the means for movement and resulting spatial effects. The rods are placed relative to programmatic gradients conceiving tempered zones of change, while the density of the rods within the zones determines the efficacy of the spatial transformation. However, the actual influence on the overall
space was minimal.

The kinetic brise soleil provided a point of departure for a spatio-temporal system, an intelligent dynamic relation between a (static) yet highly differentiated morphology and a changing environment.

Modernist discourse postulated universal space as the key paradigm for democratic space. The open plan, ideally extended to an infinite homogenous grid, for instance, was meant to deliver equal opportunity for inhabitation, while the ribbon window and glass curtain wall façade, were meant to replace privileged framed views. The preference for universal space brought with it the modularization of building elements and systems, as well as homogenization of entire climates. In order to achieve universal space and intended uniformity, each building element or system was required to perform one principle function (Primary structure, secondary structure, sun-shading, rain cover, climate envelope, etc) and was thus optimized toward that particular singular function.\(^{\text{42}}\)

The single-objective approach to optimization is based on the idea of efficiency being the minimum use of material and energy to fulfill a single task. Single-objective optimization gave rise to the notion of lightweight structures with minimum use of material to achieve projected structural capacity and performance. With this, redundancy still occurs, but is understood as an unfortunate necessity. A critical view raises the question whether an alternative understanding of optimization, efficiency and
redundancy in relation to multi-performative material systems, can facilitate a very different take on spatial organization and environmental modulation.

Recent architectural discourse has largely moved away from universal space and declared a preference for heterogeneous architectures. This preference is evident in two distinct strategies. The first strategy entails a two-step approach to varied space, commencing with generic shells that are subsequently tailor-fitted to the needs of their eventual inhabitants. The second strategy comprises the design of exotically shaped buildings that from the onset of design varied in expression and spatiality. The first strategy embraces modularized building systems, while the second operates from the differentiation of established building elements. Both strategies accede, however, in embracing standardized requirements for interior environments, such as statistically determined homogeneous interior climates for public or office buildings. The latter is evident in recently developed parametric software that is bound to established engineering and manufacturing protocols relative to material and machining technologies. While plan organization, the form of the envelope, or fittings and finishes might have become more varied, material and building systems are not being critically reviewed with respect to established types and their mono-functionality.

The homogenization of interior environments culminated with the advent of the office landscape approach of the late 1950s. The vast open-plan arrangements intended to anticipate workflow are manifested by applying a number of rules to minimize the visual, aural and tactile distractions. Subsequently this form of spatial-environmental homogenization migrated to other building types, from public
to private spaces. The ultra-modernist dream was realized when architecture became largely ‘neufertised,’ appropriate values for each purpose, program and type were statistically established and listed in useful books. Still, energy costs remain high in monofunctional element design; and moreover, the homogenized interior environment is simply unsuccessful in satisfying the multiple and contrasting needs of inhabitants.

An alternative understanding of architecture as ecology involves dynamic and varied relations and mutual modulation between material systems, macro- and micro-environmental conditions, and individual and collective inhabitation. The proposed approach to architectural design is based on the deliberate differentiation of material systems and assemblies beyond the established catalogue of types, making them dissimilar or distinct in degree and across ranges. Varied ranges of material systems can provide for diverse spatial arrangements together with climatic intensities. Instrumentalizing multiple-performance capacity requires an understanding of material elements and systems in a synergetic and integral manner. It considers these systems in terms of behavioral characteristics and capacities with respect to the purpose they serve locally and within the behavioral economy of larger systems. The concept proposes a shift from monofunctional modularized building elements, based on linear task-solution concepts, to integral systems with non-linear, complex behavior and properties.

