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Digital-[pre]fabrication

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front cover image:
www.gsd.harvard.edu/.../macdonald/index.html

architecture, a 'symbol of our time':

Simply stated, architecture is a true reflection or "symbol of our time" (Mies van der Rohe, 1950). For the first time, architecture and technology have united to become an 'expression of one another', where digital processes allow for architectural ideas to come to fruition in a purely digital environment, while simultaneously holding the 'information' for a direct translation from digital design to physical construction via digital fabrication processes. The synthesis between initial design and constructed reality is an integral process of creating architecture, a procedure only augmented by the impact of digital fabrication in the computer age. As noted by Le Corbusier in *Towards a New Architecture*, "almost every period of architecture has been linked to research in construction" (Le Corbusier, 216). Digital fabrication technologies mark the beginning of a new architectural period, one of experimentation where advances in technology allow new techniques for design and construction.

introduction to program:

The birth of modernity in architectural practice brought upon us a whole new onslaught of technologies, materials, and mass-production techniques, all viewed by Modernist attitudes as "...the essential keys to the future and were repeatedly used to justify a universal architecture of standard forms, applicable anywhere in the world, irrespective of culture or place"(Abel, 63). Modernist architects such as Le Corbusier, Walter Gropius, and Mies van der Rohe were intrigued with the image of 'machine made architecture', but were unable to successfully employ their idealistic expression of architecture as an instrument to explore mass-production principles in the form of standardized, prefabricated housing. It is within the adaptation of the "house-tool, the mass-production house, available to everyone" (Le Corbusier, 263), in which the notion of pre-fabricated housing became a commercial failure. "Happy to accept Ford's limitations of choice for their new Model 'T', American home buyers could not accept the same strictures when it came to choosing a home" (Abel, 65).

Today, through the use of digital design and emerging technologies, we are closer to achieving what Le Corbusier describes as the 'american dream' –the dream that everyone should be able to own their own home. In conjunction with emerging technologies in the field of fabrication, innovations within the "development of the internet and specialized computer networks, which are already having considerable impacts upon collaborative work patterns, and are transforming the way architecture is conceived and produced" (Abel, 83). Our society's immersion into the internet age has brought upon us a whole new relationship between client and architect, one that provides a constant loop of information, consequently allowing the client to be more informative in the overall design process.

introduction

Mies van der Rohe proclaims "...Architecture depends upon its time. It is the crystallization of its inner structure, the slow unfolding of its form. That is the reason why technology and architecture are so closely related. Our real hope is that they will grow together, that someday the one will be the expression of the other. Only then will we have an architecture worthy of its name: architecture as a true symbol of our time" (qtd. in Klinger, 239).

intervention:

In *Abstracting Craft: The Practiced Digital Hand*, McCullough defines the tool as a "...moving entity whose use is initiated and actively guided by a human being, for whom it acts as an extension, towards a specific purpose" (McCullough, 68). Today, the computer becomes a tool that operates as an extension of the mind, consequently providing a seamless link from design ideas to a virtual expression of architectural concepts. Use of the computer, "...by careful design and close attention to industrialized materials and performance, could create entirely new component designs economically for single building projects – something previously thought impossible" (Abel, 72). As suggested in *Architecture, Technology and Process*, new advancements in digital fabrication allow for an exploitation of our pre-fabricated predecessors by utilizing rapid-prototyping processes to create varying building components unique to individual dwellings. Digital fabrication's proliferation in the architectural discipline has effectively negated the necessity "... to create the right state of mind for living in mass-production houses" (Le Corbusier, 263), by enabling customization. A new digitally-[pre]fabricated housing initiative is now possible, allowing for mass-customization while providing a sense of identity to a once stoic typology.

impact of digital fabrication:

The computer age has brought upon us a whole new dimension of 'digital information'. Currently, the role of the architect lies within the creation of building information, but typically the architect does not physically construct. Through the synthesis of computer generated building information and computer controlled machines it becomes possible to intricately fabricate building components and unite the architect with the construction process. Digital fabrication, a process typified by digital-design and physical-making, is capable of yielding tangible 'objects' that can be criticized and tested in the real world, under conditions that may be unforeseen in the digital world. The evolving technology of Computer Numerically Controlled machines and CAD/CAM softwares, inherently fostered by digital fabrication processes, has consequently given birth to an environmentally responsible architecture, where simulations and component alterations performed digitally come to fruition physically via computer-driven machines. "Developments in energy saving techniques and performance testing have been paralleled by further advances in computerized visualization and production" (Abel, 80), thus proving technology, building construction, and environmental responsiveness have coalesced through the introduction of digital fabrication in the architectural discipline.

outcome:

The objective remains within the realm of construction, utilizing digital fabrication techniques to promote an adaptation from the construction of building information to the assemblage of [pre]fabricated parts based on computer generated information. Pre-fabrication, however, implies the mass-production of modular components, yet the introduction of digital-[pre]fabrication allows for flexible building parts with virtually the same ease of production, yielding custom houses which become dissociated from the 'modular' pre-fabricated housing typology. The chair lends itself as a tool by which digital fabrication techniques can be integrated with ideas of materiality and form to generate a kit-of-parts, whereas the synthesis of design and construction methodologies behind the chair are utilized to inform to the assemblage of a digitally-[pre] fabricated home. Through a layered approach that investigates the pre-fabricated housing typology, the chair serves as a vessel that exploits the physical assemblage of pre-fabricated component connections and materials, computed and fabricated digitally.

objectives:

_Develop an understanding of tools and software which are integral to the processes behind digital fabrication
_Introduce a new process of construction through the use of digital building information: assemblage
_Investigate the failures of our Modernist, pre-fabricated predecessors in relationship to the successes brought upon us through the implementation of digital fabrication into the architectural discipline
_Promote a more sustainable, economical, and materially responsible digitally-[pre] fabricated housing typology which appeases the masses through the mass-customization of varying building components

contention:

Architecture holds the capacity to reflect time. In regards to pre-fabricated housing, digital fabrication processes demonstrate an advancement from our past, Modernist pre-fabricated predecessors by successfully wedding function, performance, and constructability [manufacturing processes]. The implementation of a digitally-[pre]fabricated housing typology informed by the past and utilizing the technologies of the present will create a responsible housing typology, one which is truly a reflection of our time.

William Mitchell points out that "as buildings evolve in directions represented by new ideas and pioneering experiments, construction materials, products, and processes will change" (qtd. in Klinger, 240).

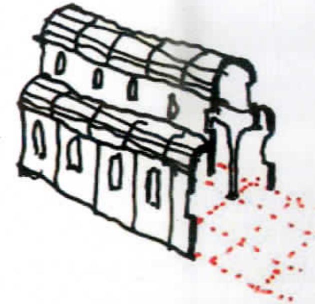
Branko Kolarevic continues this point by acknowledging that today, "building construction is being transformed into production of the differentiated components and their assembly on site, instead of conventional manual techniques" (qtd. in Klinger, 240)

architecture & technology:

a. primitive circular huts with local building materials

b. stone dome on circular plan, the purest form of geometry

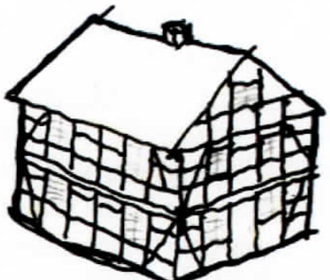
c. use of the pendentive to hold domes on the square plan while disguising structure elements inside



d. invented by the Romans, barrel vaulting with the use of masonry as a building material was a response to new building technology/materials

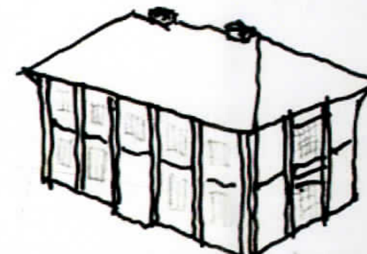
"Architecture creates boundaries out of otherwise unbounded space while the use of space can be seen as a means to organize that unbounded space. The type of space [where] boundary partitions depend on the culture and **time period it occurs in**…" (Kent, 2)

e. cross vaulting and the pointed arch allowed for heightened volumes, allowing for the introduction more windows, thus light

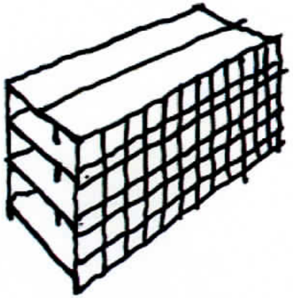


f. the introduction of timber allows the isolation of windows, while building corners were supported by corner struts and walls contained straw, mud, or clay

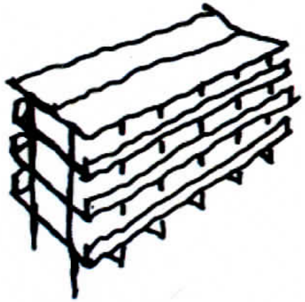
g. prefabricated panel construction becomes a quick and cheap solution to housing



h. similar to early methods of timber construction, the desire for more windows led to the stone pillar construction style in housing

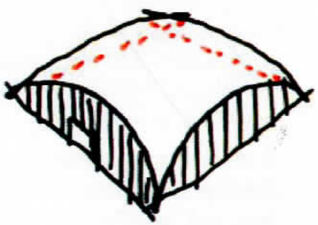


i. the introduction of steel allows buildings to span greater distances and be built higher while still being lighter in comparison to previous methods



j. the introduction of reinforced concrete works in conjunction with steel to create cantilevered floors allowing for the delaminating of structure and façade

"The built environment may be seen as suggestive in that architecture can suggest new behavior as well as being a mnemonic device for reminding users of particular types of behaviors" (Kent, 3).



k. shell structures exploit the inherent qualities of reinforced concrete

l. cable structures have been used since the beginning of time, but here begin to demonstrate the power of advancements in materials wed with technology

experimental architecture:

In Architecture, Technology and Process, Abel discusses the inherent connections between architecture and technology. Abel notes that " the clear lesson for the future is that architects are unlikely to make to most of the emergent possibilities for creating a more responsive architecture, unless they also learn to master the new modes of production" (Abel, 89). Demonstrated through the series of diagrams, the beginning of architectural practice can be associated with form derived from construction, whereas today with the introduction of new building materials architecture has become a formal abstraction of the past. As noted in *Architecture in the Digital Age: Design and Manufacturing*, Kolarevic notes that today architects have become obsessed with the expression of surface. "It is the surface and not necessarily the structure that preoccupies the work of the digital avant-garde in its exploration of new formal territories" (Kolarevic, 39). Additionally, the architect of today serves to "harness contemporary technical possibilities extensively and exploit their artistic potential to create buildings that express the ethos of the modern world" (Neufurt, 36). Thus, architecture has arrived at an experimental period where architects who have embraced advancements in construction, materials and manufacturing processes are furthering the field of architecture and exploiting the boundaries between advances in technology and architecture.

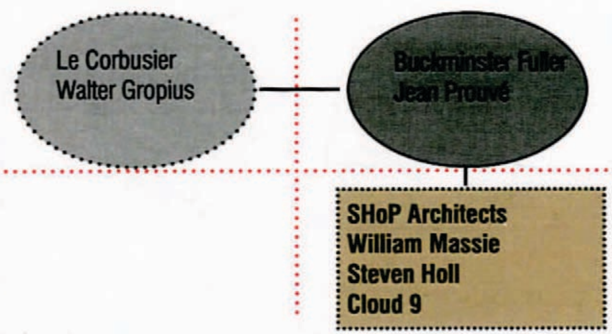
sketches conceived from: (Neufert,38)

for the first time:

Currently, the architectural discipline has fully immersed itself into the digital age, such that the architecture of today could simply not be comprehended without the use of technology. Architect William Mitchell notes that before our dependence on the computer, "...architects drew what they could build, and built what they could draw" (Kolarevic, 32). Our immersion into the digital age has upon us a whole new process of designing and representing architecture, a process adopted from the cross-disciplinary study of manufacturing procedures.

A brief return to the history of pre-fabrication, specifically a Modernist ideal inspired by the growing interest in mass-production processes, reminds us that today 'experimental' architects such as Foreign Office Architects, SHoP Architects, and Bill Massie are pioneers of their age. They have successfully wed technology and construction processes as one, and consequently exploited the benefits of designing and constructing in the digital age. A noteworthy indication of the power behind the computational design process can be assessed through innovative design firms such as SHoP and Foreign Office Architects. As pioneers in our age, they **"participate in the total process of design and fabrication to produce sophisticated, complex solutions resulting from the negotiation of design, site, performance, and manufacturability constraints"** (Klinger &Vermillion, 83).

from then to now:



- Failure in the lack of knowledge of manufacturing processes
- Failed to achieve 'acceptable mass-living aesthetic' yet offered a rare glimpse of what a genuine industrialized architecture could be (Abel, 71).
- **A revolutionary success intertwining technology, construction, and architectural design process.**

from then to now: what it looks like

a b

c d

a. (Le Corbusier, 241)
b. http://www.vandasye.com/wp-content/uploads/Walter-Gropius.jpg
c. http://myvintage-home.unblog.fr/files/2009/02/jean-prouv.jpg
d. bohemianhellhole.typepad.com/.../07/index.html

e. http://www.aiany.org/eOCULUS/2007/images/0109/SHoP-12.jpg
f. http://img.blog.yahoo.co.kr/ybi/1/d6/61/nuno1129/folder/9/img_9_1039_3?1162360945.jpg
g. http://www.shedandshelter.com/compacthouse/turbulencehouse.jpg
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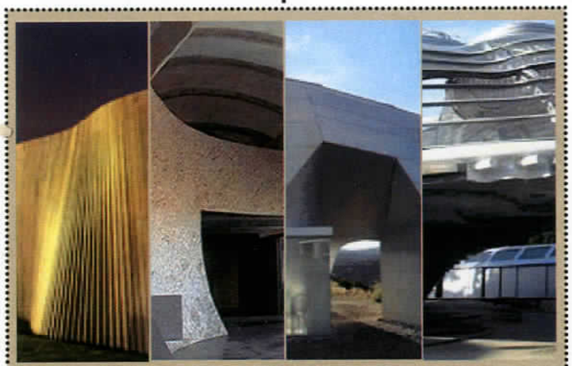


e f g h

architecture & technology: conclusion

Certain cutting edge architects of today have embraced new technologies, and devised a process which at the small, experimental scale has the ability to create an architecture that responds to the negotiation of program, site constraints, environmental performance, and materiality. Learning from the history of prefabrication while simultaneously embracing current technologies and computational design processes allows for the possibility of a new, digitally prefabricated housing typology.

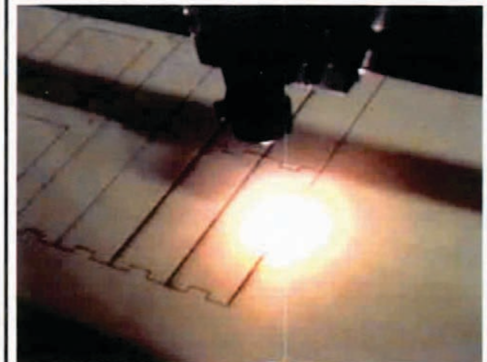
the chair to understand digital fabrication:

The inherently concise scale of the chair lends itself as a tool by which digital fabrication techniques and processes can be tested through an investigation of material sensibilities, fabrication procedures, varying component connections, and ideas of assemblage. As digital fabrication is a culmination of design and physical production, the chair, "an application ripe for material and conceptual experiments" (Newton) becomes an important tool to better understand the application of digital fabrication in the architectural discipline.

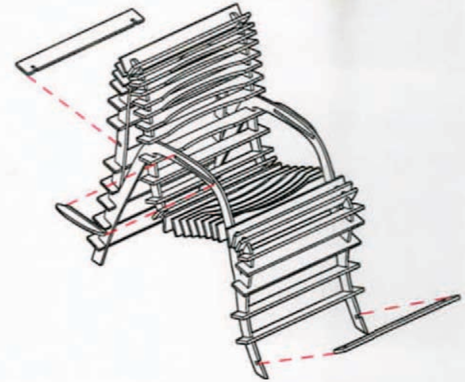
two-dimensional fabrication:

The most common digital fabrication technique, two-dimensional fabrication processes are most often associated with CNC or laser cutting. Architecturally, two-dimensional fabrication processes are commonly used to yield laminated [horizontal or vertical], or waffle [interlocking-intersecting elements] building components which typically assemble quickly and with ease.

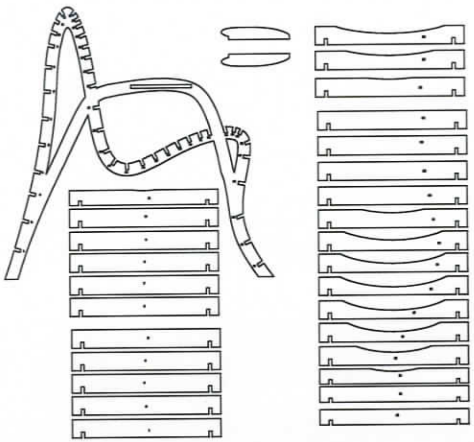
tools and software:

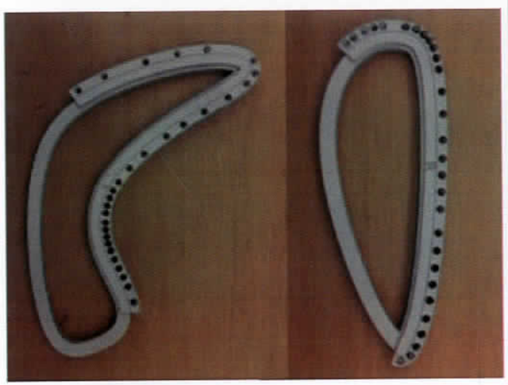


materials/connections:

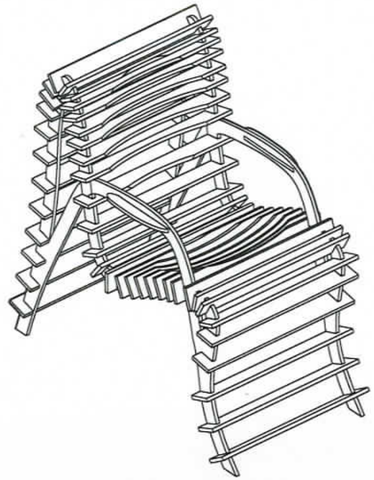


varying building components:





assemblage:



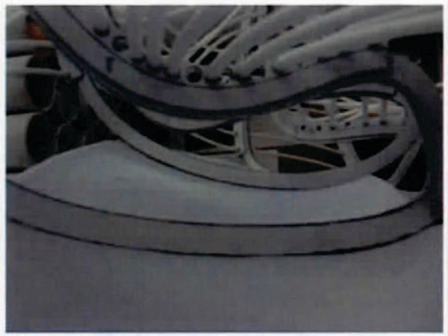
post 'construction' conclusions/observations:

A total of two chairs were designed and fabricated as to learn the inherent possibilities of two dimensional fabrications in architecture. The first chair utilized digital design to vertically serial section the overall form of the chair. This process, only feasible through the computer, becomes an example of utilizing 'digital information' during phases of design to output for construction. These serial sections were then sent to a laser cutter and their profiles were cut and assembled according to the computer generated model.

The second chair was designed to test the 'waffle construction' system in regards to stability/component connections and assembly. The physical assembly of the chair required no glue in that laser cut components were precise enough to simply slot into one another. The 'waffle system' seems to have positive implications within the realm of construction, but in reality how precise can we actually cut full scale building components and account for variables such as the expansion and contraction of materials? Additionally, the computer generated components were strategically labeled before cutting in hopes that the physical construction of the chair became a process more closely related to that of assembly.

varying building components:

assemblage:



post 'construction' conclusions/observations:

The third chair created was conceived under the conditions that every basic digital fabrication technique would be exploited through the design and assembly of the object. Although the object was at the concise scale of the chair, the implementations of subtractive fabrication are similar to that of large scale construction applications. Through digital design, a double-curved surface was easily computed and digitally fabricated through the use of a CNC Mill. This surface, designed to make contact with the ground and support the vertical ribs of the chair, traditionally could not have been conceptualized without the use of the computer.

However, subtractive fabrication has its limitations. Firstly, building components must be conceived around the inherent tolerances associated with the tools of subtractive fabrication. In the case of the chair, the double-curved base surface was constantly re-configured in order to be feasibly cut. The 3-axis CNC Mill used was only capable of cutting in the 'x', 'y', and 'z' directions, limiting the output of design, and drastically changing the conception of what the surface originally was intended to look like. However, large scale versions of the CNC Mill often associated with manufacturing disciplines, operate at 9-axis, allowing for almost any conceivable shape or contour to be profiled. It is within the large scale implementations of subtractive fabrication that this digital fabrication technique can be envisioned and applied to the architectonic scale.

**vacuum forming:

"In formative fabrication mechanical forces, restricting forms, heat or steam are applied to a material so as to form it into the desired shape through reshaping or deformation which can be axially or surface constrained" (Kolarevic, 38).

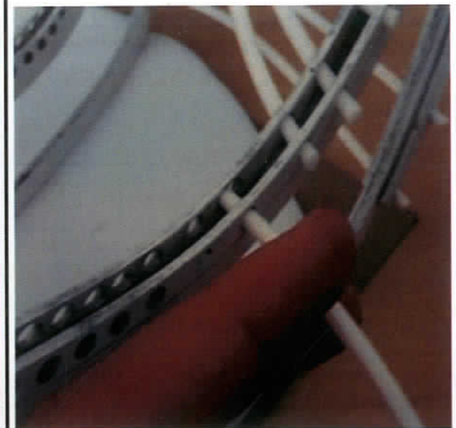
** Vacuum-forming is the only process described thus far that is not directly categorized as a 'digital fabrication technique', yet it remains an important post-process of both two-dimensional and subtractive fabrication outputs.

tools and software:

materials/connections:

varying building components:

assemblage:



post 'construction' conclusions/observations:

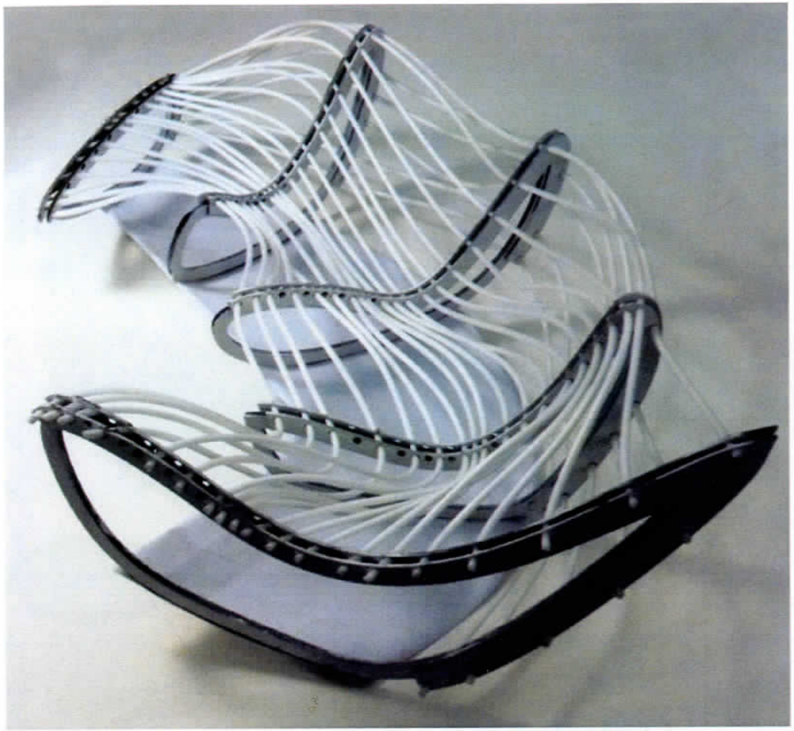
The processes associated with vacuum forming were applied to the construction of the third chair. CNC machines were used in the creation of foam molds, which were then used in the process of vacuum forming. Although vacuum forming is not traditionally viewed as a digital fabrication technique, it is however a process often used in conjunction with other digital processes such as subtractive fabrication.

Vacuum forming used in conjunction with other processes has the potential to drastically alter the way building components are created. Through the benefits associated with digital design, building information can be exported to a CNC Miller for the creation of formwork or molds. These molds can then be 'pressed' by the vacuum former an infinite amount of times. The resulting surface becomes the 'male' component to the 'female' or subtractive component used as the mold. This 'rapid prototype' fabrication process inherently becomes an application in which to test material sensibilities and surface techniques due to the infinite amount of variations that can be achieved through the use of a mold.

chair 1

chair 2

chair 3

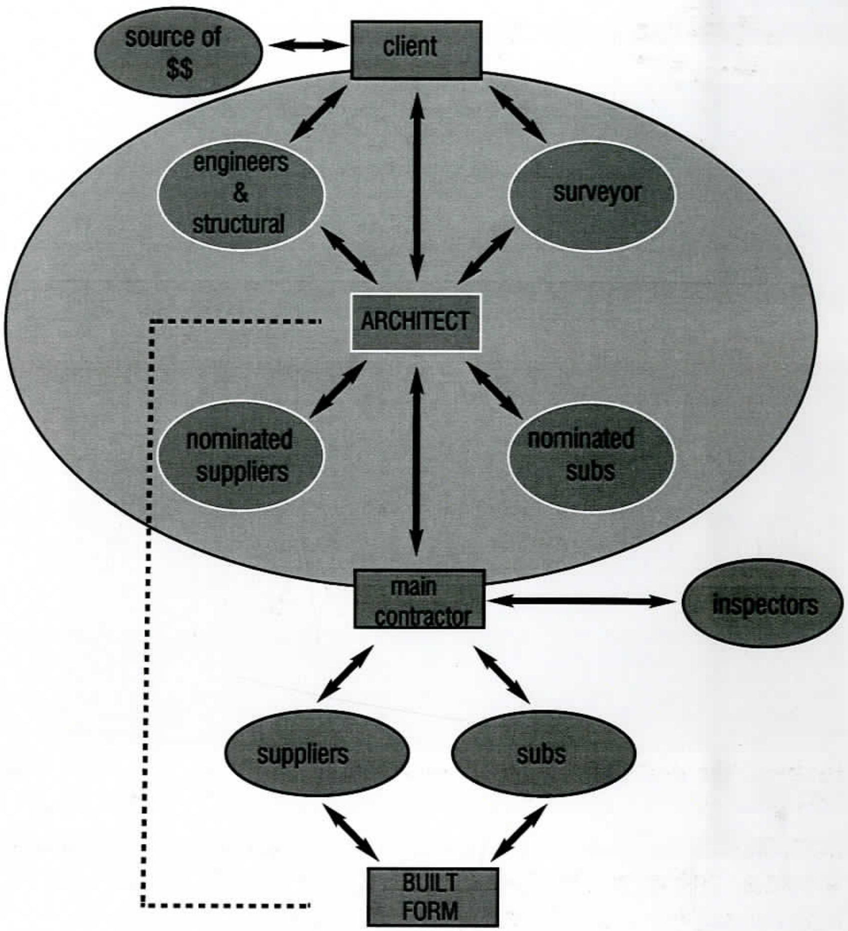


existing role of the architect:

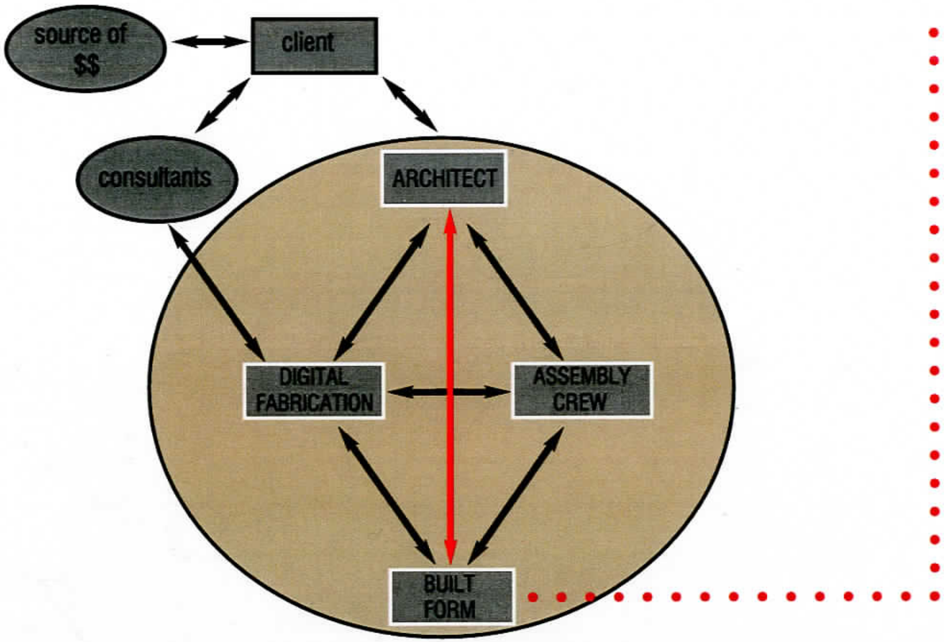
More often than not, the architect's role has been diminished to mediating the construction through a process of checks and balances in partnership with the constructor, in attempt to alleviate or protect against ambiguities or omissions in construction caused by the misinterpretation of architectural drawings. While the architect remains responsible for the creation of building information, the contractor ultimately interprets this information and is accountable for the translation from drawing to construction. There are inherent discrepancies in this process, yielding buildings which are not constructed to the precise restrictions to which they are drawn and conceived.

The introduction of digital-[pre]fabrication into the architectural process can alleviate these discrepancies from drawing to construction, where digital building information is utilized to precisely 'cut' building components and are seemingly assembled rather than constructed.

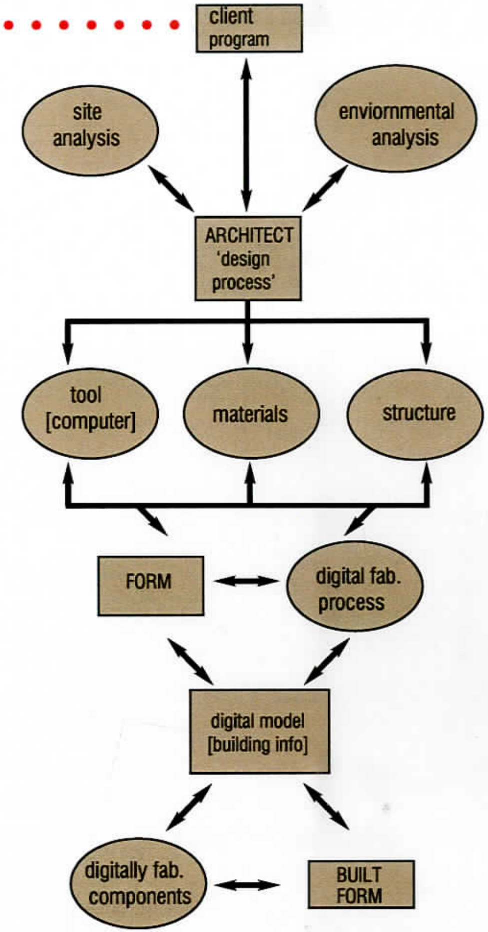
existing role of the architect:



architect as master builder:



process of digital fabrication:



On the issue of craft in building construction, Kolarevic notes that in the past, "The precision of the craft depended upon the knowledge and skill of the craftsman, and the ability to translate ideas into built form given the tools of the craft. A master builder architect deeply understood this relationship between tool, material, structure, and form" (qtd. in Klinger, 240).

overview:

Assuming architecture is a direct 'symbol of our time', and that we are currently in a period where 'architecture and technology have become an expression of one another' then:

Learning from the history of manufactured housing as well as today's current advancements in technology and construction should ultimately leads to a provocative conclusion where digitally-[pre]fabricated housing offers new possibilities for the proliferation of contemporary single-family homes.

For the purpose of discovering the successes and failures of the past in order to better understand the benefits of digital fabrication in mass-produced housing today, four pre-fabricated and four digitally-fabricated precedents were chosen. First, the organization of these precedents into categories of materiality, shape/form, and construction methodology will assist in the analysis of one typology of housing to the other.

pre-fabricated

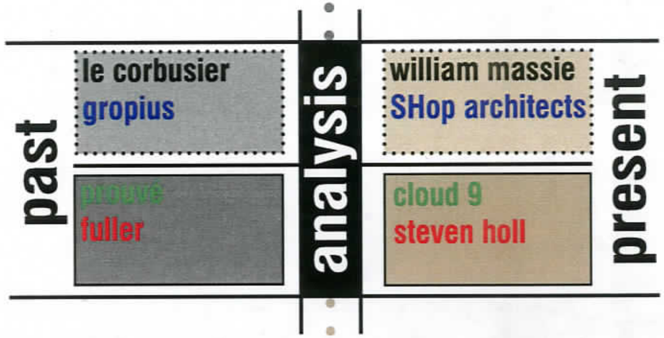
architect	walter gropius	buckminster fuller	jean prouve	le corbusier
project	packaged house	dymaxion house	meudon houses	citrohan house
material				
concrete				■
wood	■			
metal		■	■	
shape				
spherical/curvilinear		■		
square/rectangle/linear	■		■	■
building type				
panellized	■		■	
modular				■
manufactured		■		■

digitally-fabricated

	SHop architects	steven holl	cloud 9	william massie
project	camera obscura	turbulence house	villa NURBS	big belt house
material				
concrete			■	■
wood	■		■	■
metal	■	■		
shape				
spherical/curvilinear	■	■	■	■
square/rectangle/linear				
building type				
digitally fabricated	■	■	■	
panellized		■	■	
serial sectioned			■	■
assembly-of-parts	■			■

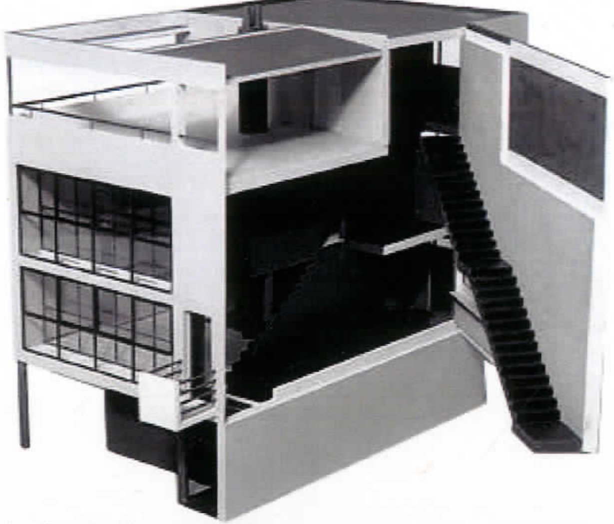
pairings: past & present

How is digital fabrication an advancement of our pre-fabricated predecessors?



_program
_site constraints
_environmental performance
_materiality
_manufacturing limitations

le corbusier: citrohan house, 1921

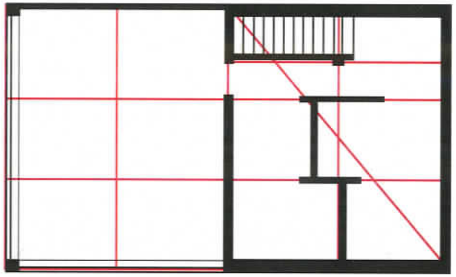


above image:http://en.wikiarquitectura.com/indexphp?title=Maison_Citr%C3%B6han

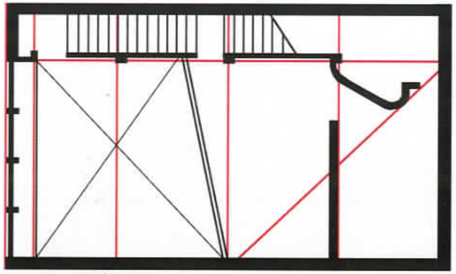
“Citrohan: that is to say, a house like a motor-car, conceived and carried out like an omnibus or a ship’s cabin. **The actual needs of the dwelling can be formulated and demand their own solution” (Le Corbusier, 240-241).**

The Mansion Citrohan is one of three different prototypes produced by Le Corbusier, all demonstrating his interest in industrialization in the form of housing that could appeal to the masses through affordability associated with mass-production. The name is in reference to ‘the machine for living’, thus pre-fabrication was suggested for construction.

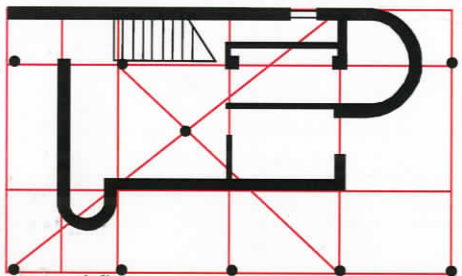
proportion/modularity:



terrace

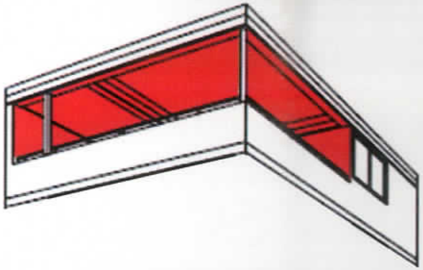


second floor

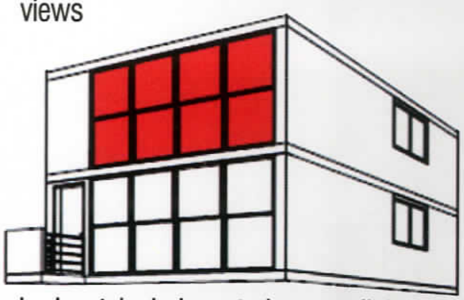


ground floor

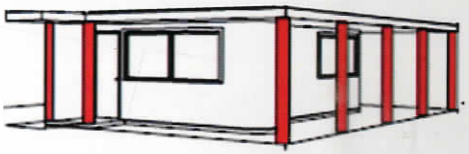
interaction with environment:



roof garden for private exterior space and views

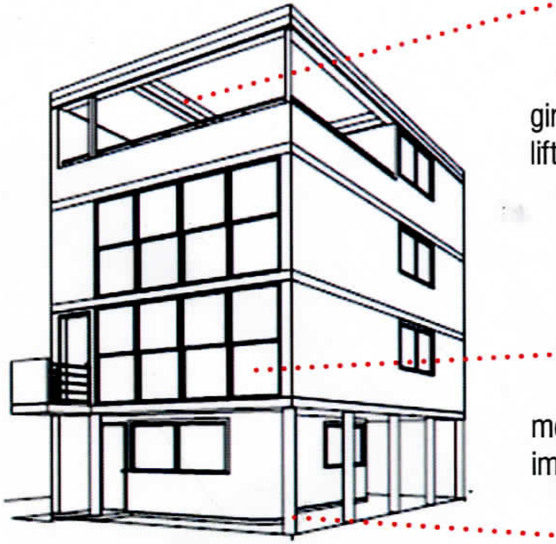


horizontal windows to improve lighting

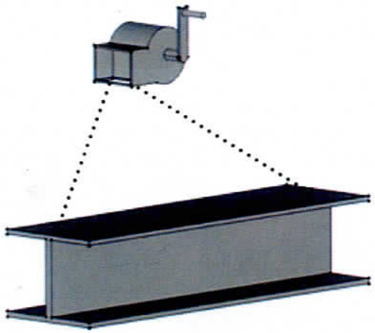


pilotis raising the house from the ground to introduce more light and to free the ground space for parking

assembly strategy:

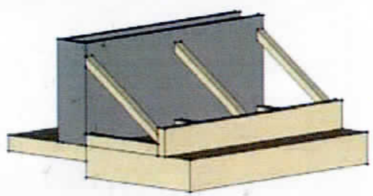


above image:http://en.wikiarquitectura.com/indexphp?title=Maison_Citr%C3%B6han



girders were made on site and lifted into place with a hand winch

modular, factory windows were implemented into the design



formwork was assembled on site

conclusion:

Le Corbusier, one of the primary leaders in the pre-fabricated - mass-produced housing industry brought on by the industrial revolution, conceived of the Citrohan dwelling through the successes brought on by the automobile and manufacturing industries. Le Corbusier notes " ... tools in the past were always in man's hands; today they have been entirely and formidably refashioned and for the first time being are out of our grasp" (Le Corbusier, 271). The trouble with mass-produced housing at the birth of the machine age was simply that architects were not traditionally trained or frequently associated with the processes of machine made craft. Le Corbusier and others alike, sought to solve social issues of affordable housing through processes that they were not in tune with, thus manufacturing processes and architecture must become united, and only then can the socialist dream of mass-produced housing become a successful reality.

william massie: big belt house, 2001

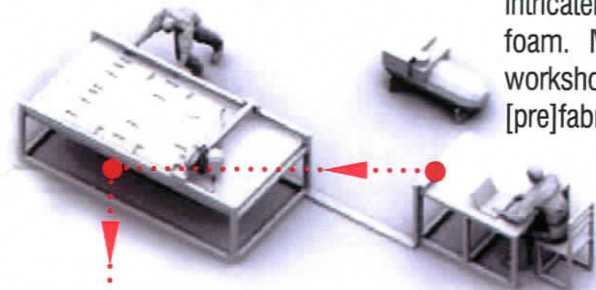
above image:http://www.iaacblog.com/2008term01/course05/?p=198

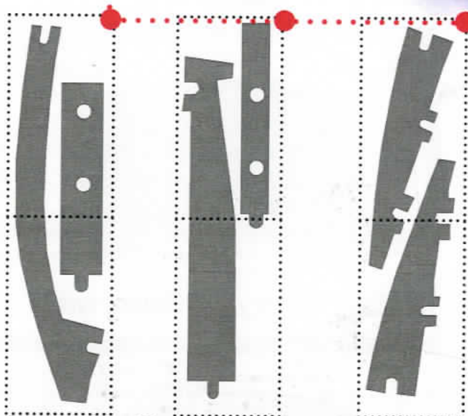
Simply stated, William Massie is one of the pioneers at the forefront of the digital revolution, using “the computer to manufacture a new set of building components and so inventing a whole new system” (Jacobs, 247). The Big Belt House in Montana is a perfect example of Massie’s unique approach to combining architecture with manufacturing processes and site conditions through the implementation of digital fabrication. As noted by Massie, “I don’t think I can reduce the cost of building a conventional building, but I think I can meet the cost of conventional building and make a more extraordinary thing. And that’s as much as I can do” (qtd. in Jacobs, 256). The Big Belt House is a perfect example of a unique building that provides alternative solutions to traditional pre-fabricated housing.

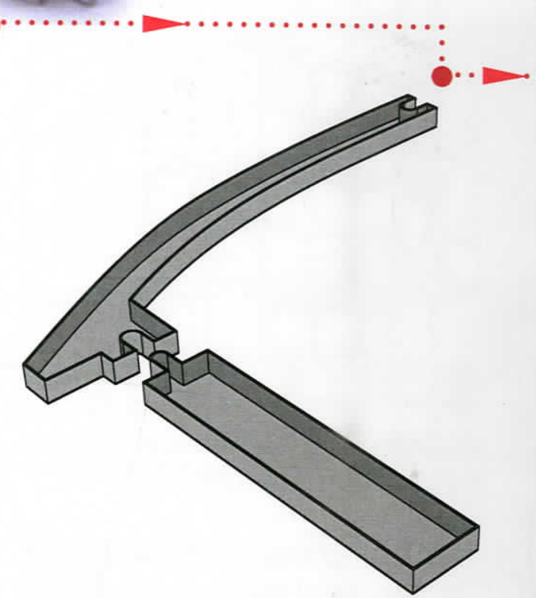
digital processes _ assembly:

image below:http://www.yatzer.com/assets/Image/5.may08/moma/HomeDelivery6.jpg

Digital design information is assembled and sent to a CNC Milling machine which intricately cuts individual molds out of foam. Massie performs this task in his workshop, then delivers the digitally-[pre]fabricated parts to the site.

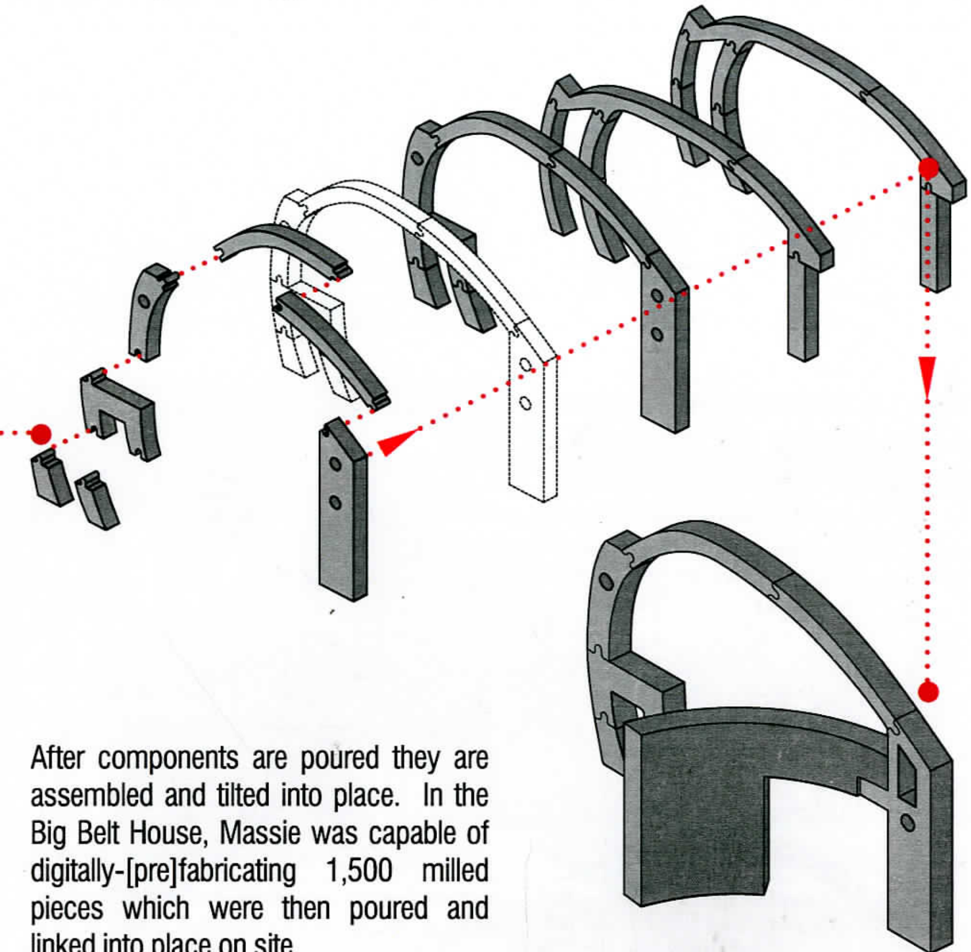






Next, the milled foam pieces are assembled to make forms for concrete at the site. Pieces which interlock are poured together using rebar to stabilize the two building components.

assembly strategy:



After components are poured they are assembled and tilted into place. In the Big Belt House, Massie was capable of digitally-[pre]fabricating 1,500 milled pieces which were then poured and linked into place on site.

conclusion:

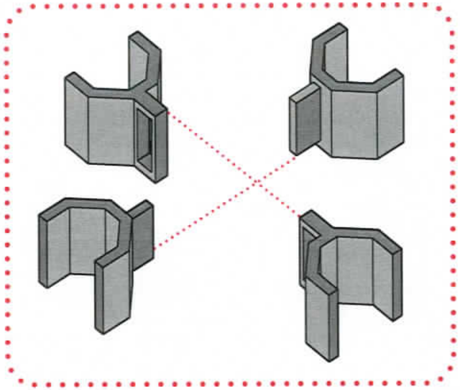
Opposed to his pre-fabricated predecessors such as Le Corbusier, William Massie remains an architect on the forefront of technology, one who has successfully wed manufacturing processes and architecture to create a new housing typology. Massie, like Le Corbusier, is an architect operating to "make great architecture for regular people. Modernism has become this bourgeois condition that costs a huge amount of money" (Jacobs, 242). Through the benefits associated with digital fabrication processes and computer generated design, Massie has developed a procedure where digital design information translates to physical reality through the adoption of manufacturing techniques such as laser cutting and CNC milling. Architecture and technology have a long rooted history and it is through architects such as William Massie that we begin to understand the successes brought on by the onslaught of the digital age, and consequently the inherent predicaments associated with Le Corbusier and a whole generation of architects who were seemingly disassociated from cutting edge advancements.

walter gropius: packaged house, 1942

above image: (Demchak, 66)

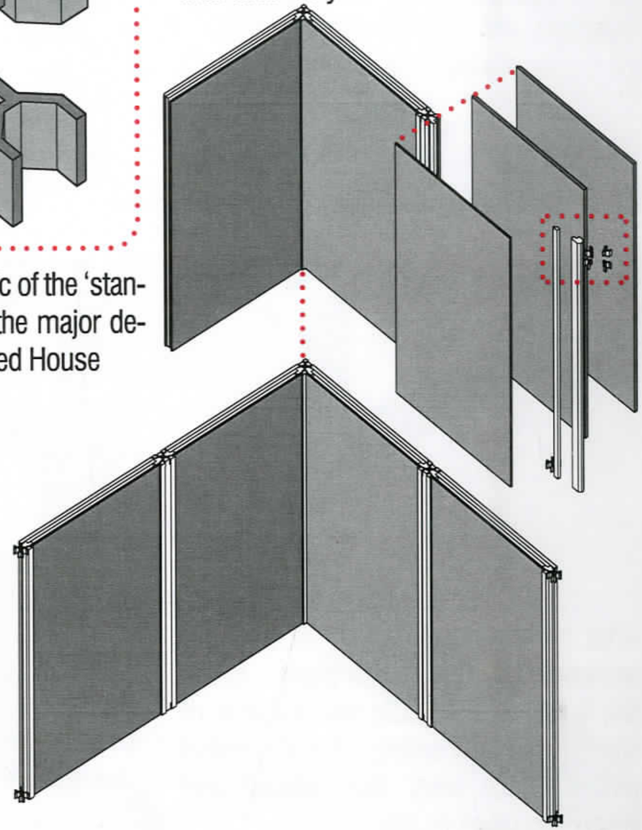
In 1942, Walter Gropius and Konrad Wachsmann established the General Panel Packaged Home concept with the daunting intent to resolve the problems of pre-fabricated housing. The principle behind the Packaged House lied within a single, standardized metal joint which served to connect modular panel units to one another. The failures of the Packaged House were in the joint itself, which limited the panels to 90 degree connections, severely constricting the arrangement and flexibility of design, two concepts that the pre-fabricated housing typology sought to alleviate. Additionally, the designs of the metal panels themselves were severely inhibitive, as they were based on the metric system and only were available in as little as ten variations. The pre-fabricated house proved to be a seemingly troublesome dilemma architecturally and stylistically throughout the modernist-industrial movement. In conclusion, "A system needs to be developed that can attain a great many stylistic conventions, while also being precision manufactured and prefabricated" (Demchak, 66).

limitations of the metal joint connector and modular panels:



Above: Exploded axonometric of the 'standardize metal joint', one of the major design setbacks of the Packaged House

The exploded panel axonometric below begins to examine the metal connector's interaction with the Package House's wall assembly.



assembly/limited panel variation:

image: a

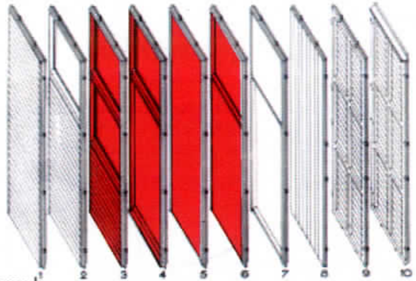


image: b

One major design flaw was the limited amount of panel variation from wall to floor/roof.