The approach transcends scale, resulting in a necessary derivation from strict architectural practices to learn from biological entities. In the building sector connections between parts and elements are almost always discontinuous and articulated as dividing seams, instead of smoother transitions in materiality and thus functionality (such as is seen in the way tendon and bone connect, deploying the same fiber material yet across a transition of mineralization that effects the elasticity or rigidity of the material.) The overall form is an evolution of analytical diagrams that studied occupant and programmatic influences relative to five architectural responses (view, sun/solar, privacy, advertisement, and ventilation.) In this case, ‘diagrammatic’ thinking is involved as much in the structuring of the process, the tools, the experiment or the research parameters, as in that of the ‘product.’

The project is working simultaneously in two scales, interrelated and intimately linked. The macro scale from where the overall form is
derived includes occupant and programmatic influences relative to each aforementioned architectural layer of dependent concern, while the micro scale is concerned with the detailed amalgamation and optimization of the layers.

The aim is to develop an approach to design that integrates analytical and generative methods. Analysis is of central importance to the entire generative process, not only in revealing behavioral and self-organizational tendencies, but also for assessing and designing spatial-environmental modulation capacity. In this way, feedback between stimuli and responses and the condition relation between constraint and capacity will become the operative elements of heterogeneous spatial organization. This suggests an architecture that modulates specified ranges and gradient conditions across space and over time, and that is based on strategically nested capacities within the material systems that make up the built environment.
Notes

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Appendix

Precedents

Open Columns
Omar Khan

Open Columns is a system of nonstructural columns that reside collapsed in the ceiling of a space. They are made from composite urethane elastomers and can be deployed in a variety of patterns to reconfigure the space beneath them. These patterns create gradations of enclosure, either in plan through the full deployment of columns, in section through their partial unfurling to change ceiling heights or through a combination of the two. The system is a mutable architecture that can change the perception and inhabitation of the space within which it is deployed.

At its most trivial, the columns can be programmed to deploy themselves in prescribed configurations. This can be effective for re-proportioning a large space into smaller spaces or reorganizing the circulation of people through it. A more complex program ties the columns to real time sensing such that they can respond to inhabitants’ perturbations in space. The columns, working from a simple set of rules, respond to data coming from a carbon dioxide (CO2) sensor. In a reasonably enclosed environment CO2 values can radically change with the inclusion of people. The columns are programmed to come down when CO2 levels are going up resulting in people dispersing into smaller groups. If the CO2 levels are going down the columns respond by going up, effectively inviting people into the space. If however the CO2 value stays static the columns cycle through a random set of configurations until the CO2 either goes up or down. If a particular configuration causes a change in CO2, either going or coming down, that is put into the system’s memory and reused the next time a static situation is encountered. If, however, the next time a round the stored configuration does not yield the necessary result then it is lowered in rank and purged if on subsequent uses it does not perform. In this way the columns, over time, learn about their space based on their own actions within it. This creates a ‘teleonomic’ environment, one that acts on particular goals but has no determinate goal to which it is ultimately driven.
Biomedical Science Research Building
Polishek Partnership Architects
Ann Arbor, Mich

The research facility is sited between the University of Michigan’s main campus and its medical school, creating a new link between the two. Its primary programmatic elements are discernable in the building’s overall form. To the north, a rectilinear L-shaped block contains laboratories and support spaces, separated from the offices by a sky-lit atrium. The offices are arranged in an organically shaped, curvilinear band facing south, toward the street and the main campus. The laboratory block is enclosed predominantly in insulating glass and rain screen panels of terra-cotta and stainless steel. The most innovative enclosure system is the double-skin curtain wall of the south-facing offices.

The inner curtain wall consists of a standard stick system with extruded-aluminum mullions, insulating glass, and insulated spandrel panels. The outer wall is prefabricated unit system with frames of extruded aluminum, structurally glazed single-pane glass, and no spandrels. At curved portions, the inner wall is faceted, while the outer wall employs bent glass and curved mullions. The two walls are separated by an air space of about four feet, with the outer wall supported on steel outriggers at each mullion. The air space contains adjustable blinds, maintenance catwalks, and track-mounted moveable platforms for glass cleaning. In summer, the stack effect is used to ventilate the air space; as heated air escapes at the top of the wall and fresh air is drawn in at the bottom. In winter, the air space remains sealed and is heated by the sun, creating a buffer between disparate exterior and interior air temperatures.