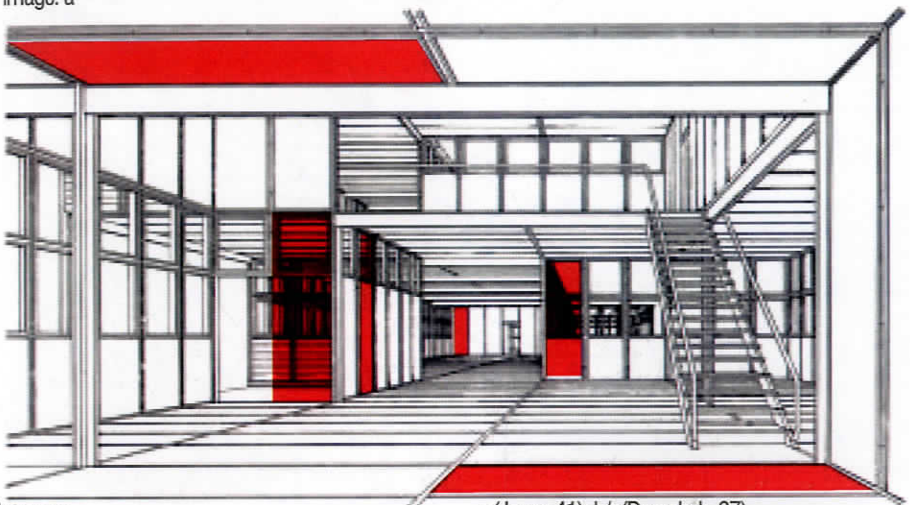


image: c

a:(Jones,41); b/c(Demchak, 67)

conclusion:

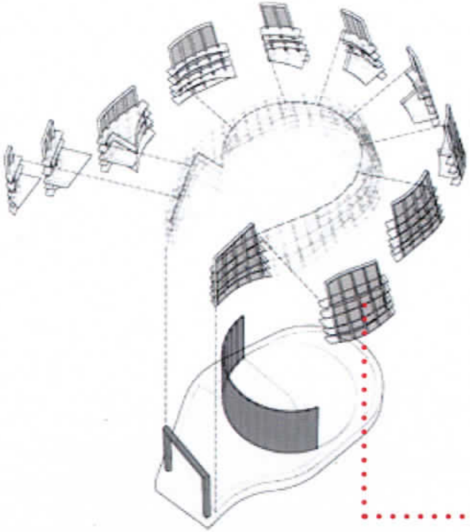
Operating at the height of the Bauhaus movement, Walter Gropius served to integrate architecture and technology using pre-fabrication as a vehicle to explore the newly defined, machine-made aesthetic. However, Gropius was against an idea of "total prefabrication…he recognized that formal variation is an architectural necessity; that it is what separates trailers, manufactured homes, and other mass-produced buildings from 'architecture'" (Jones, 40). Thus, Gropius devoted years to the development of a single component which could allow mass-produced panels to connect to one another, comprising an overall building system. The creation of this inventive connection module consequently became the demise of the Package House typology, where "the otherwise brilliant wedge connector makes for a fairly 'dumb' box: right-angled connections enforce a strict orthogonality under an 8-foot by 4-foot proportional system" (Jones, 41). Apart from the strict-modular aesthetic associated with the fall of the Packed House and the post-war housing boom which also led to the demolition of the General Panel Corporation, Gropius still proclaimed "the designer and builder [should] have at their disposal, say, a box of bricks to play with for adults, offering an infinite of such component parts for building which would be interchangeable" (Jones, 39). An idea which has continued to inspire architects working to solve the issue of pre-fabricated housing today.

SHoP architects: camera obscura, 2005

above image:http://www.aiany.org/eOCULUS/2007/images/0109/SHoP-12.jpg

The Camera Obscura project in Greenport, NY was 100% digitally fabricated from prototype to final construction. Three-dimensional drawings generated from the computer model of the structure mark a new method of representation in the practice of digital architecture, thus providing mere locations and assembly directions rather than providing dimensions and material/product specs. This methodology of representation allowed the construction crew to work without the use of tools, including the tape measure. The end product, a series of component assemblies, was compared to a 'scaled-up model airplane kit'. (Klinger & Vermillion, 84).

diversity of digital fabrication processes/fabrications:

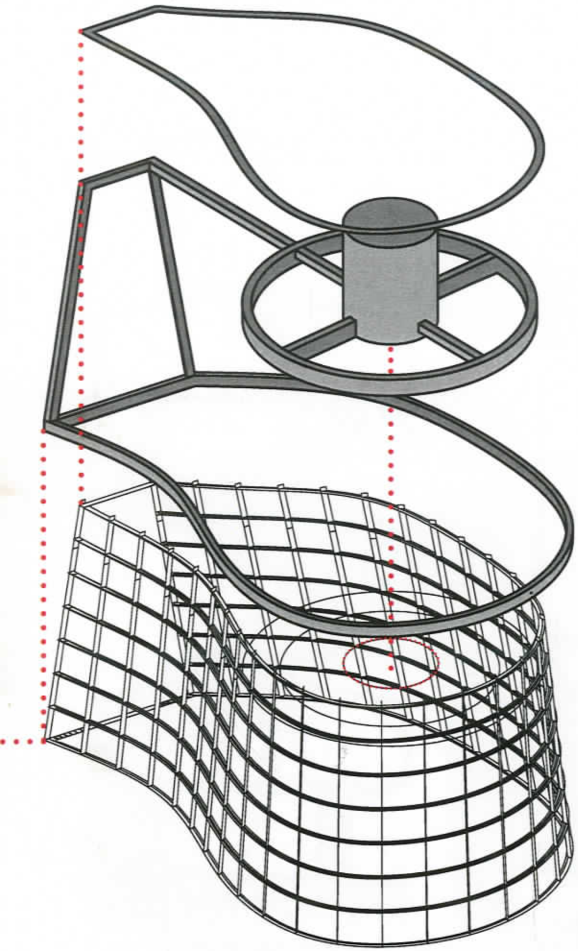


above image:http://www.shoparc.com/#/projects/all/camera_obscura

above image:http://www.shoparc.com/#/projects/all/camera_obscura

The use of digital fabrication techniques from the beginning of design enabled the SHoP design team to produce varying building components. The seemingly small 350 square foot building in footprint was not small in terms of overall scope. According to SHoP's website, "for the first time we brought together multiple processes to test tolerance and coordination issues" (http://www.shoparc.com/#/projects/all/camera_obscura).

assembly strategy/component connections:

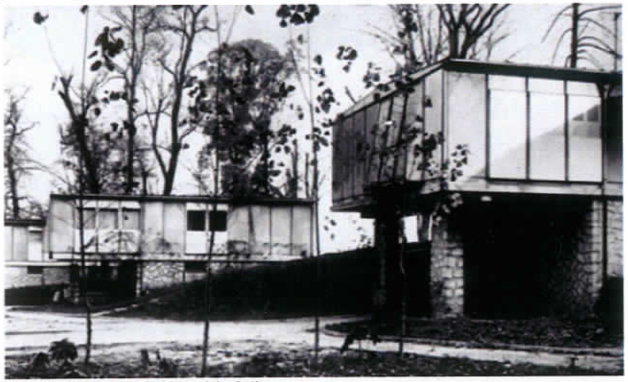


above image:http://www.shoparc.com/#/projects/all/camera_obscura

conclusion:

Although SHoP's Camera Obscura project is not programmed as a dwelling, the digital design and fabrication process provides a model for transforming the construction process. The architects were forced to develop a transition from design information to fabrication parameters, consequently eliminating the necessity of shop drawings. The resulting architectural construction document set for the project avoids plans, sections, elevations and even dimensions, but instead includes drawings such as the exploded axonometric to guide the constructor through the assembly process.

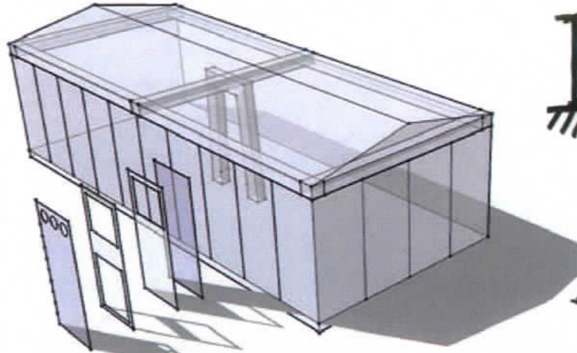
jean prouvé: meudon houses, 1949

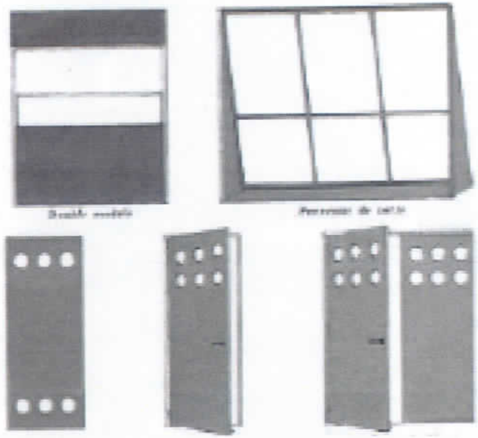


above image:(Pedreschi, 25)

The Meudon Houses were developed by architect Jean Prouve as a reaction to temporary military airfield housing shortages. In total, 25 houses were constructed using a panel pre-fabricated system for rapid assembly. Each house, quotes Prouve, "can be delivered by a single truck and assembled by four men in just one day"(Pedreschi, 20). All components are modular and light enough for one person to carry, and most importantly interchangeable, where façade window, door, or solid panels can be re-configured or swapped for a different material. Prouve strived to develop a system that could seemingly appear different from one construction to the next utilizing his material and component variation, yet the aesthetics of these homes were restricted to the number of modular, interchangeable panels, which did not produce a high degree of variation in the aesthetics of the resulting configurations.

proportion/modularity:

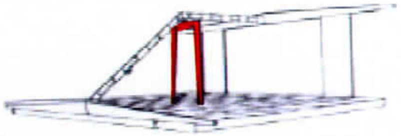




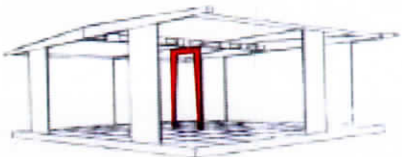
above image:(Pedreschi, 25)

interaction with site restraints:

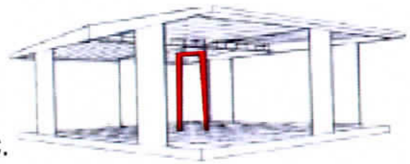
assembly strategy:



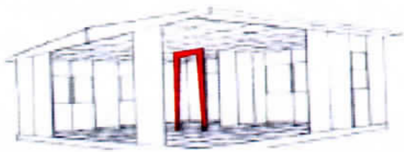
a.



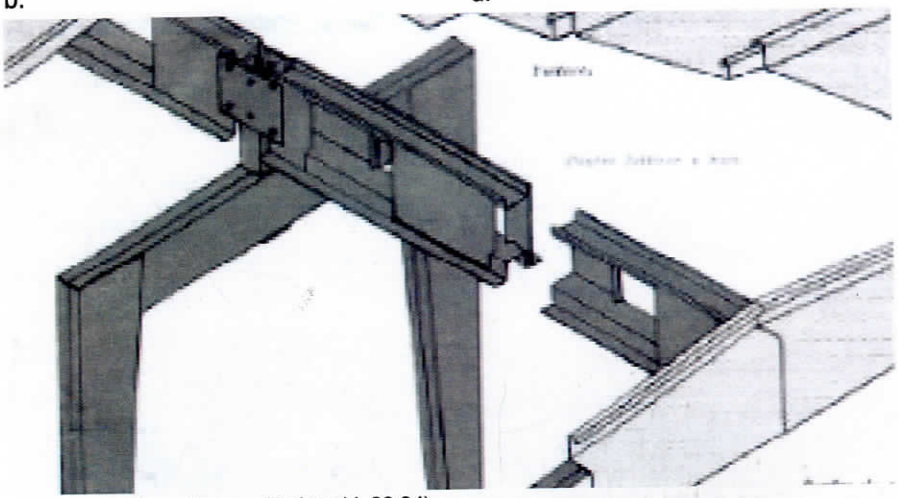
b.



c.



d.



above images:(Pedreschi, 22,24)

conclusion:

Not dissimilar from the goals and aspirations of Gropius, Prouvé's Meudon Houses provide yet another example where the pre-fabrication of component systems simply cannot appease to the masses. Prouvé, seemingly well versed in the actual manufacturing of metal building components, sought to appeal to the masses through allocating variation amongst components, yet his houses were still associated with the 'boxy' machine-made aesthetic.

Prouvé also introduced to the pre-fabricated housing typology the idea of the dwelling's interaction with the landscape. This becomes an interesting venture because the Meudon Houses are by no means site specific; they are simply conceived to provide economically efficient, mass-produced housing solutions for the masses. In order to satisfy a number of landscape variations, thus making the dwelling more marketable, Prouvé provides the solution to three different landscapes, one flat, one built on a hill, and one elevated completely in the air. Prouvé's rather trivial solution to dealing with local site restraints only augments the importance of providing a responsible dwelling, born through the use of digital design, to satisfy a number of parameters in regards to single family housing typology.

cloud 9: villa NURBS, 2008

above image:http://www.ruiz-geli.com/04_html/04_villanurbs.html

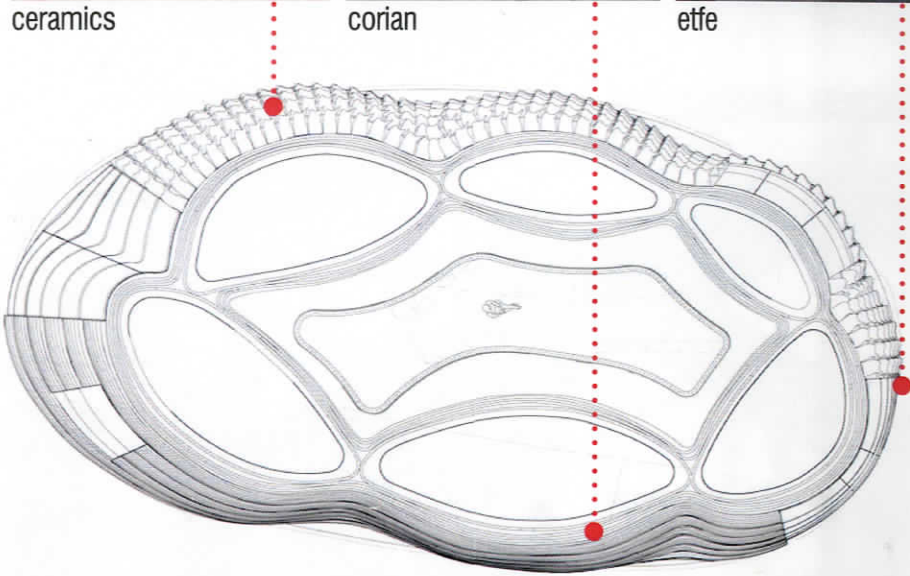
The Villa NURBS located in the outskirts of Barcelona, is yet another project that has thoroughly integrated digital fabrication processes into design. The buildings form offers a direct relationship to digital fabrication, where architect Ruiz-Geli notes "People dreamed of this but could never do it. Digital technology, parametric design — this allows a level of complexity that couldn't be built before. The skin, structure, climate, technology are all in balance. It allows us to build today the utopia of before" (Ouroussoff, 114). The Villa NURBS, a name inspired by our immersion into the digital age of computer design, serves as a perfect example of the advancements in pre-fabricated housing enabled by digital fabrication technologies. The house "represents the next step on that evolutionary chain, one that is more finely tuned to individual desires" (Ouroussoff, 114), notes the architect.

component variation:

ceramics

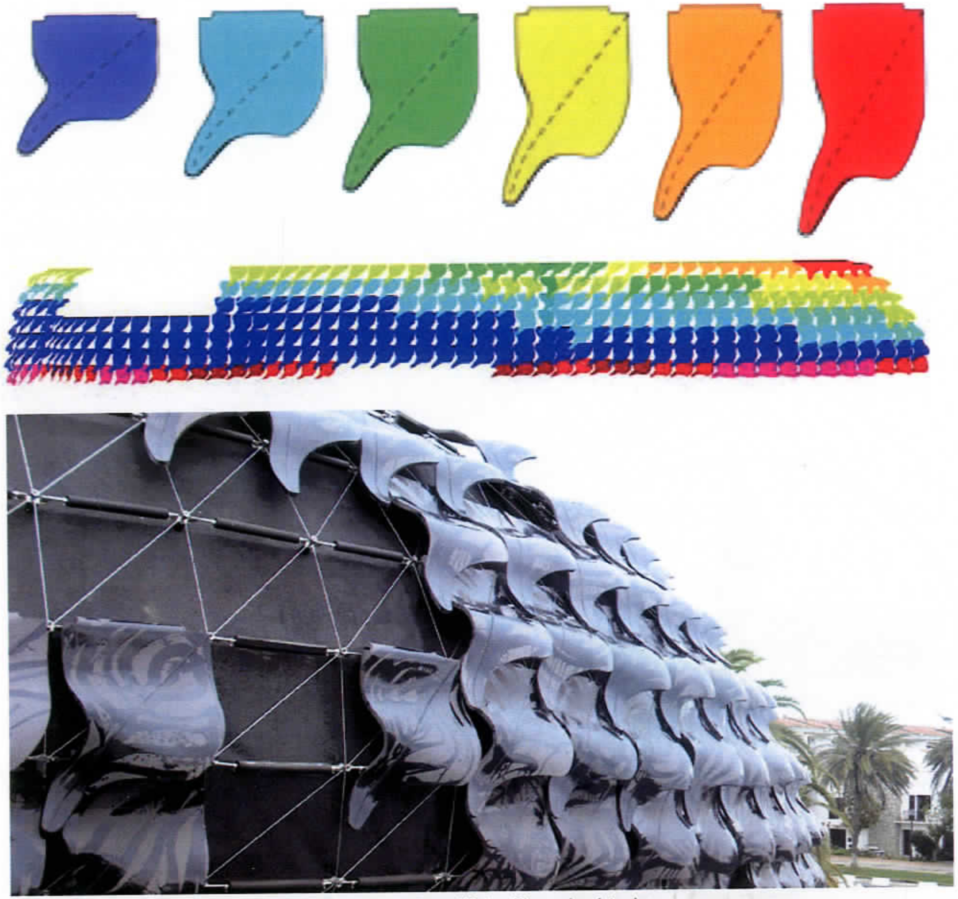
corian

etfe



above images:http://www.ruiz-geli.com/04_html/04_villanurbs.html

performance analysis/assembly strategy:



above images:http://www.ruiz-geli.com/04_html/04_villanurbs.html

conclusion:

The Villa NURBS by Cloud 9 architects serves as a seemingly perfect model in regards to the argument for a new digitally-[pre]fabricated housing typology. The villa, similar to our pre-fabricated predecessors, utilizes mass-production processes to translate design to built form. However, the introduction of technology, specifically the computer, allowed the Villa NURBS to be intelligently designed to become a responsive negotiation of different design and site parameters. What separates this dwelling from other precedents is the buildings utilization of digital fabrication in order to explore the impact of the mass-customization of building components. The façade of the dwelling almost becomes a showcase for intelligent materials and component connections, becoming an inspiring exploration of the possibilities inherent within digital fabrication processes.

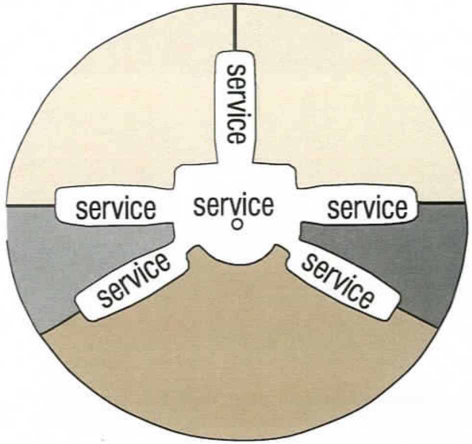
buckminster fuller: dymaxion house,1945

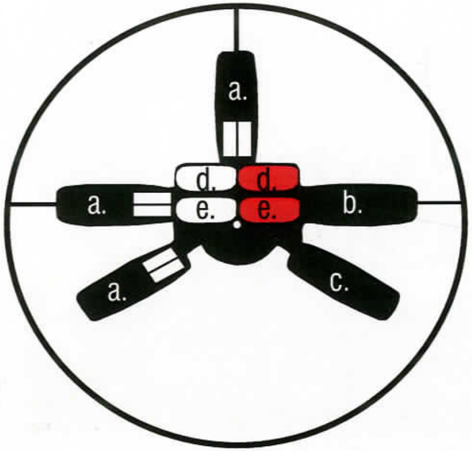
above image:http://200905weirduniv.s3.amazonaws.com/dymaxion_house.jpg

Buckminster Fuller viewed the work of Le Corbusier, and most of the architects of that period, as "trivial since it did not seek to fulfill the need for shelter from an engineering viewpoint, and without conforming to the demands of "style or tradition". Fuller believed "homes should be thought of as service equipment, not as monuments" (Barrow, 4).

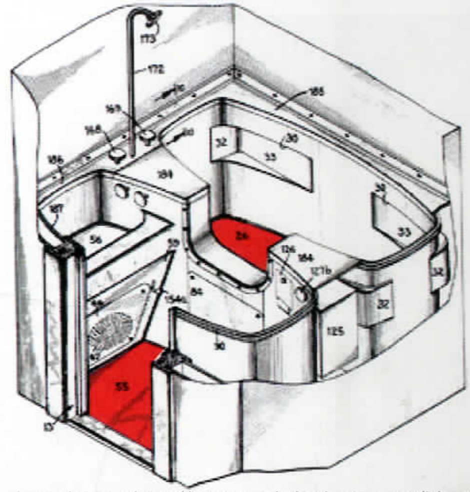
Fuller also believed that in order to "fully utilize the economies of mass production, identical housing units should be manufactured as a whole in the factory and flown to their final destination" (Barrow,4). The interior of the Dymaxion House remains completely disassociated with the building's exterior skin, thus interior partitions or components can be plugged into and rearranged based on the needs of the occupants.

home as service equipment:



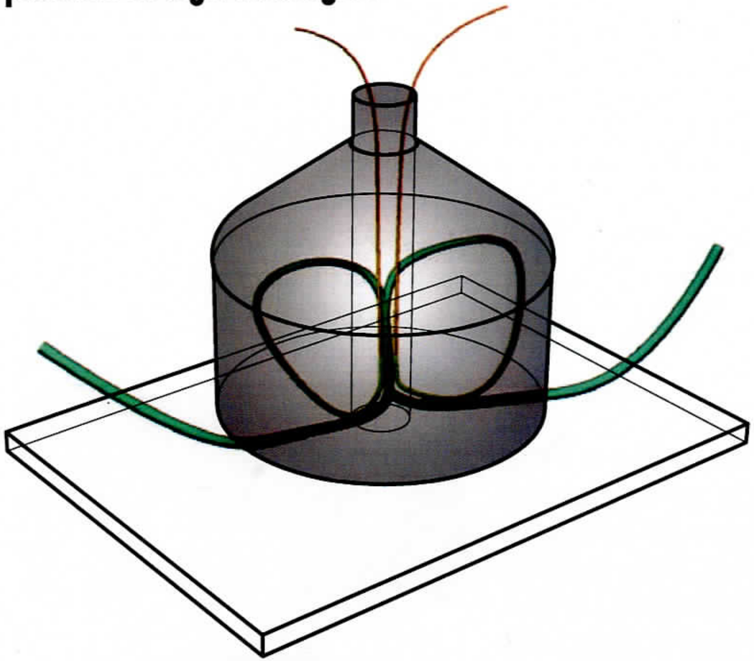


Fuller strived to solve the problem of prefabricated housing strictly through the adaptation of manufacturing processes in order to gain precision, but most importantly variation through component swapping. The service cores of the Dymaxion House are designed such they can be at anytime swapped out for a new component or unit. Additionally, these service components can be easily re-arranged to adapt to the necessities of the client, a provocative invention in the realm of pre-fabricated housing.



above image:http://www.weirduniverse.net/blog/comments/2824/

passive design strategies:



Passive design strategies were inherent within the design of Fuller's Dymaxion House, whereas the house is lifted slightly off of the ground in order to allow air from outside to enter the main flu in the center of the dwelling. Through the stack effect, this air is naturally drawn upwards where vents allow the colder outside air to filter into the living spaces. Vents were also placed in the floor so that once the room temperature rose higher than the air coming into the room; the warmer air was once again pulled back into the main flu and vented out of the top of the building.

conclusion:

The Dymaxion House is yet another example of pre-fabricated housing which suffers tremendously from the machine produced aesthetic. However, it is within this 'style' that the architect, Buckminster Fuller, found beauty in his creation. The design allocates little room for personal customization of the dwelling on the exterior, yet the internal ideal of component swapping allows individuals to not only change the layout of their environment, but also change out the interior components altogether. This idea of component swapping provides a provocative way in which one can constantly alter the interior mood or aesthetic in relation to general needs or aesthetics reflected through various time periods.

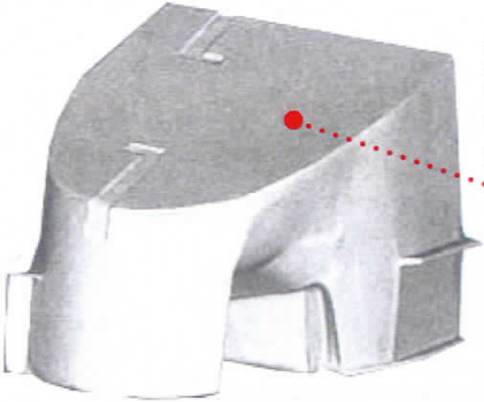
The Dymaxion House also becomes a pioneer in regards to pre-fabricated housing in that it serves to utilize passive design strategies in order to cool the dwelling. Passive design coupled with component swapping modularity are two innovations born within the pre-fabricated housing typology that initially sparked the force towards creating sustainable, efficient construction methodologies adopted by architects such as Norman Foster demonstrated in the Hong Kong Shanghai Bank.

steven holl: turbulence house,2005

above image:http://www.shedandshelter.com/compacthouse/turbulencehouse.jpg

The Turbulence House is a contemporary iteration of the pre-fabricated house, where Holl uses the computer to design a form based on the site's environment. The site, located on a windy mesa in New Mexico, heavily influenced the orientation and form of the building itself. The home's sloping roof is a reaction to harnessing southern light, while the strategy of carving away the middle of the house alludes to the windy nature of the site. Western winds are channeled through the house and are used to passively cool the interior. Working in conjunction with a sheet-metal fabricator, with the aid of digital wireframe computer models, the team devised an aluminum rib-and-stressed-skin envelope, which merged enclosure with structure.

from physical to digital:

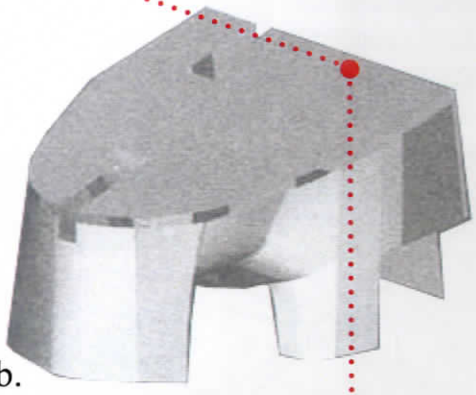


a.

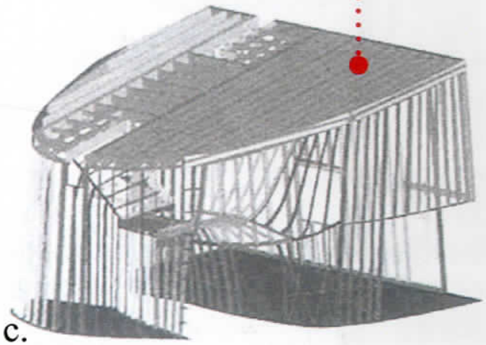
Above, image 'a' is the resultant of a three dimensional computer scan of a physical model built of the house during the design phase. Holl was then able to apply this now digital 'building information' and break up the model into a series of panels which could be digitally fabricated. These panels are shown in image 'b'. Finally, once the modularity and placement of the panels was decided, engineers were able to translate this digital information and produce a structural model which was informed by the previously computed metal panel skin.

above images a,b,c: (Barrow, 5)

The whole process is linked to digital processes, and the construction phase became directly influenced by digital fabrication, where CNC machines were driven by the derived building information from the architect's original 3-d model.

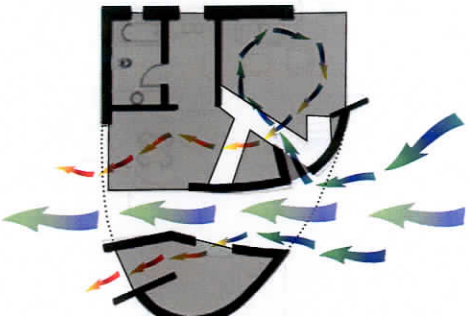


b.

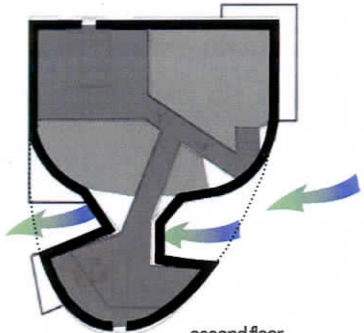


c.

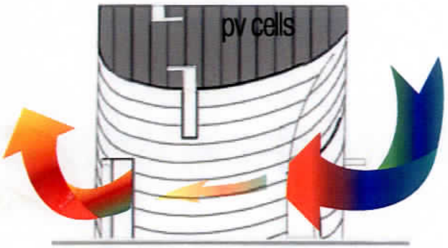
passive design strategies, wind/light:



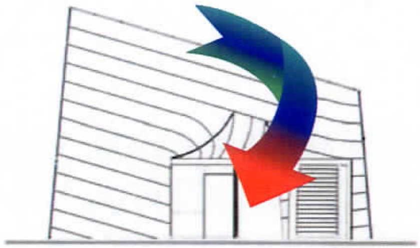
first floor



second floor

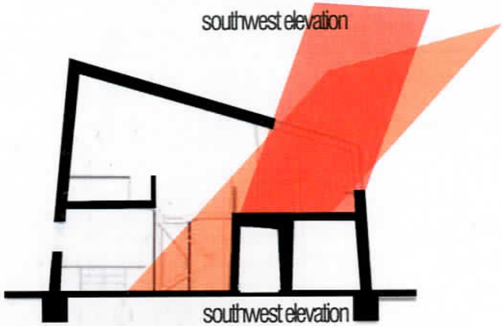


southeast elevation



southwest elevation

northeast elevation



southwest elevation

above images: (Broadhurst, 63)

conclusion:

In tune with the lessons previously described in the works of Buckminster Fuller, Steven Holl in the Turbulence House has fully integrated site, program, and environmental variables for the creation of a house born through the digital age. Unlike the Dymaxion House, an engineered module designed to be grounded anywhere, the Turbulence House is a project firmly grounded to its site. The notion that architecture can become responsive and operate within its environment is something that the architects of today should strive to perfect, something which is made feasible through digital design and the implementation of digital fabrication into the discipline of architecture.

summary:

In conclusion, although an investigation of Modernist manufactured housing provides many positive examples, there were also many failures in the Modernist mass-housing movement. The birth of the digital age finally allowed architects to fully embrace the power of manufacturing processes often used in other disciplines through the use of the computer and digital fabrication processes. Architects on the cutting edge of technology today have the means, resources, and skill set to successfully explore the possibilities inherent in the pre-fabricated housing typology and digital fabrication techniques. Digital fabrication inherently re-defines the architectural design process as well as the construction or 'assembly' of building components. The digitally fabricated buildings of today reflect the flexibility intrinsic to digital design, allowing buildings to become informed by site constraints, but most importantly become environmentally responsible, serving as a true reflection of our time.

lessons [failures] of the past:

mass production
designed for any site
component driven
manufacturing retraints

"The stereotype about prefab is that it creates houses all alike, all in a row…" (Herbers, 118).

improvements of today [technology/digital process]:

mass customization
site/contextually driven
environmentally responsible
knowledge of manufacturing processes

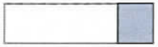
"But the reality is that, instead of mass production being the driving force behind what is created, mass customization is much more often the approach. Within a system, an almost limitless number of designs and houses can be created, according to the individual buyer's needs, wants, and budget; the site, the region of the country; the climate; and the tastes of the moment" (Herbers, 118).

overview:

Four general plan arrangements have been selected, each utilizing the same modular system to comprise the dwelling layout. A range of square footages and spaces were chosen to appeal to the masses, ranging from 2 to 4 bedrooms and 1 to 3 bathrooms. No layout is particularly more appealing than the next, as the point is to use these general arrangements to test performative analysis, site constraints, and manufacturing capabilities. Each configuration provides varying square footage and basic relationships from one space to the next, yet ultimately the configuration on each site will be dictated by lot size and the capability of each arrangement to conform to environmental responses. Digital fabrication design processes allows these modular units to be configured and cut through the use of the computer, serving as a system to which varying exterior components can be attached. In conclusion, through these technologies, the dwelling becomes a hybrid typology, digital-[pre] fabrication, where mass-customizable components are assembled according to aesthetics, site, passive heating and cooling, and advancements in manufacturing.

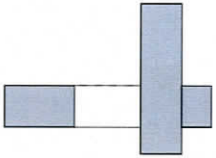
program, 4 typical arrangements:

bar_a:



920 square feet
2 bedroom
1 bath
Kitchen/living/dining
Office

L:

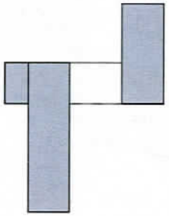


1890 square feet
3 bedroom
3 bath
2 upper decks
Kitchen/living/dining
Living 2/office

bar_b:

1370 square feet
2 bedroom
1 bath
Kitchen/living/dining
Upper deck
Living 2/office

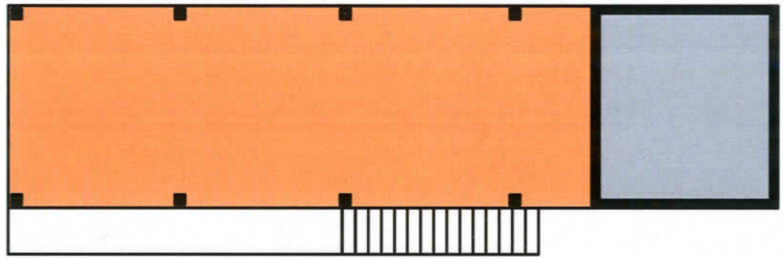
Z:

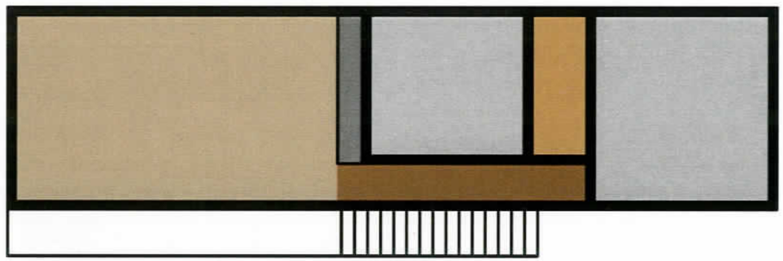


2050 square feet
4 bedroom
3 bath
2 upper decks
Kitchen/living/dining
Living 2/office
Day room/bedroom 5

bar_a:

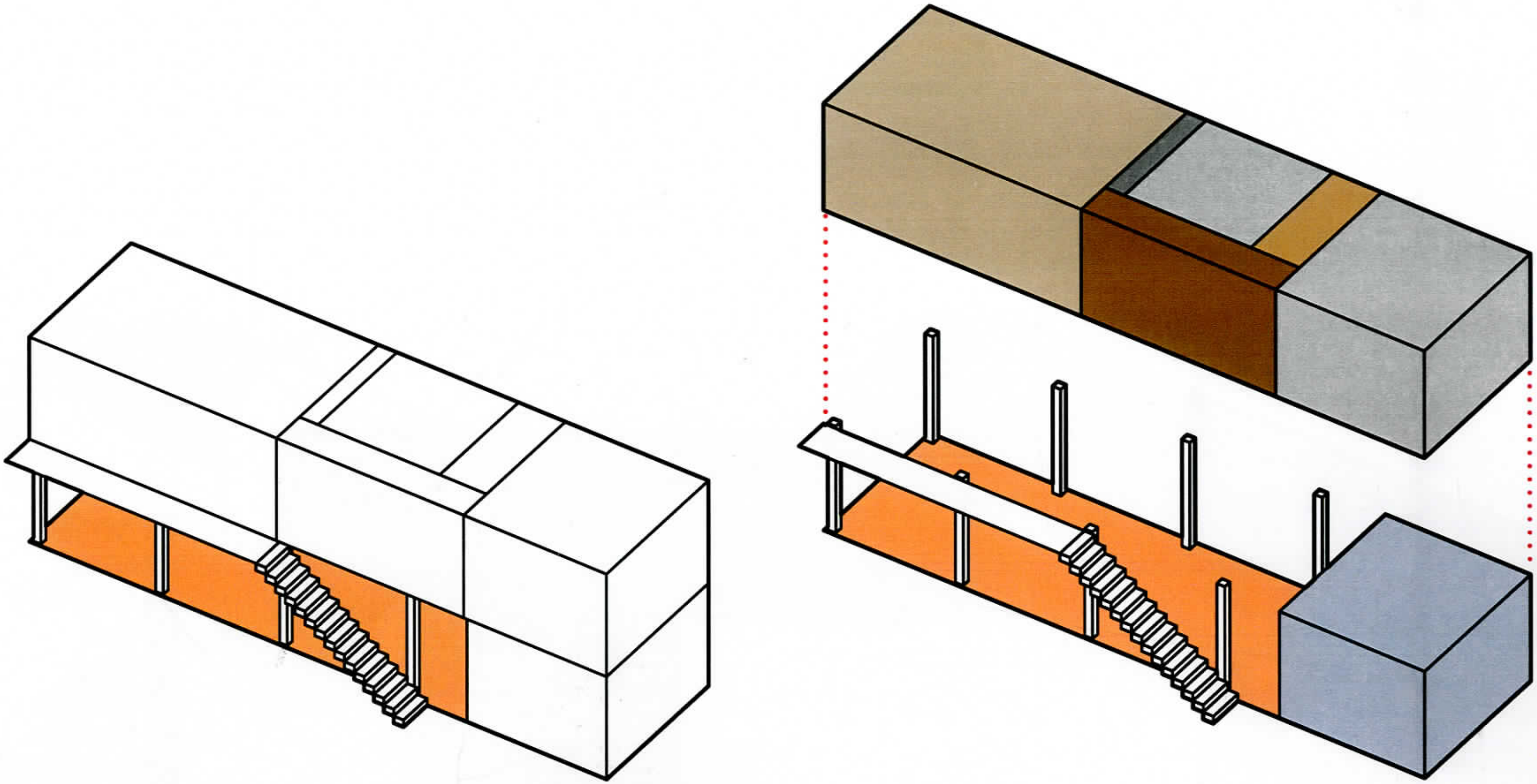
920 square feet
2 bedroom
1 bath
Kitchen/living/dining
Office





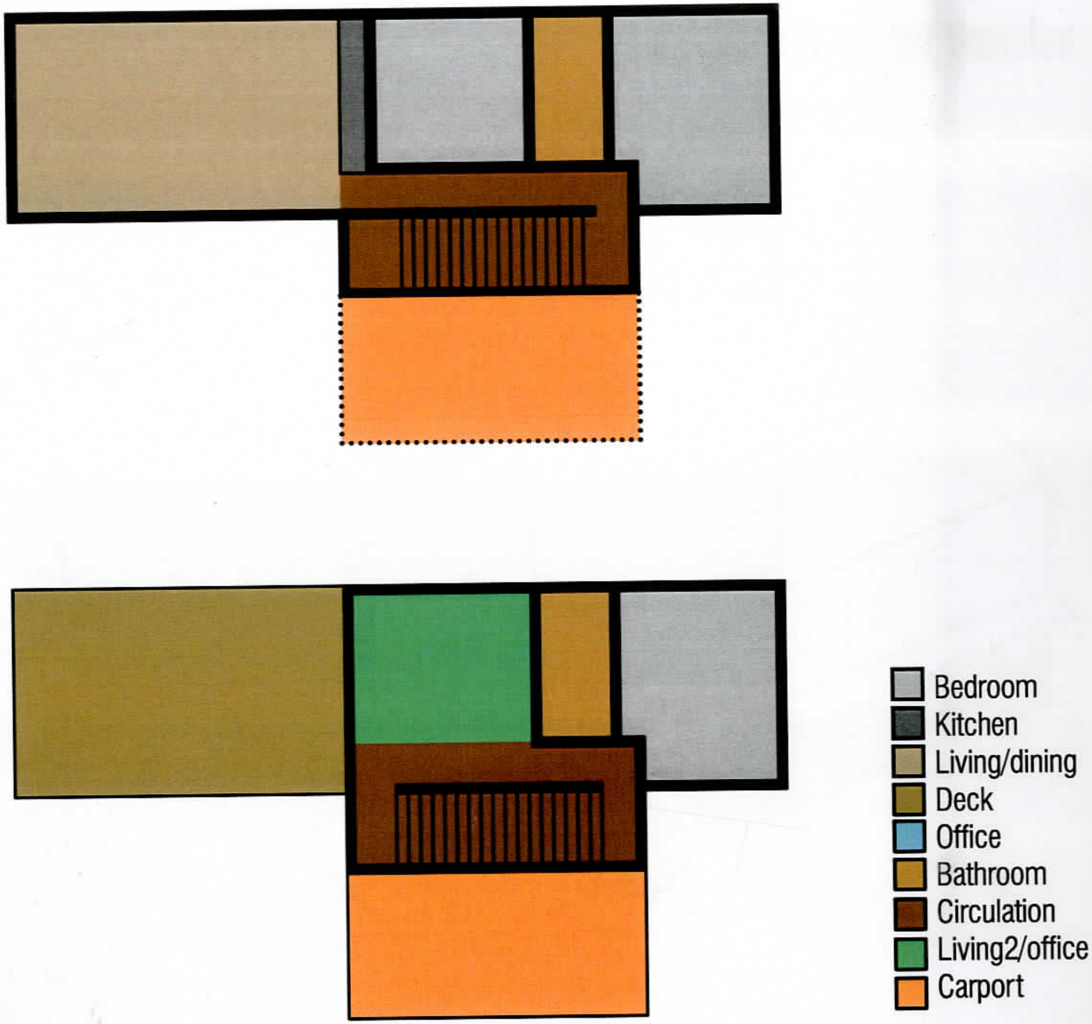
- Bedroom
- Kitchen
- Living/dining
- Deck
- Office
- Bathroom
- Circulation
- Living2/office
- Carport

volumetric/programmatic study:

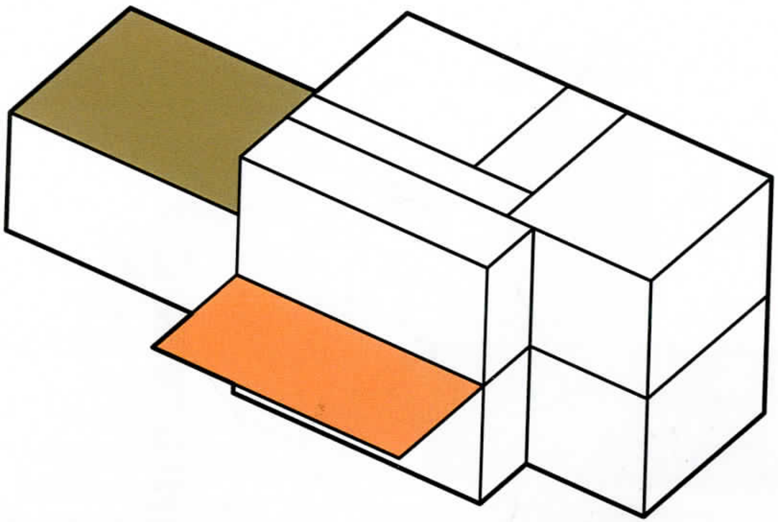


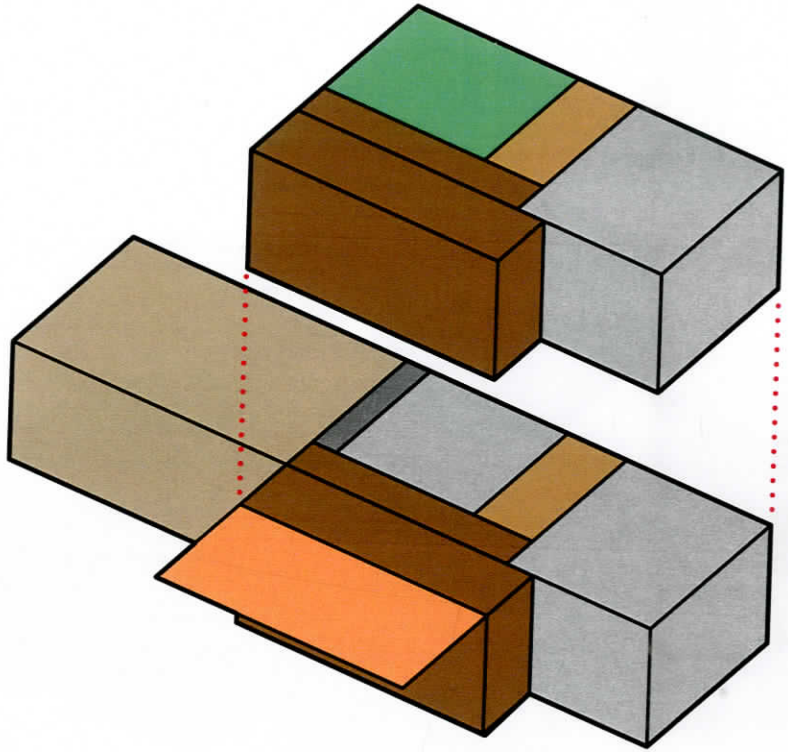
bar_b:

1370 square feet
2 bedroom
1 bath
Kitchen/living/dining
Upper deck
Living 2/office



volumetric/programmatic study:

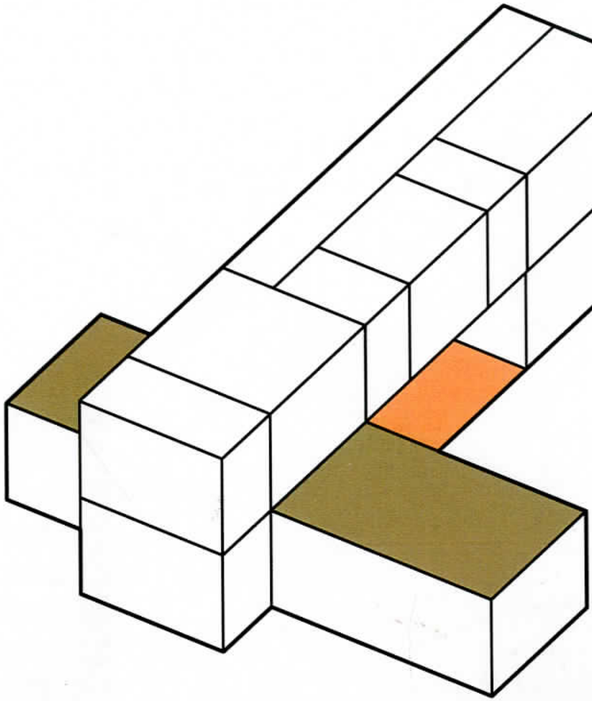


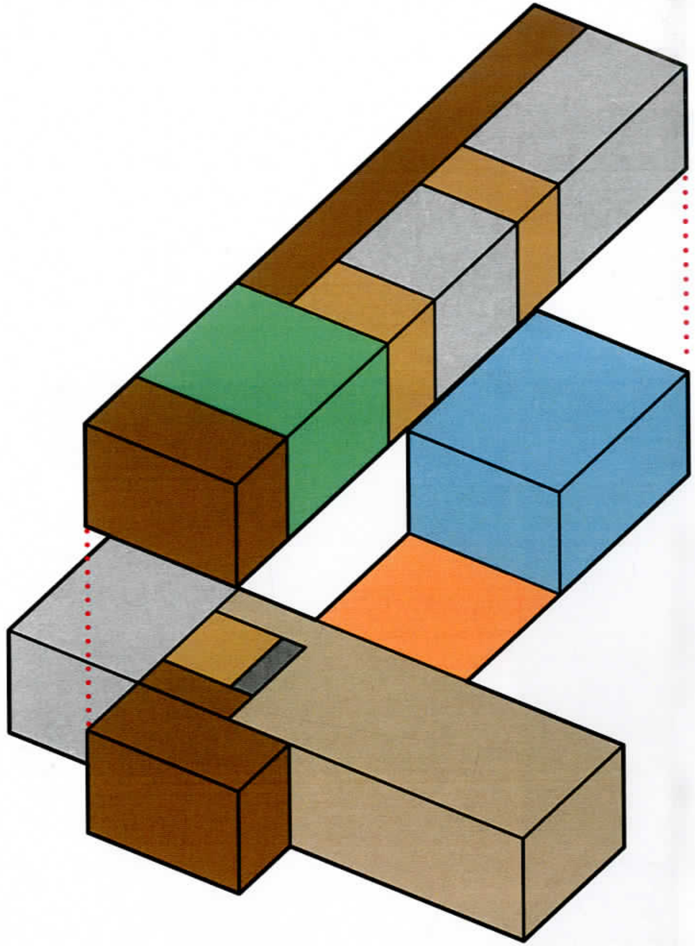


L:

1890 square feet
3 bedroom
3 bath
2 upper decks
Kitchen/living/dining
Living 2/office

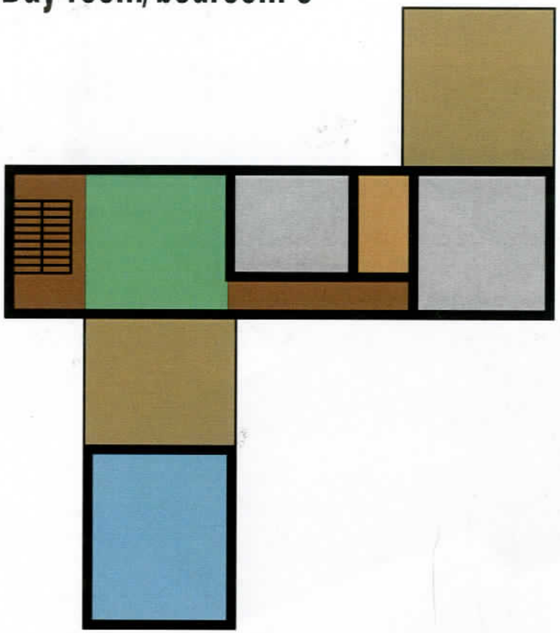
volumetric/programmatic study:

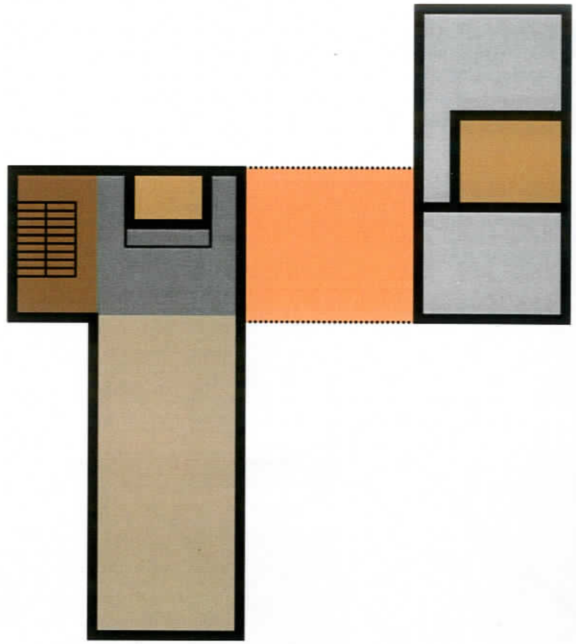




Z:

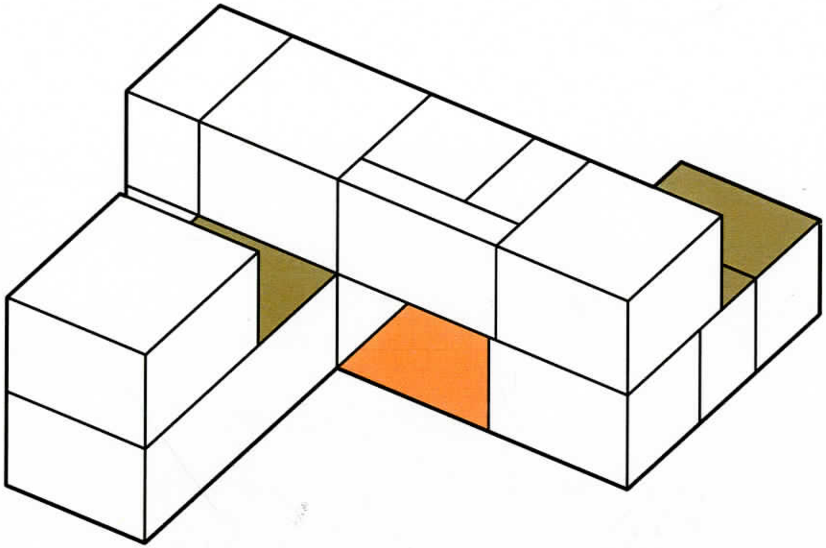
2050 square feet
4 bedroom
3 bath
2 upper decks
Kitchen/living/dining
Living 2/office
Day room/bedroom 5

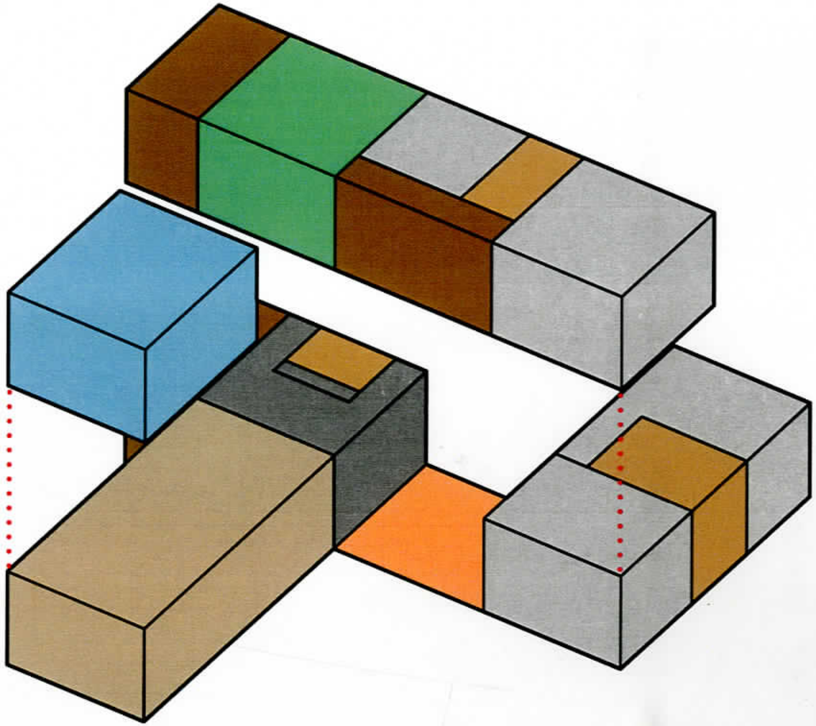




- Bedroom
- Kitchen
- Living/dining
- Deck
- Office
- Bathroom
- Circulation
- Living2/office
- Carport

volumetric/programmatic study:

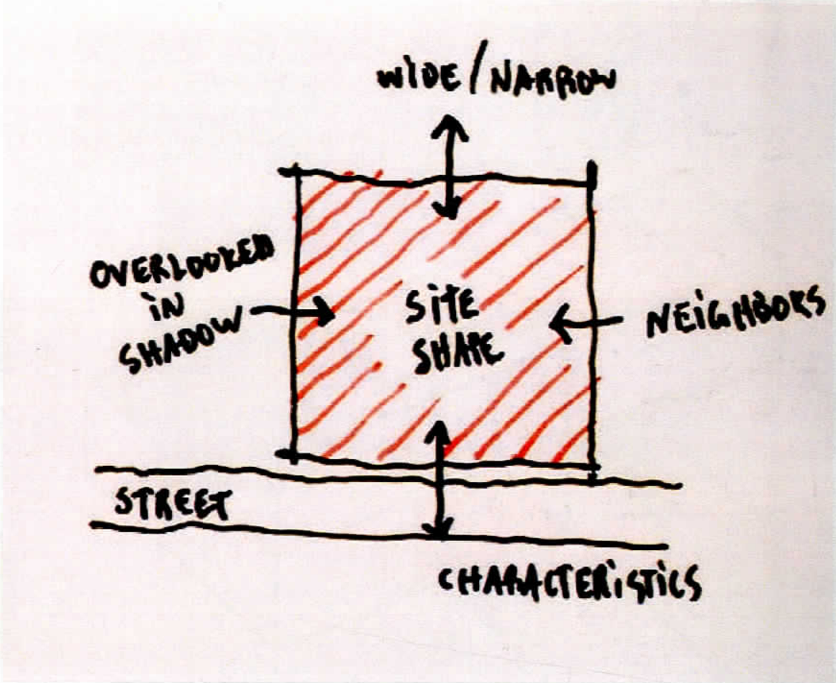




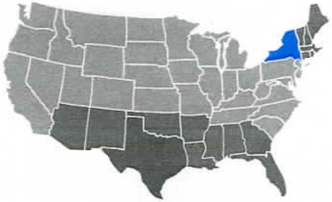
overview:

Two sites, one in a warm-suburban climate and one in a cold-urban climate, will serve as the basis for the integration of digital-[pre]fabrication techniques at the architectonic scale. The program on each of the sites will be a digitally-[pre]fabricated dwelling utilizing the same module to comprise the houses structural [static] components, however different configurations of these modules could initiate differing square footage totals. Each site will drive design decisions for the project, where site restrictions and environmental analysis will play a role in the overall form, material, and consequently the environmental performance of the dwelling as a whole.

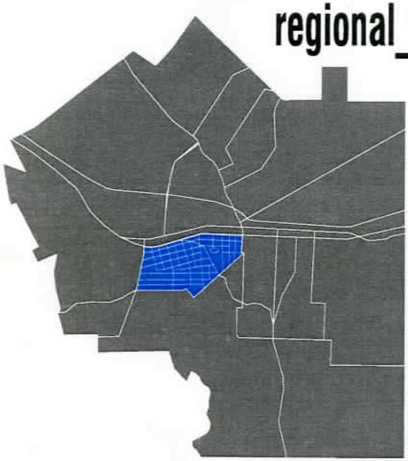
how do we negotiate site constraints?



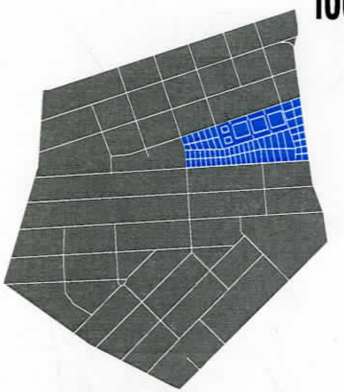
new york



regional_the west side

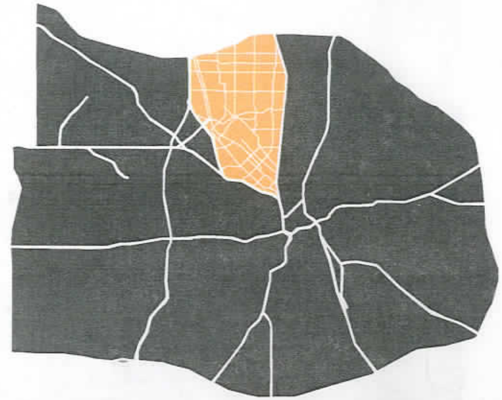


local_gifford street

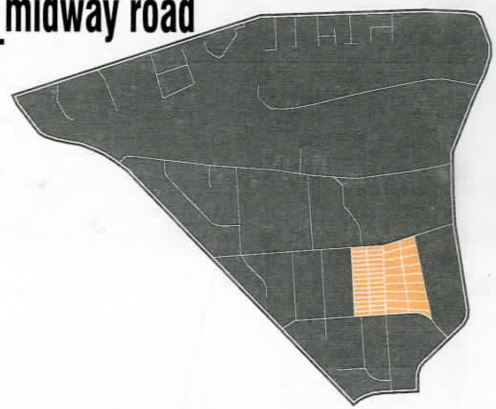


texas

regional_north dallas



local_midway road



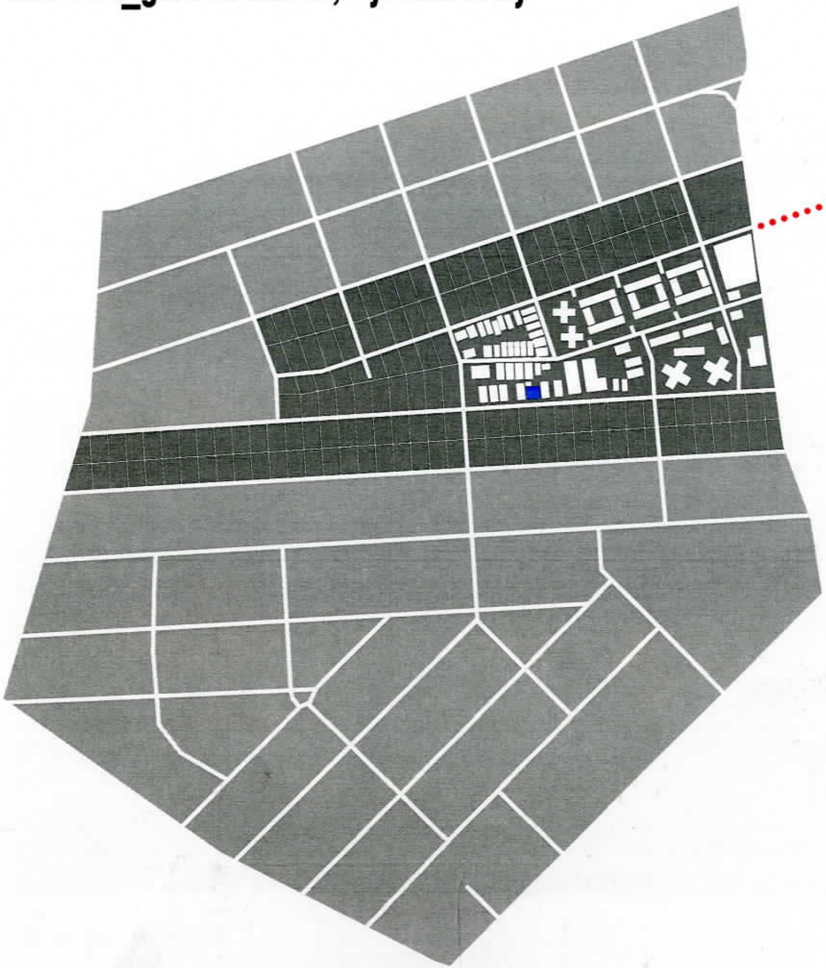
what does the neighborhood look like?_gifford street, syracuse ny

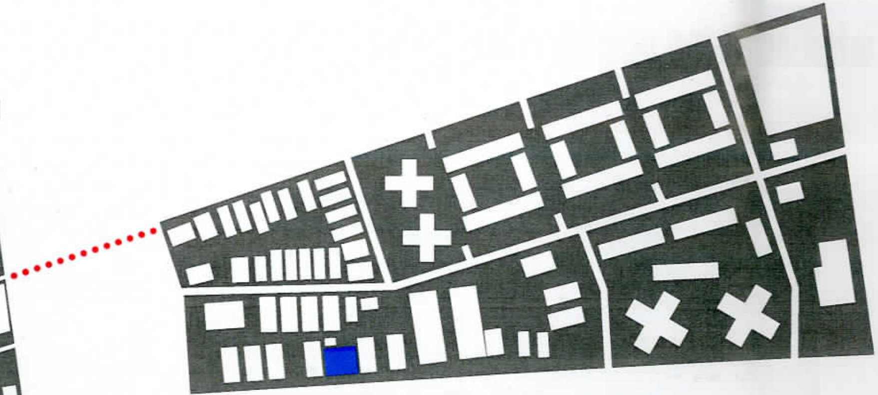
above images: google earth

what does the neighborhood look like?_midway road, dallas tx

above images: google earth

the site_gifford street, syracuse ny





average household size:

this zip code: 2.3 people
new york: 2.6 people

median age:

median resident age: 35.1 years
new york median age: 35.9 years

estimated house/condo value:

13208: $77,947
new york: $311,000

average gross income:

here: $26,177
state: $59,519

chart statistics from :www.citydata.com

the site_midway road, dallas tx

average household size:

this zip code: 3.0 people
texas: 2.7 people

median age:

median resident age: 33.5 years
texas median age: 32.3 years

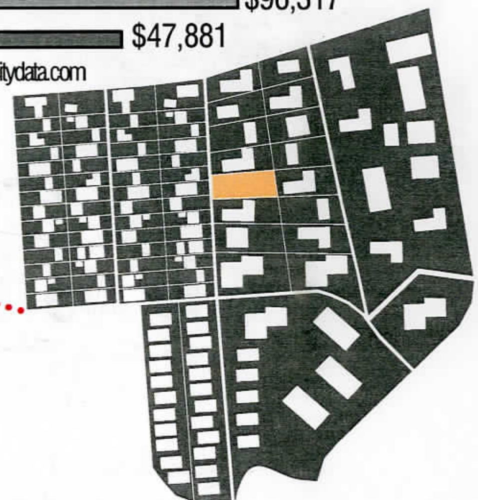
estimated house/condo value:

75019: $319,655
texas: $120,900

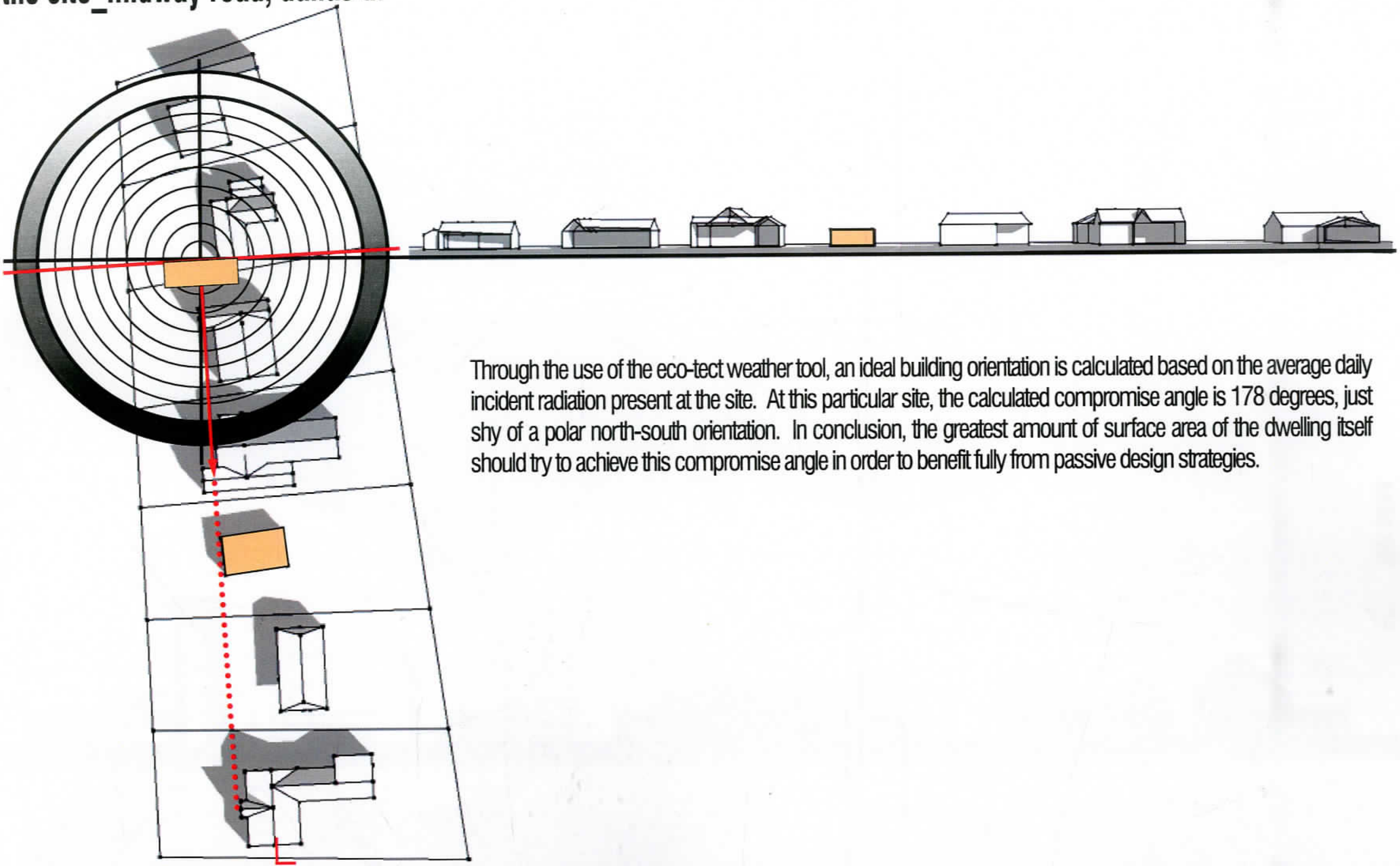
average gross income:

here: $96,317
state: $47,881

chart statistics from :www.citydata.com



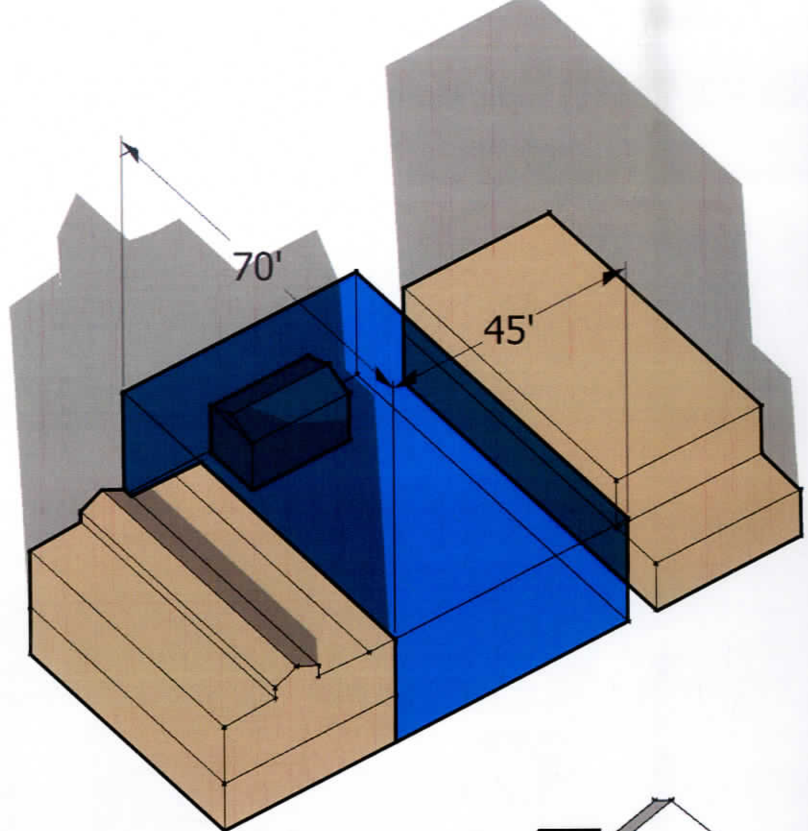
the site_midway road, dallas tx

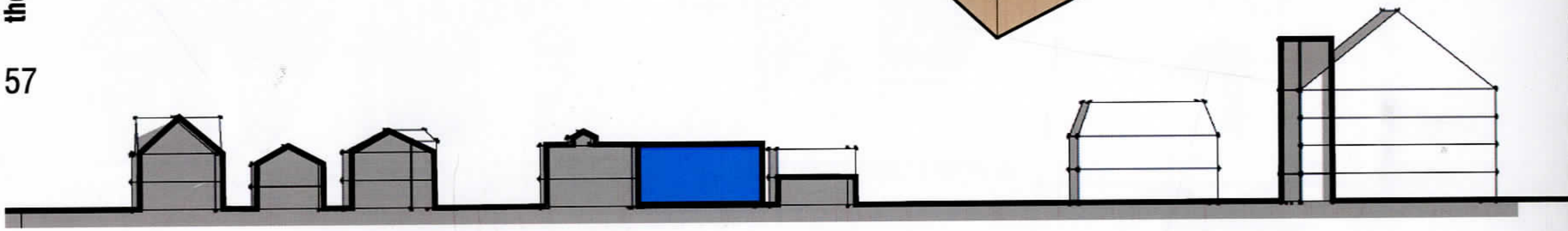


Through the use of the eco-tect weather tool, an ideal building orientation is calculated based on the average daily incident radiation present at the site. At this particular site, the calculated compromise angle is 178 degrees, just shy of a polar north-south orientation. In conclusion, the greatest amount of surface area of the dwelling itself should try to achieve this compromise angle in order to benefit fully from passive design strategies.

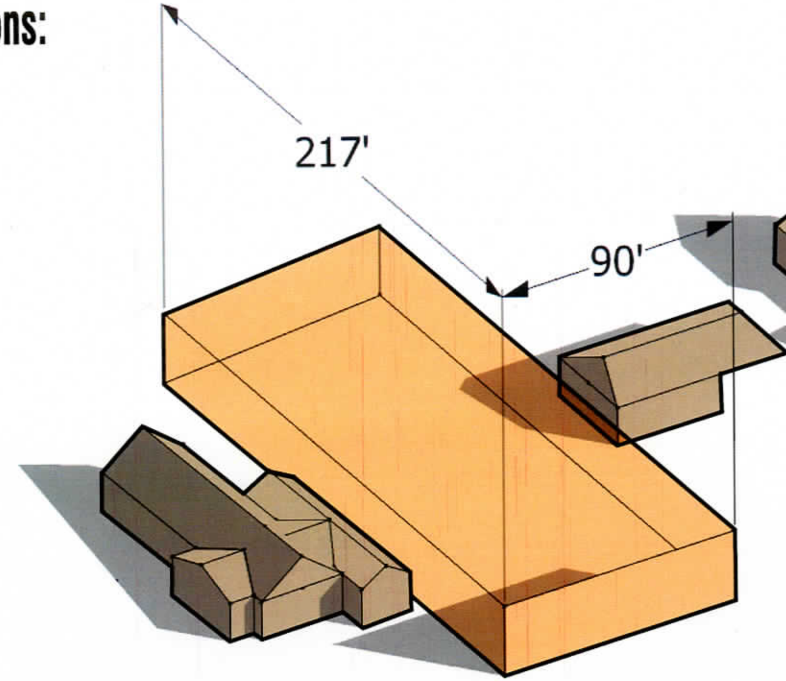
volumetric studies of local site limitations:

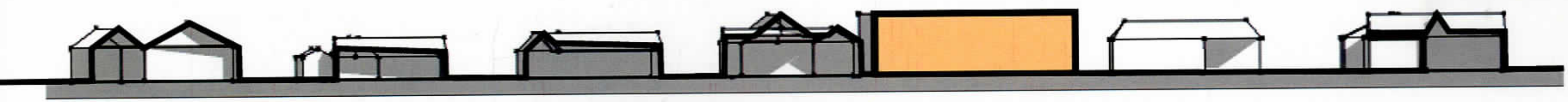
Volumetric studies of the site's limitations are tested in order to fully understand the site variables present, something that will greatly impact the negotiation of design parameters such as ideal building orientation and program arrangement on the site.





volumetric studies of local site limitations:

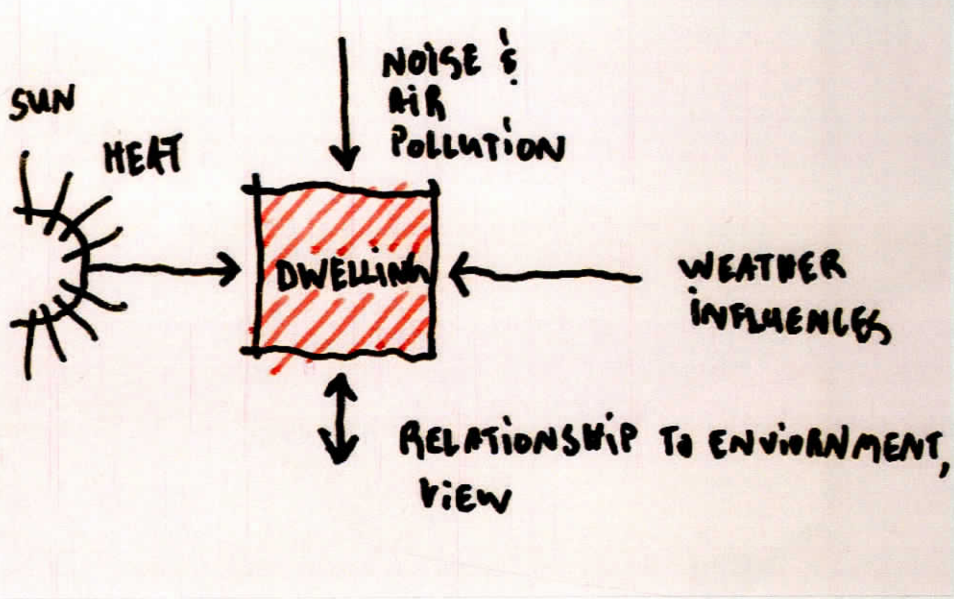


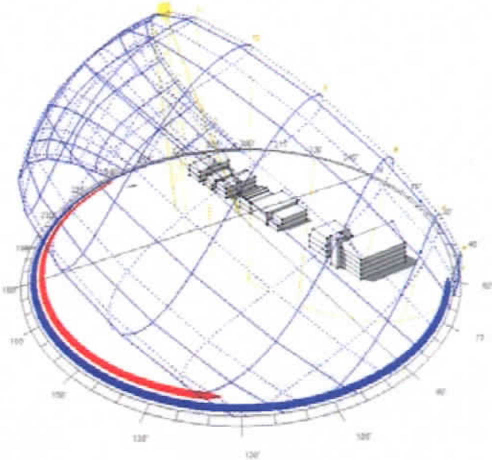
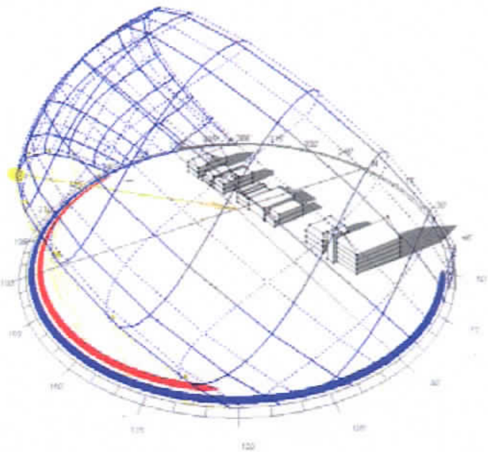
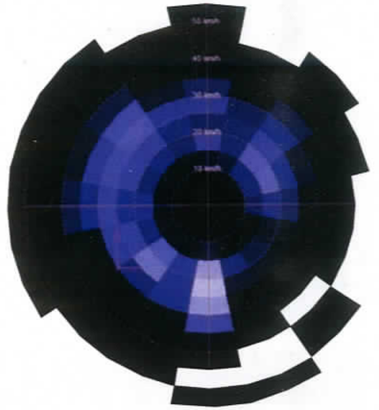
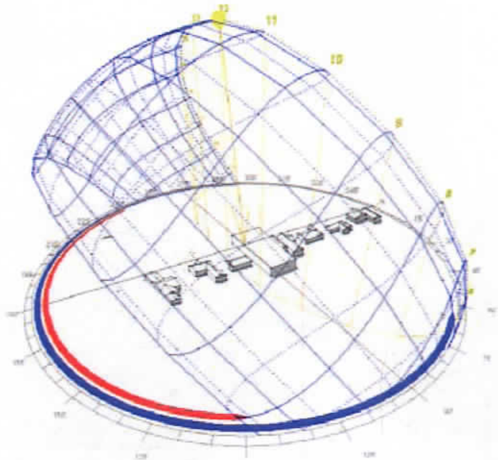
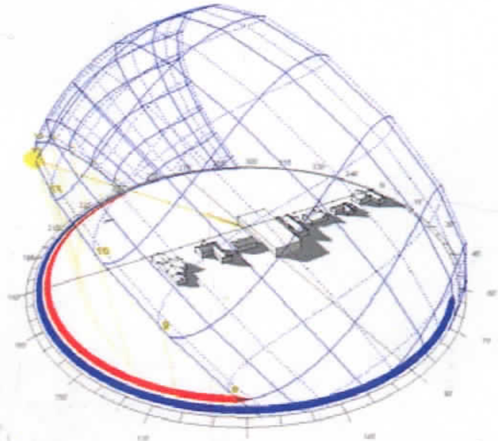
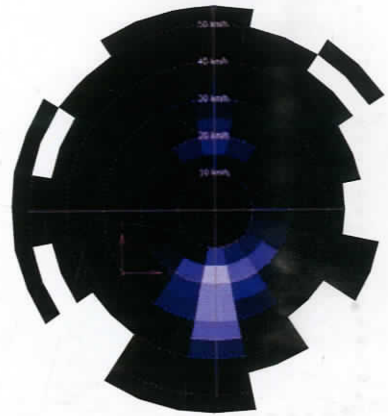


overview:

There are a number of factors which satisfy the overall performative functions of a dwelling. Simply stated, a carefully designed house should best utilize orientation based on an environmental analysis of both light and wind, and the impact the dwelling will have on the micro-climate of the site itself. Current environmental analysis softwares allow for a comprehensive, digital analysis of both the impact a building will have on its environment as well as the impact the environment should have on the building. The four basic dwelling arrangements documented above will be analyzed through the lens of passive design in regards to light, heat and wind eventually leading to selected house arrangements which can best utilize performative techniques through passive design as well as properly oriented building volumes. After optimal arrangements are analyzed, site restrictions and constraints must be applied in order to promote sustainable, site-responsive design.

how do we conceive of today's *responsible* dwelling?



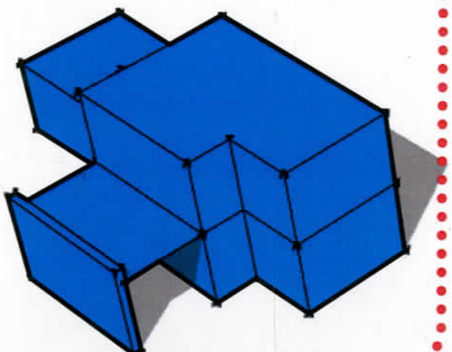
	june, 12pm	december, 12pm	prevailing winds
syracuse			
dallas			

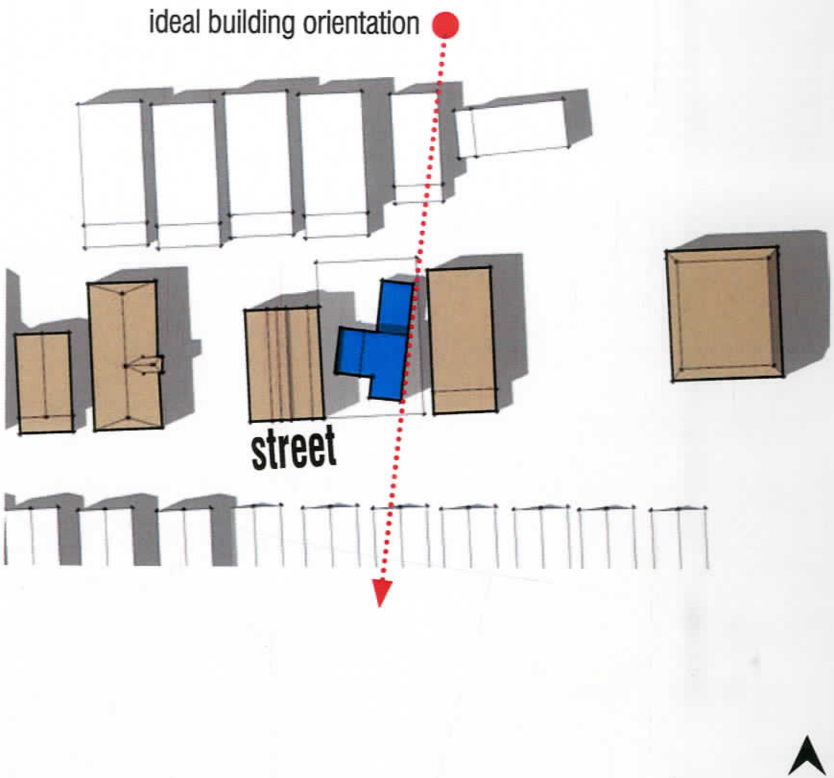
what have we learned: syracuse?

_reasonably low income
_average of 2.3 people per household
_house prices are low
_site restraints are 'tight'
_houses are not set back and have prominent street presence

bar_b: possible syracuse 'module'

- 1370 square feet
- 2 bedroom
- 1 bath
- Kitchen/living/dining
- Upper deck
- Living 2/office



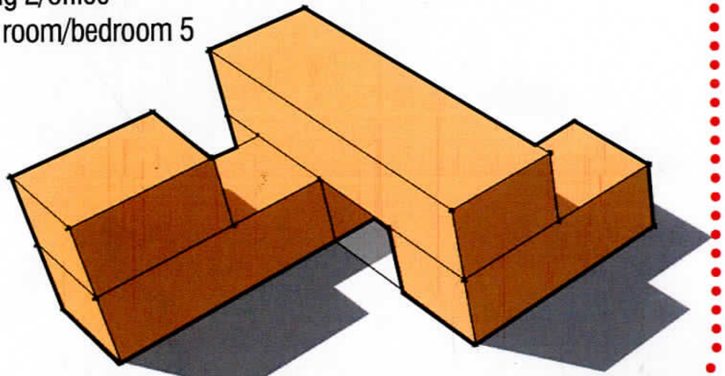


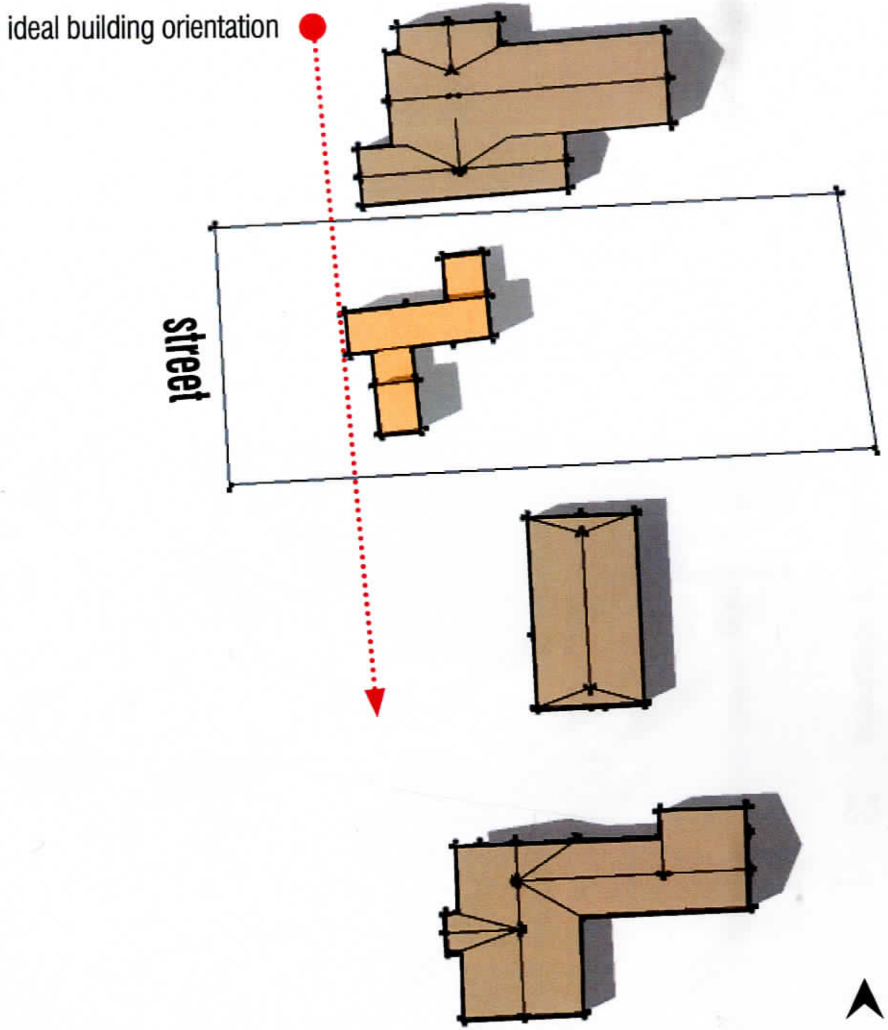
what have we learned: dallas?

_higher income
_average of 3 people per household
_house prices are high
_large, flat suburban site
_houses are set back off street

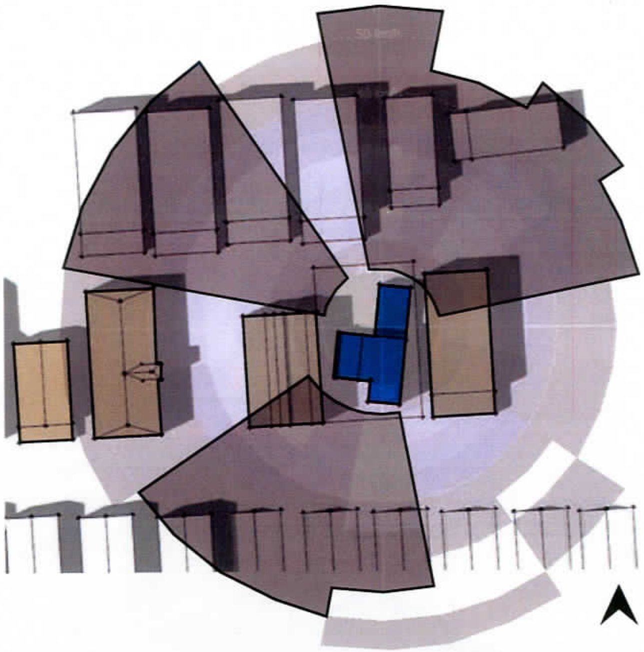
Z: possible dallas 'module'

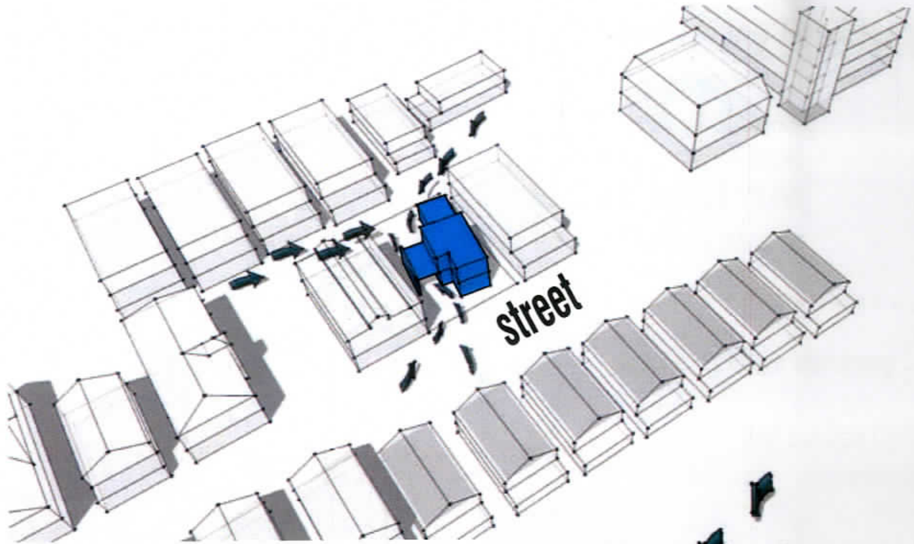
- 2050 square feet
- 4 bedroom
- 3 bath
- 2 upper decks
- Kitchen/living/dining
- Living 2/office
- Day room/bedroom 5