Compared to a conventional single-layer glass curtain wall, the double wall provides expansive views and a higher level of thermal comfort for office occupants, improved acoustical separation from the street, and lower energy use.
New York Times Building
Renzo Piano
New York, New York

Fifty-two-story tower features a custom-unit curtain wall system with floor-to-ceiling insulating glass and a second layer of external sunshading ceramic rods. The building represents an application of the brise-soleil concept on an immense scale, unprecedented in New York City.

The curtain wall incorporates ultraclear insulating glass in prefabricated units, framed by extruded-aluminum mullions that are anchored to the edge of each floor slab. The vertical mullions, spaced on 5-foot (1.5-meter) centers, also support the external sun-shading veil of ceramic tubes—positioned about eighteen inches in front of the glass—which reduce solar heat gain by up to 50 percent. In addition to providing critical sun-shading, the ceramic rods (186,000 in all) create a unique diaphanous skin that defines the character of the building. The white rods reflect external environmental conditions, altering color with the changing sky—gray in overcast weather, bright white in midday sun, orange and pink as the sun rises and sets.
The United States Federal Building
Morphosis
San Francisco, CA

The U.S. General Services Administration, acting as client, sought an exemplary building that would reduce consumption on natural resources, minimize waste, and create a healthy, productive workplace for the building’s daily users. The architects responded with a design featuring advanced sustainable technologies in an emphatically nontraditional wrapper. The building envelope is a machine that not only provides light, views, and protection from the elements, but also circulates air and reduces energy use.

The main component of the complex is an eighteen-story tower conceived with a slender floor plate measuring 65 feet wide, to maximize views and incoming light and to enable natural cross-ventilation of the offices, taking advantage of San Francisco’s temperate climate. The two broad faces of the tower are enclosed by walls of clear floor to ceiling insulating glass with operable windows. To protect these walls from excessive solar heat gain, sun shading is provided at the southeast elevation by an external armature of perforated stainless steel panels and, at the northwest elevation, by light-diffusing translucent glass fins. The articulation of these two shading systems, with the details of their fabrication and assembly clearly on display, defines the building’s character: a machine aesthetic that celebrates the importance of orientation and responsiveness to climate.

The building skin is not static. A centralized computer system automatically opens and closes windows and sunshade panels in response to interior air temperature and external environmental conditions, such as temperature, wind speed, and wind direction. (Manual override controls are also provided for use by individuals.) At night, the windows open to flush out heat that has built up during the day, allowing nighttime air to cool the building’s concrete interior. The thermal mass of the exposed concrete walls, columns, and ceilings keeps the interior cool throughout the day.
166 Perry Street
Asymptote
New York, New York

166 Perry Street provides an alternate take on the glass-clad residential building. Here, the glass wall is not a continuously flat, vertical surface; the curtain wall angles variably inward and outward in vertically articulated bands. Due to the specification of a slightly reflective low-E coating on the glass and the angled positioning of the units, the curtain wall reflects both sky and ground conditions, changing color throughout the day and presenting a collagelike assemblage of contextual imagery. The primary focus of the building envelope design is thus a celebration of access to light, air, and views—precious commodities in any Manhattan residence.

Illustrative of the ongoing globalization of the façade industry, 166 Perry Street’s curtain wall units were assembled and tested in Shanghai, China, with finished prefabricated units then shipped to the construction site, where they were installed on pre-mounted anchors at the edge of each floor slab. The slabs cantilever beyond the structural frame, allowing for uninterrupted vision glass from floor to floor, without spandrel panels. The custom designed unit frames consist of extruded-aluminum mullions, to which insulating glass is structurally glazed with silicone sealant. Out-swinging operable windows are provided within most of the curtain wall units for natural ventilation.