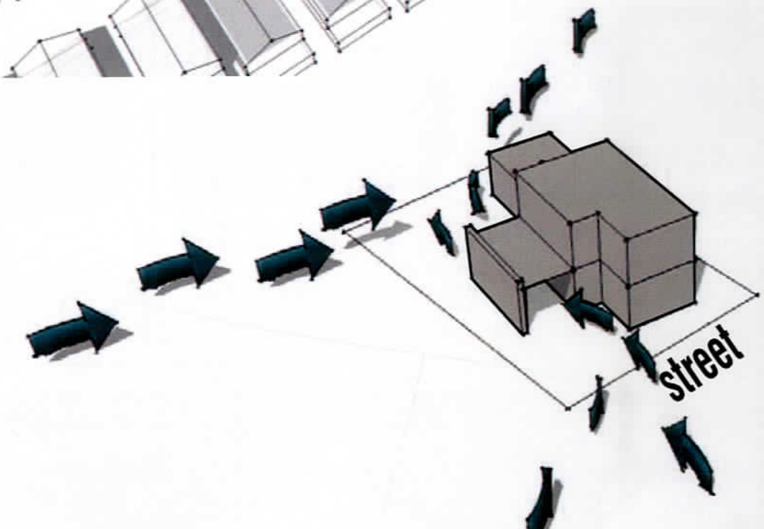




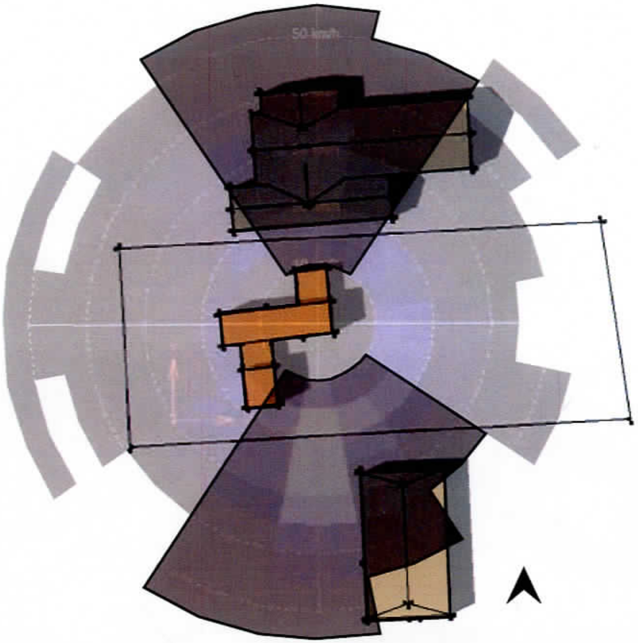
prevailing winds:syracuse

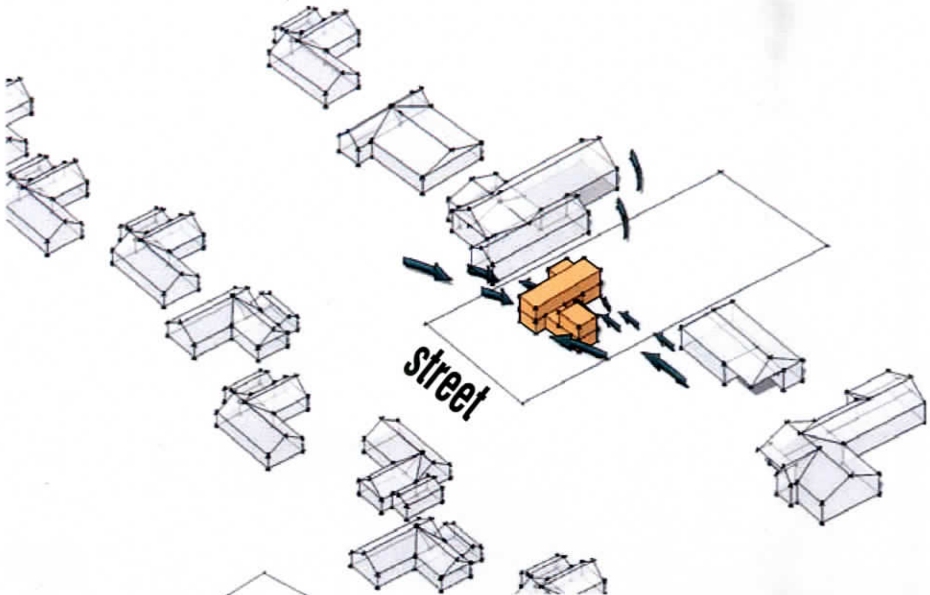


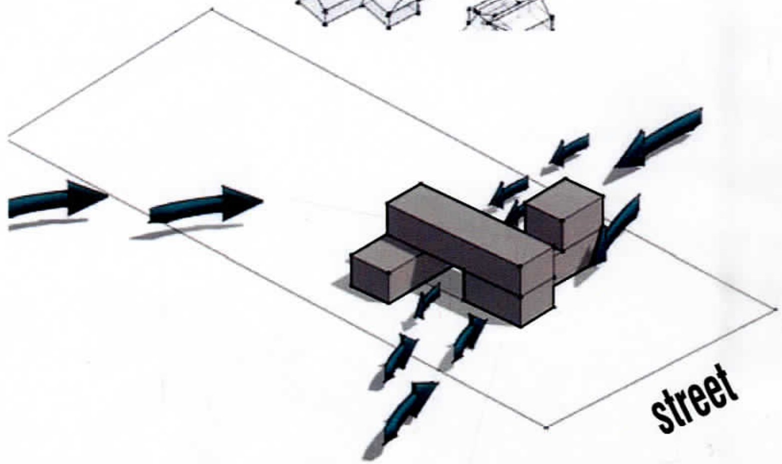




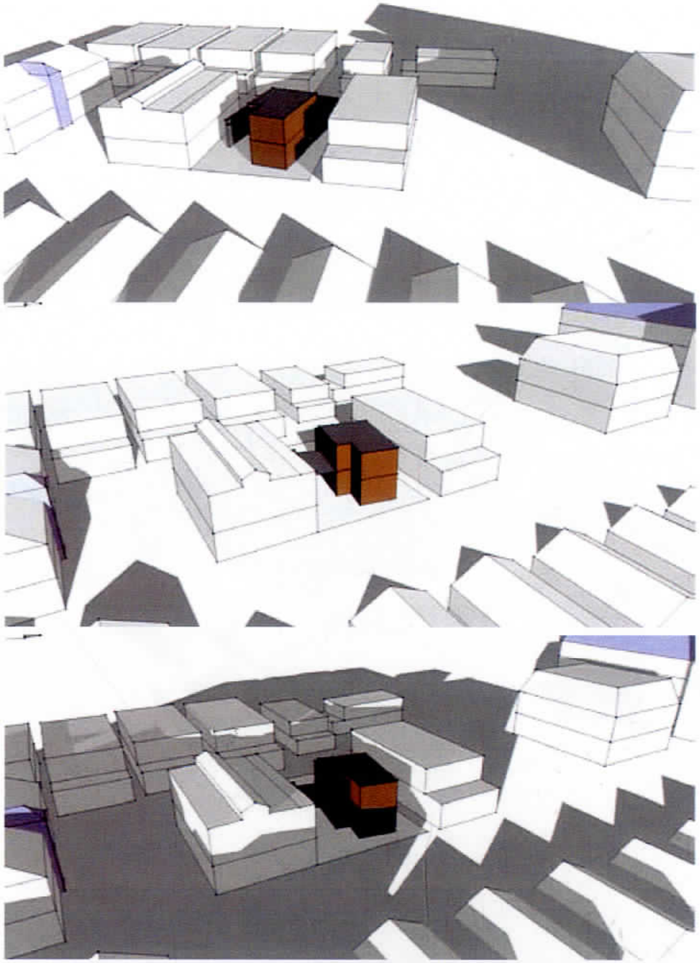
prevailing winds:dallas



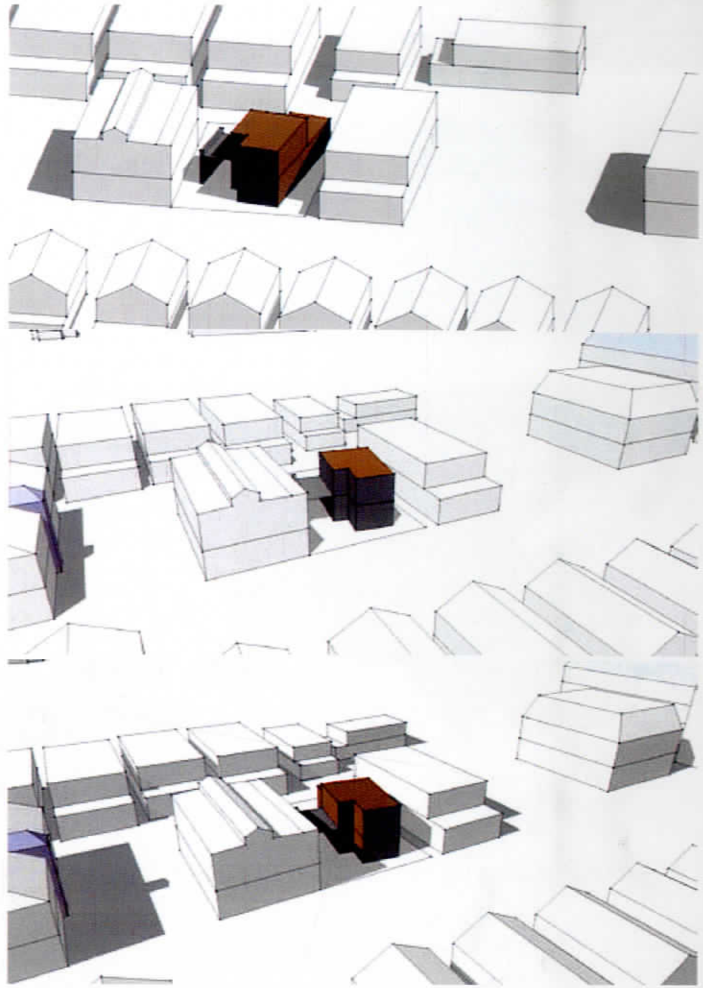




light analysis:syracuse_december



light analysis:syracuse_june



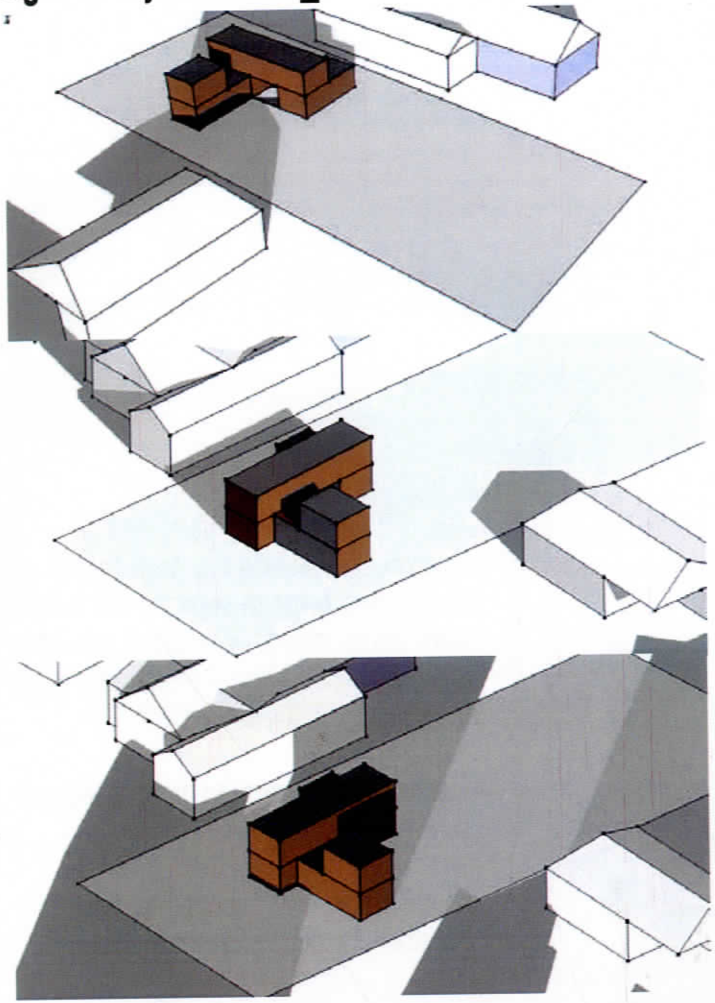
9 am

1 pm

4 pm

light analysis:dallas_december

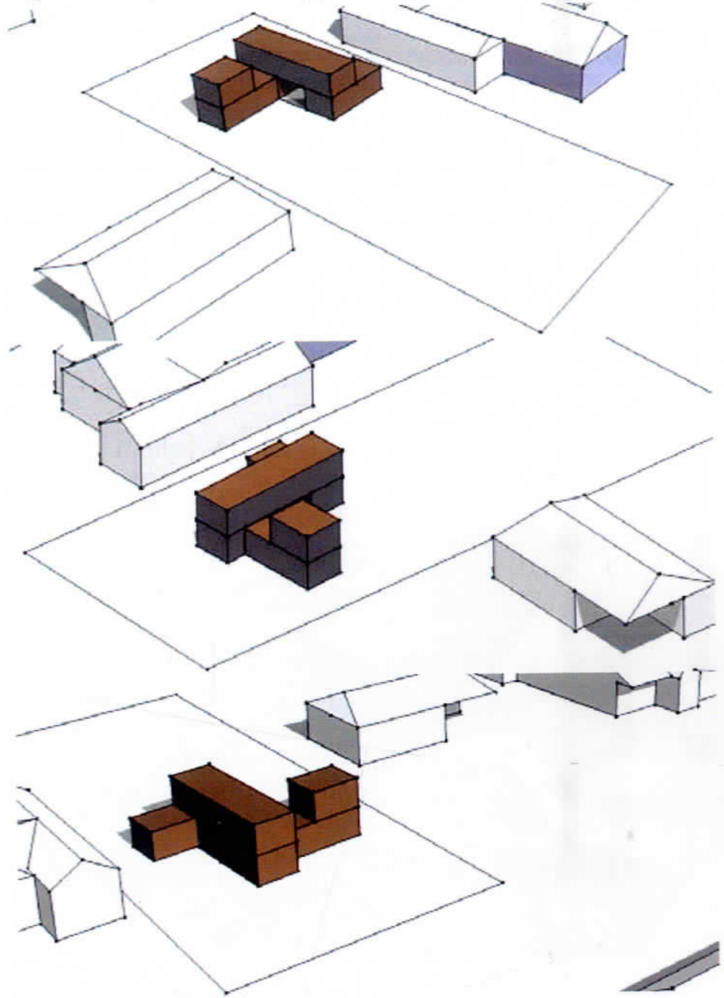
light analysis:dallas_june



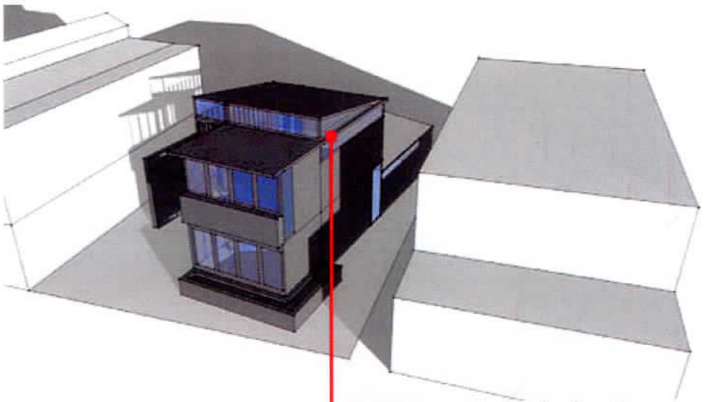
9 am

1 pm

4 pm

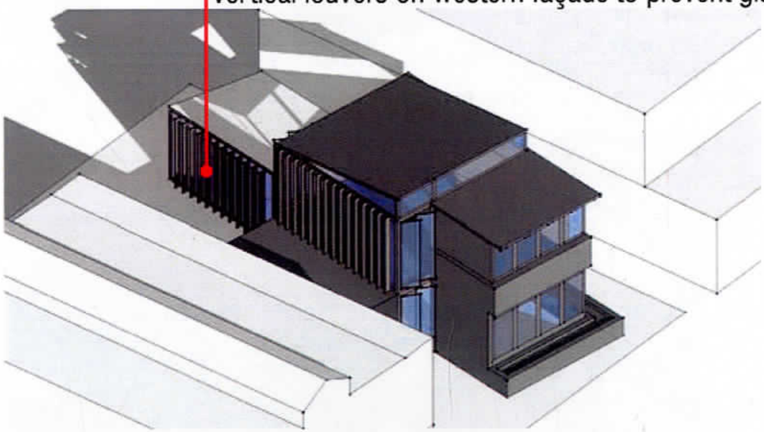


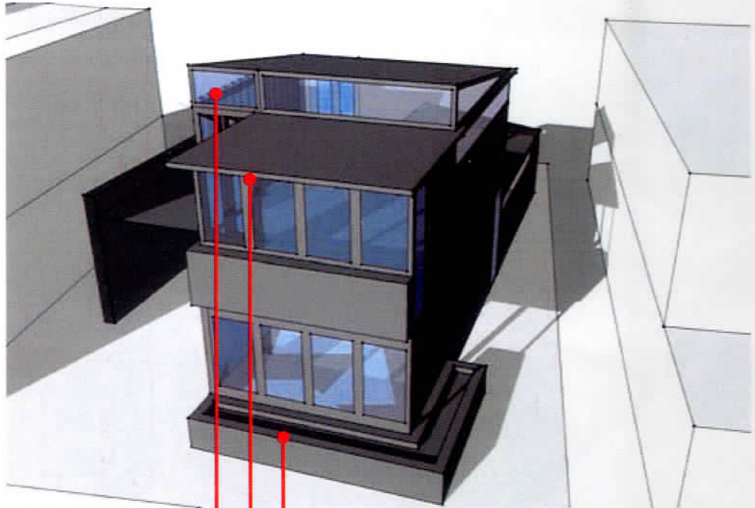
passive design strategies: a summary of site restraints/environmental analysis_syracuse



narrow eastern glazing to prevent glare

vertical louvers on western façade to prevent glare



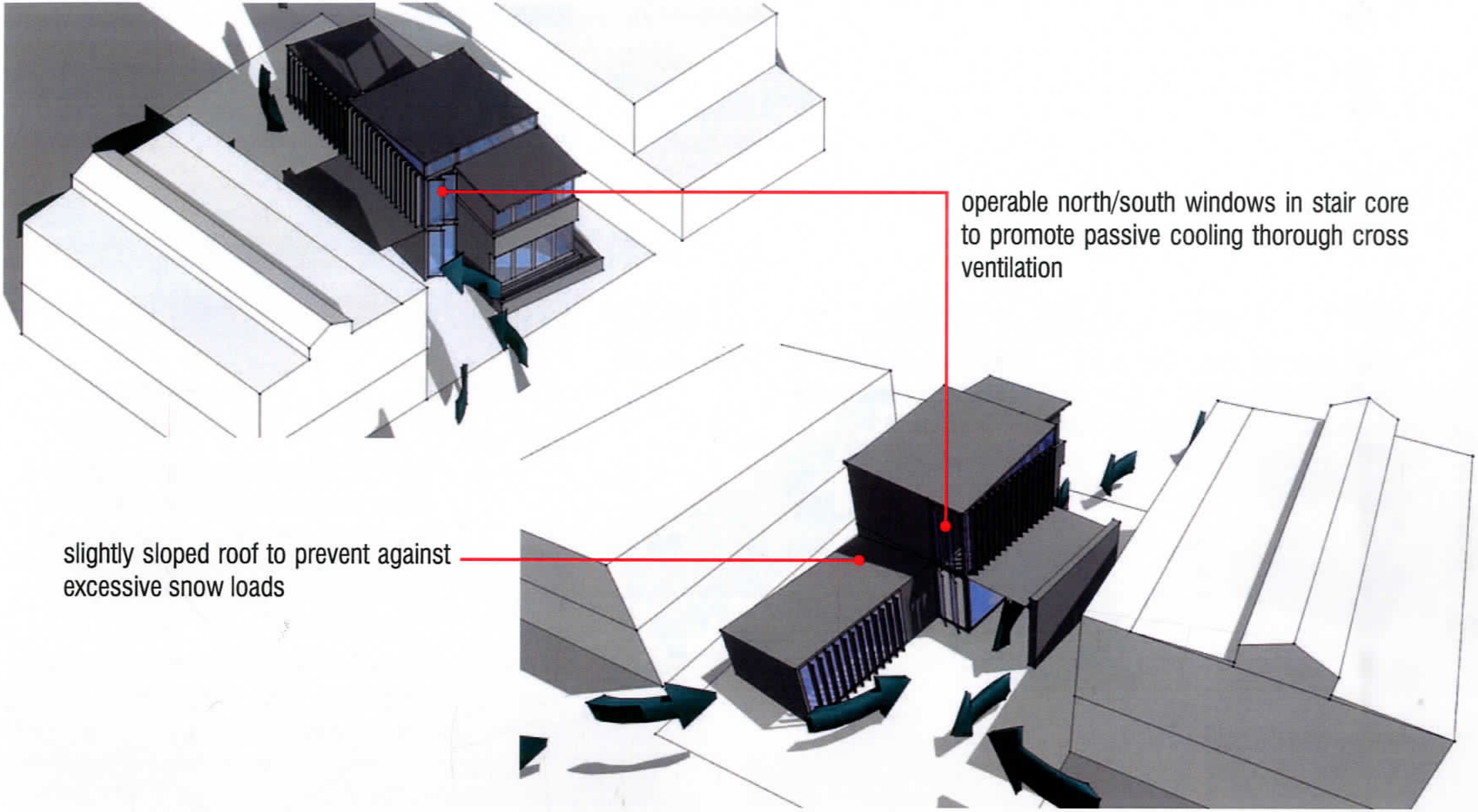


an extrusion around the front façade of the building helps to separate the façade from street activity, promoting views to the exterior but protecting the house from the street through partition

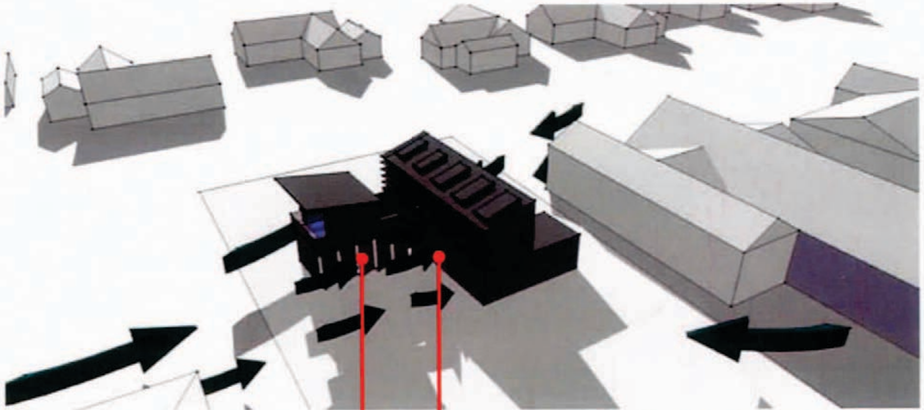
southern overhangs to protect against summer overheating

southern oriented 'scoop' to help sun penetrate the depths of the dwelling

passive design strategies: a summary of site restraints/environmental analysis_syracuse

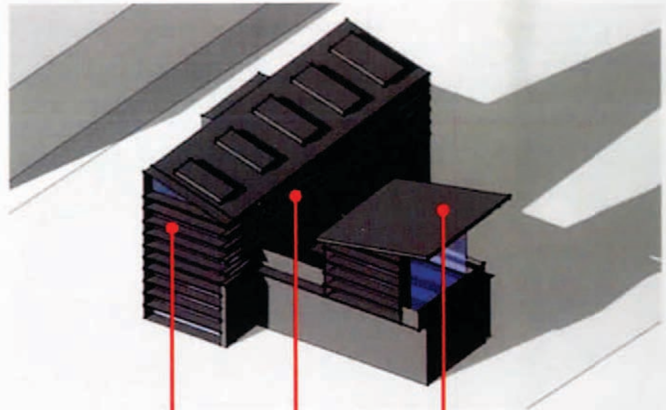


passive design strategies: a summary of site restraints/environmental analysis_dallas



angled windows allow prevailing winds to enter dwelling

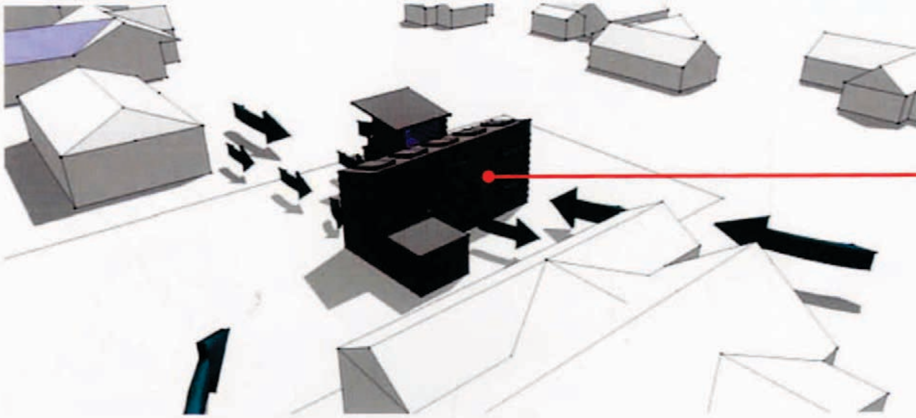
center opening in dwelling to allow prevailing winds to pull through site



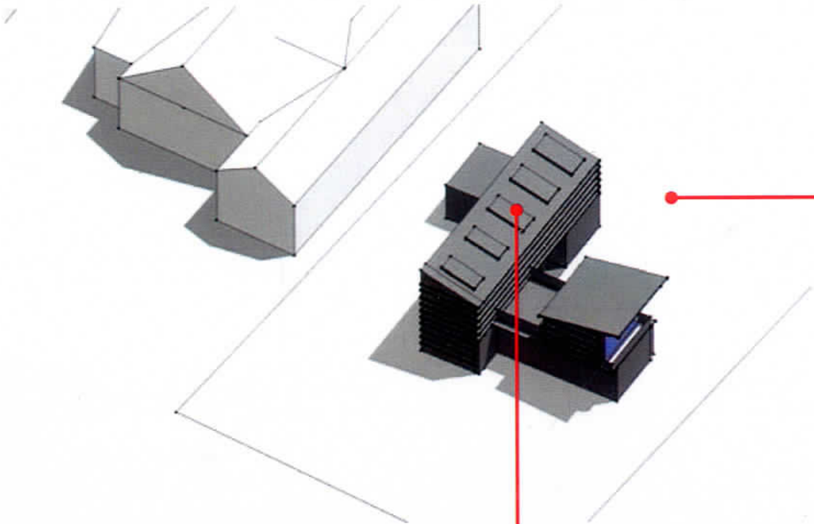
deep eaves to protect against southern sun

recessed south & west façade to protect from overheating

horizontal louvers across south & west façades eliminate glare/overheating, but allows views to street



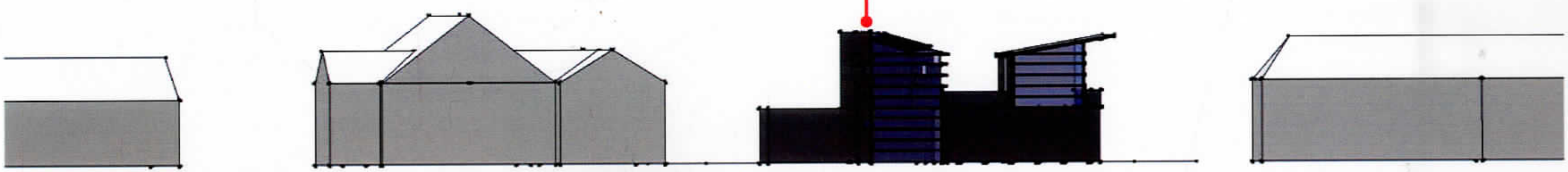
punched, operable windows on the north façade allow for natural cross ventilation to occur in the dwelling.. properly managed openings can help reduce summer cooling loads due to occupant comfort brought on by naturally circulating winds throughout the house



the general massing or formal quality of the building presents itself to the street, however also alludes to the rear of the dwelling, allowing a backyard to become an extremely important aspect to the house design. large plots of land in this suburban neighborhood allow houses to be set back from the street, but still have functional 'green' space in the rear

sloping roof lines help to integrate the dwelling into the context of the neighborhood. Pre-fabricated housing often has the stereotype of yielding buildings that are not properly responsive to the local aesthetic of the neighborhood

the roof's constant exposure to southern sun allows for the integration of photovoltaic panels placed on the roof sloping towards the south for maximum efficiency



conceptualizing the transformation from the 'static' module: adaptive component systems

At Cornell University multiple seminars were conducted to better understand varying component systems and their implication into the architectural discipline. The **Component System II** seminar specifically "examines parameters for variability through the integration of contemporary industrial processes incorporated directly into design methodology, merging the capabilities of parametric design tools with digitally controlled fabrication" (Epi-Phyte LAB). The course introduction notes that "the failure of prefabrication lies primarily in its resistance to an adaptive response to various geographical, topological and climactic variables inherent in the specificity of site" (Epi-Phyte LAB), thus the integration of digital fabrication into the existing pre-fabricated housing typology has the potential to produce a new, generative design process. This process is capable of intertwining a variety of variables, eventually leading to the creation of a new typology, one which unites site, environment, and manufacturing constraints to produce adaptive or varied building components. It is within these varied components which allows a digitally-[pre]fabricated housing typology to co-exist with the technologies of today, while simultaneously offering the potential to change the quality of the built environment at the housing scale.

The question remains, how does one incorporate the information gathered from analyzing local site constraints and climactic variables to create responsive component systems which make the digitally-[pre] fabricated housing typology so inherently different from that of pre-fabricated dwellings?

analysis, design process and adaptive components

site analysis:
_volumetric building restrictions
_optimum building orientation
_local statistics/data [household income, house value, ect.]
_general aesthetic of neighborhood

+

climatic variables:
_wind analysis
_light analysis
_passive design techniques

+

manufacturing processes:
_two-dimensional fabrication
_subtractive/additive fabrication
_formative fabrication/vacuum forming
_efficiencies associated w/ each process

=

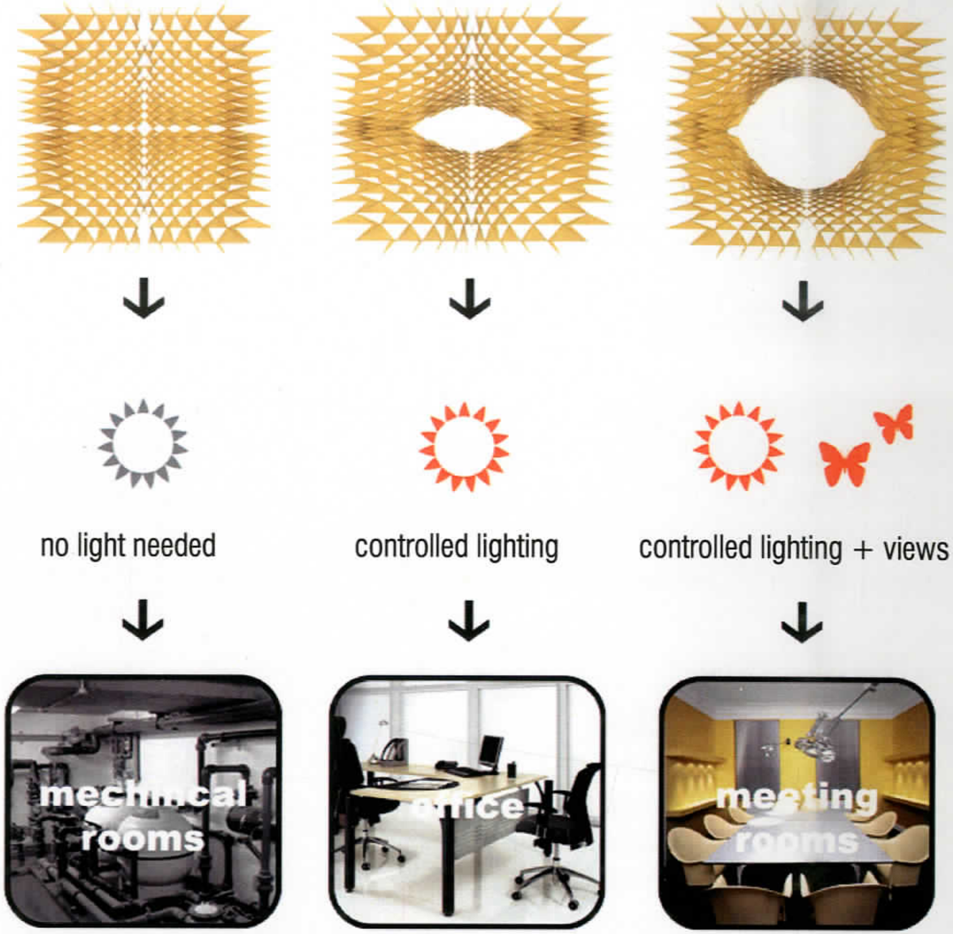
adaptive building components:
_inherently becomes the byproduct of site, climate, and constructability
_what functions do these adaptive components hold?
_what limitations do we put on their design?
_how do they interact with program?

solar scoop:

This variable façade system works to control the amount of light which enters a space, consequently mediated heating loads of interior environments as well as directing and controlling views. Most importantly, the design of the adaptive component relates closely to the programmatic requirements of the space, thus it becomes a synthesis of building function as well as site/environmental response.

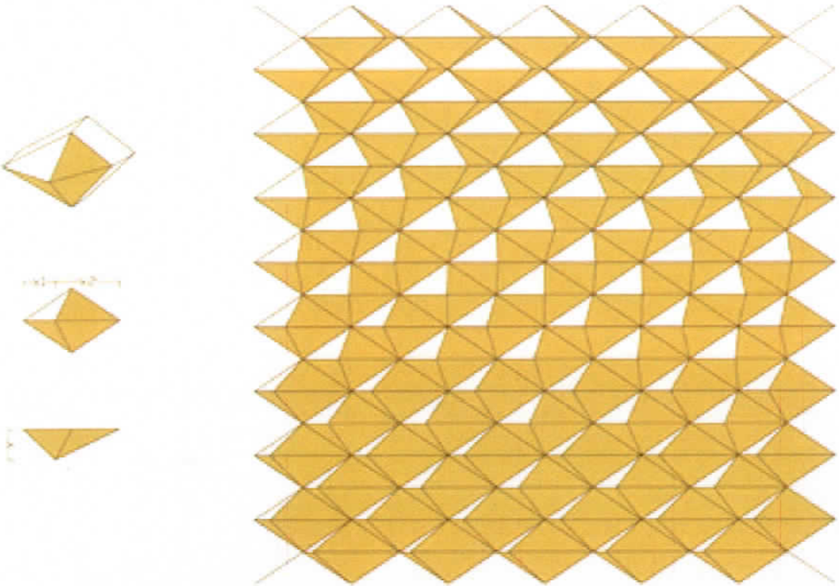
In this adaptive façade strategy, light is controlled by two distinct variables, the opening of the aperture, and the depth and direction of the apertures themselves.

The process for the design of this component system becomes a constant synthesis of digital design and testing in conjunction with the physical fabrication of the overall system itself.



above images:http://blogs.cornell.edu/adaptivesystems/files/2009/08/010-SOLARSCOOP_FACADE-12.jpg

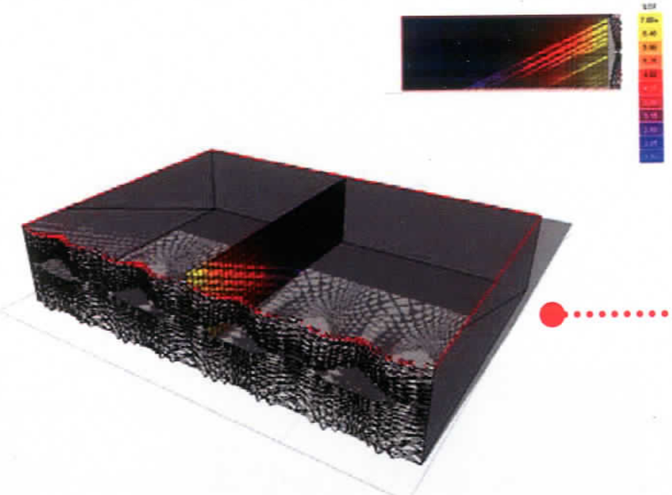
original component/ component gradient based upon indoor needs

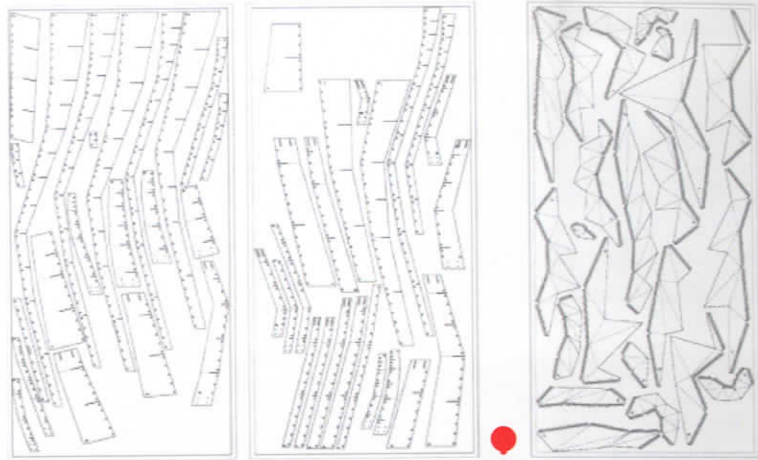


above images:http://blogs.cornell.edu/adaptivesystems/files/2009/08/010-SOLARSCOOP_FACADE-12.jpg

The creation of an adaptive component, and consequently a system which supports this component, is digitally altered based on programmatic functions in regards to the amount of light, view, and thermal control necessary. As depicted, the system is able to operate at various scales in order to alleviate the parameters of both our interior and exterior environments. Above, direct sunlight is blocked, yet indirect light is bounced into the depth of the room providing light for the whole space.

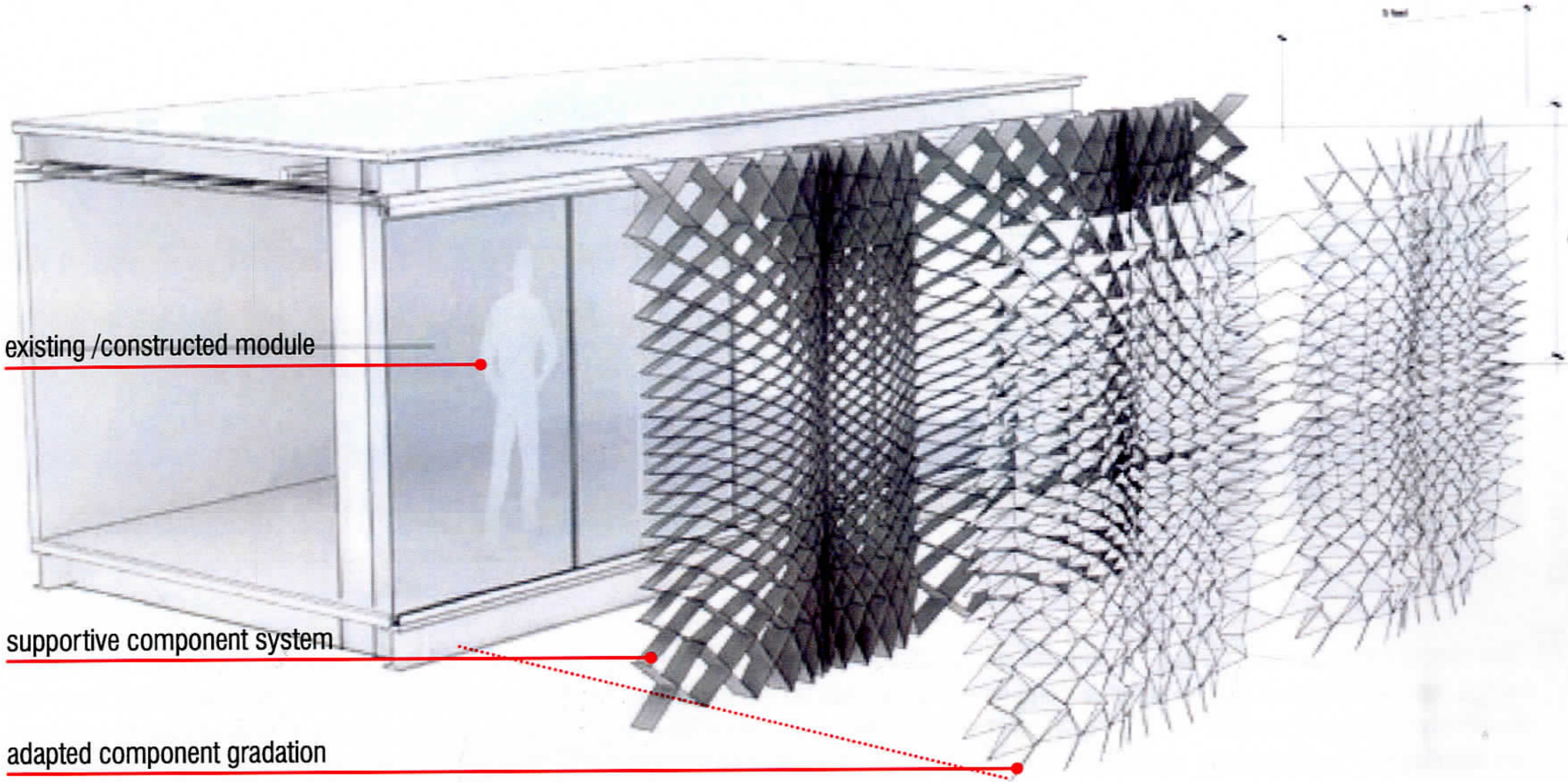
synthesis of digital testing and digital fabrication:





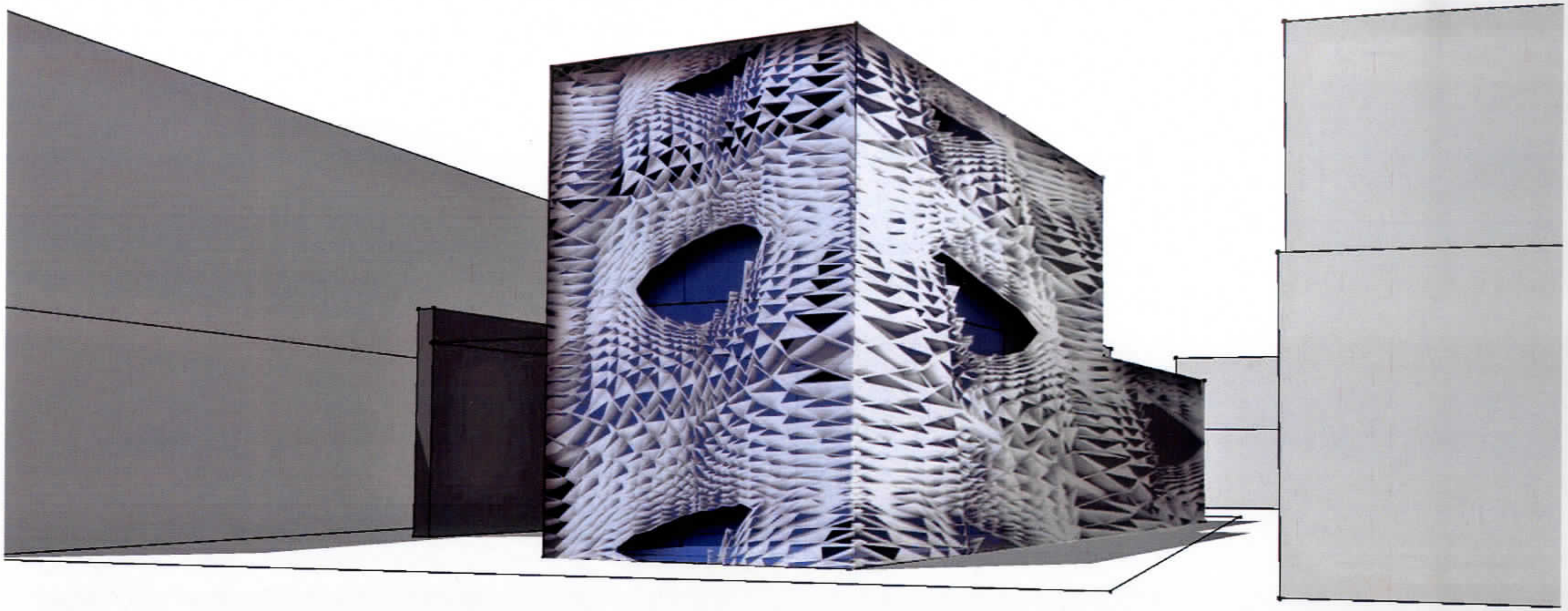
above images:http://blogs.cornell.edu/adaptivesystems/files/2009/08/010-SOLARSCOOP_FACADE-12.jpg

exploded system components:



above images:http://blogs.cornell.edu/adaptivesystems/files/2009/08/010-SOLARSCOOP_FACADE-12.jpg

adaptive component conclusions:



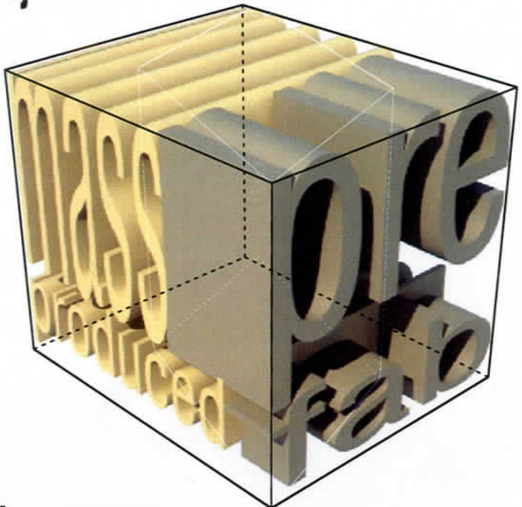
EPI-PHYTE LAB

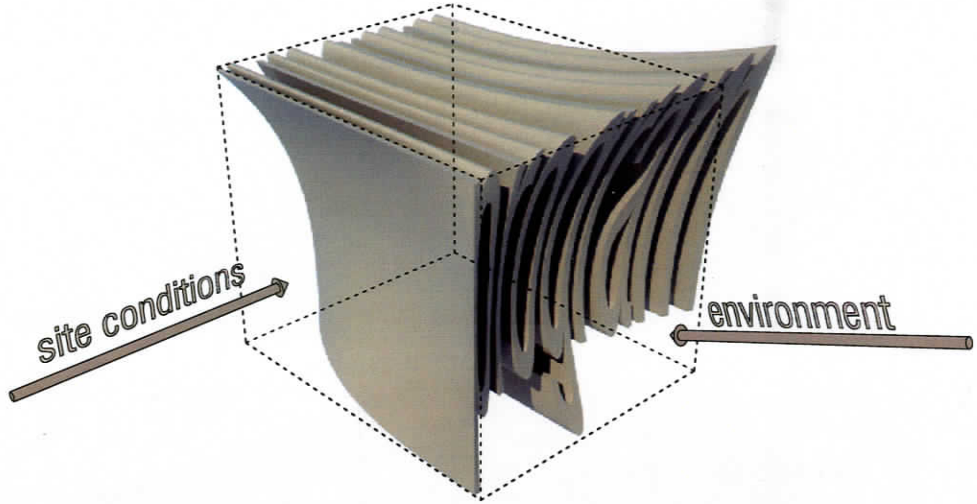
77 The integration of the solar scoop component wall system onto the 'static' module of the Syracuse dwelling becomes a provocative image which best depicts the ability an adaptive component system has on the transformation from a 'static' module to a dwelling which becomes responsive to its environment. As this component system intelligently becomes a response to climactic variables as well as internal program, an adaptive wall system which responds to light and wind can be conceived for both the Syracuse site as well as the Dallas site. Thus proving that digital fabrication as well as computer generated modeling holds the power to distinctly transform the way we live today.

part II:

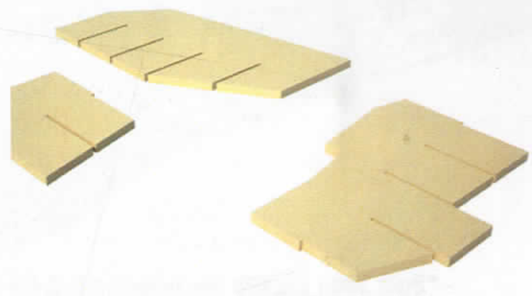
Today's mass produced prefabricated dwelling has been reduced to differentiation within modular arrangements, limited by the constraints of the prefab box. Digital design and manufacturing processes provide a new depth of control and variation in design instigating a seamless transition from digital information to the assembly of manufactured components. The flexibility and variety associated with digital fabrication processes holds the potential to transform or 'deform' the traditional prefab box yielding unique forms and spaces by negotiating program, site conditions, and environmental influences.

objectives:

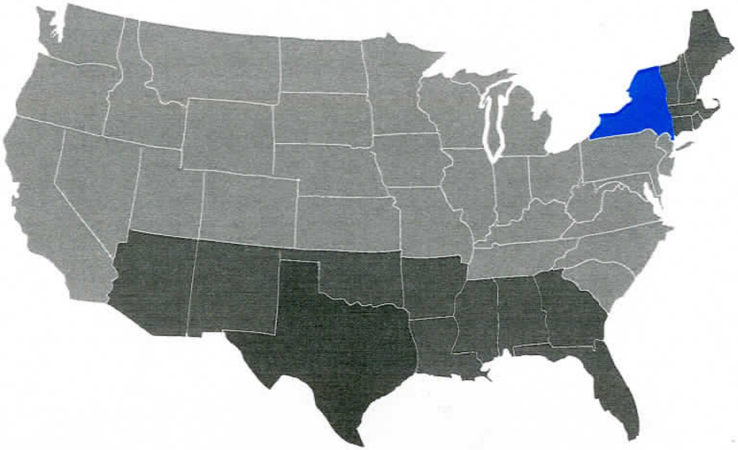




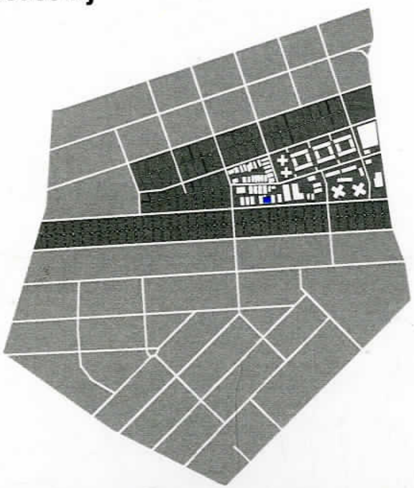
the process:

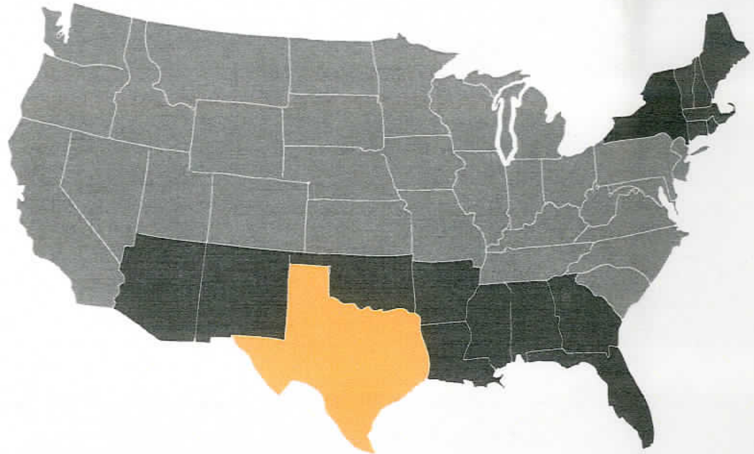


final site selection:

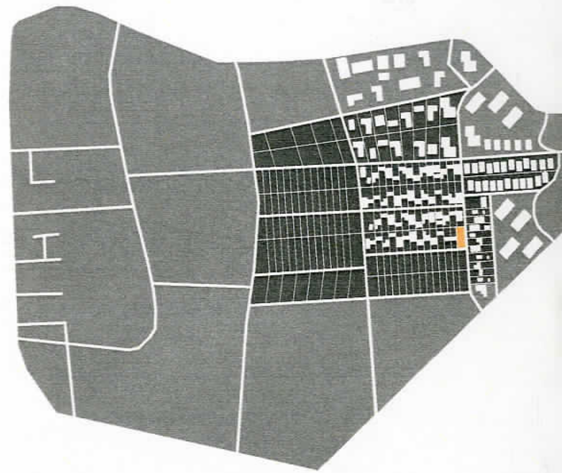


near westside, syracuse ny





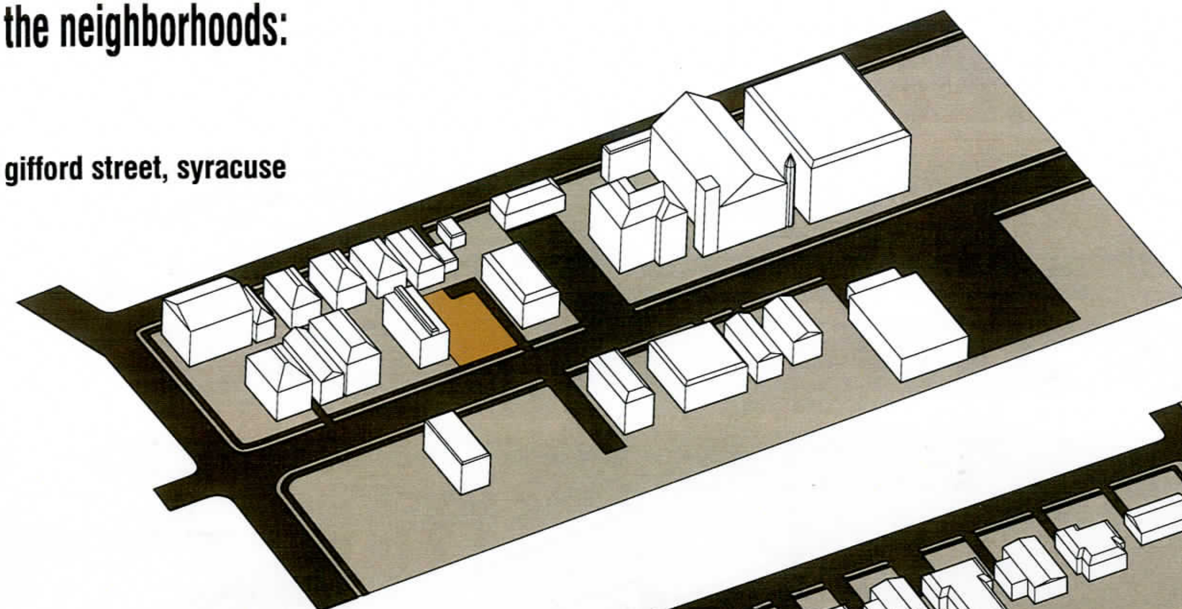
greenway park, north dallas



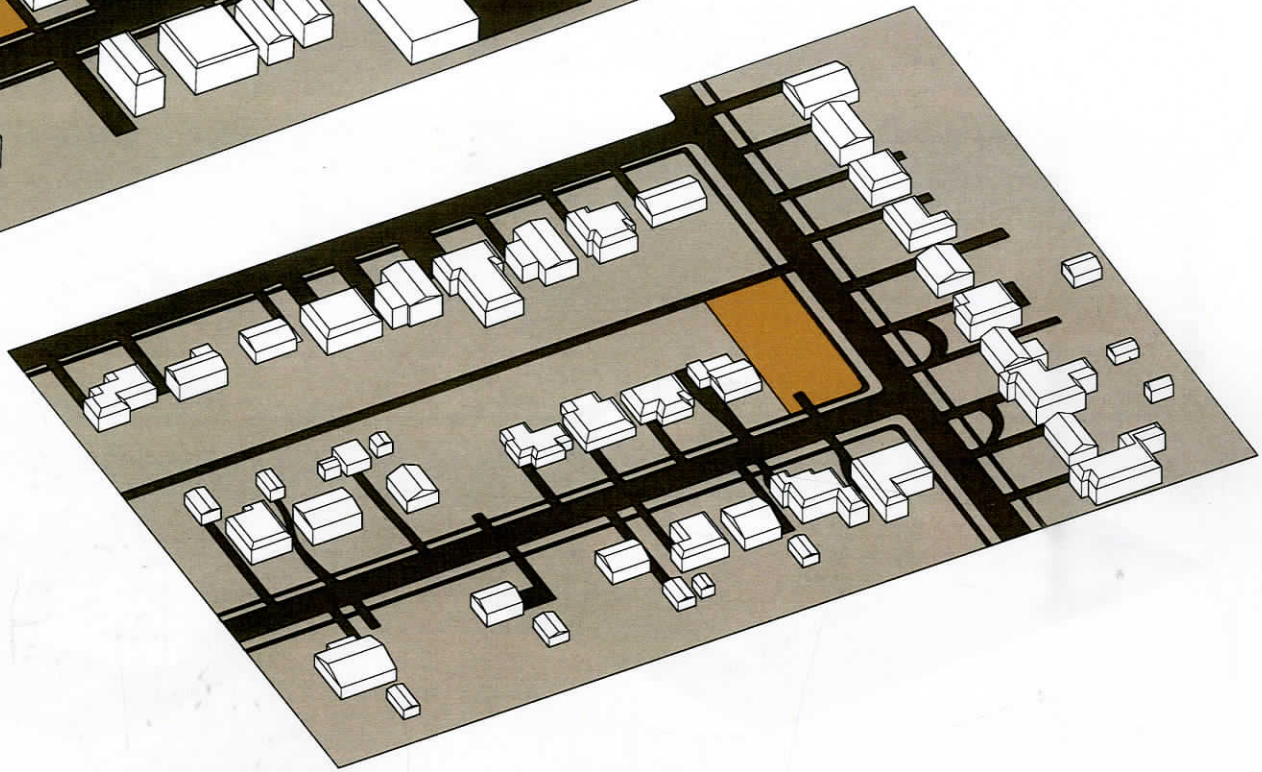
*Both sites chosen are oriented N/S for ideal building orientation

the neighborhoods:

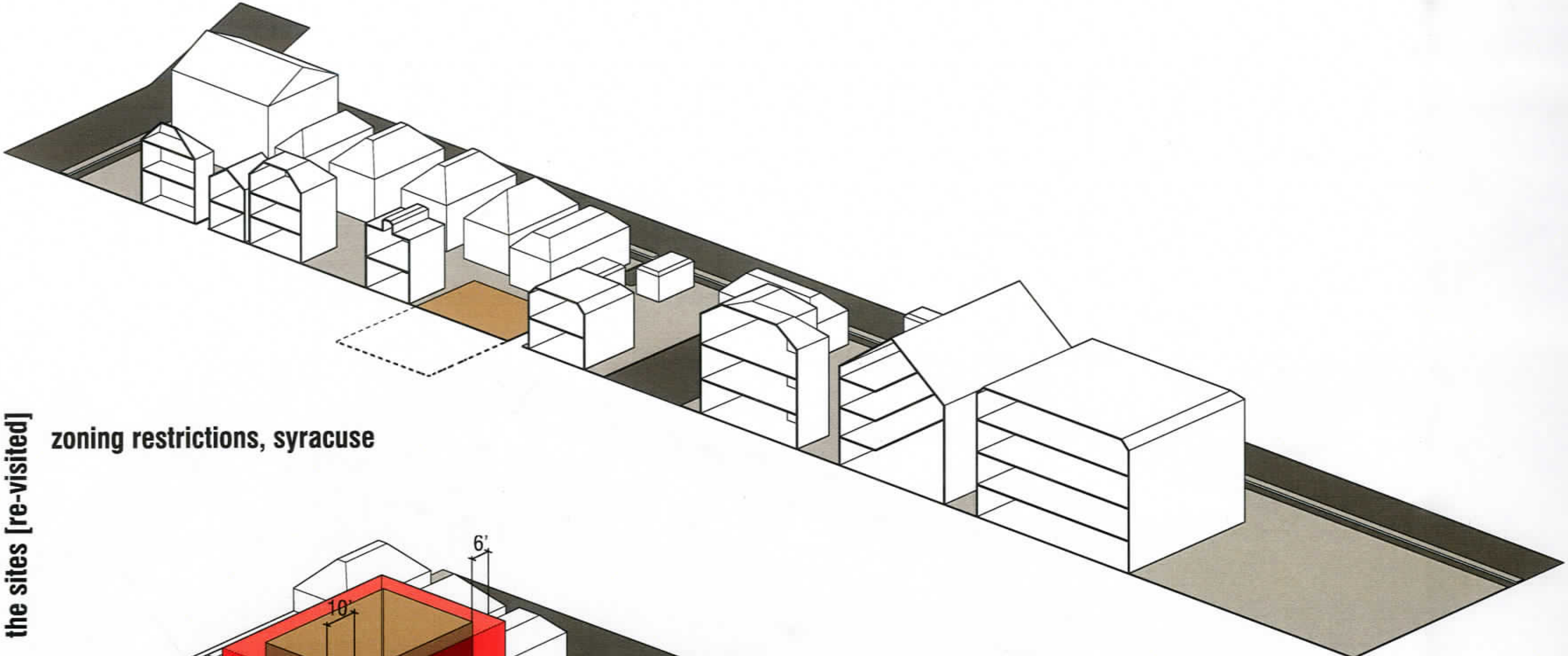
gifford street, syracuse



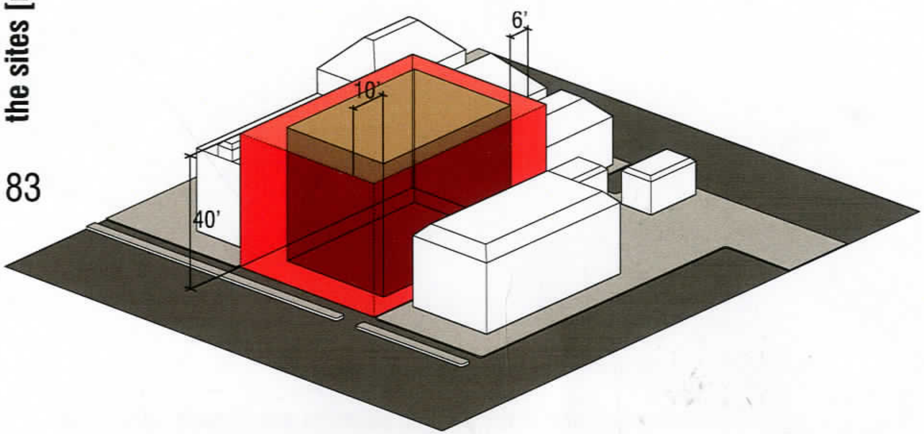
cowan ave, dallas



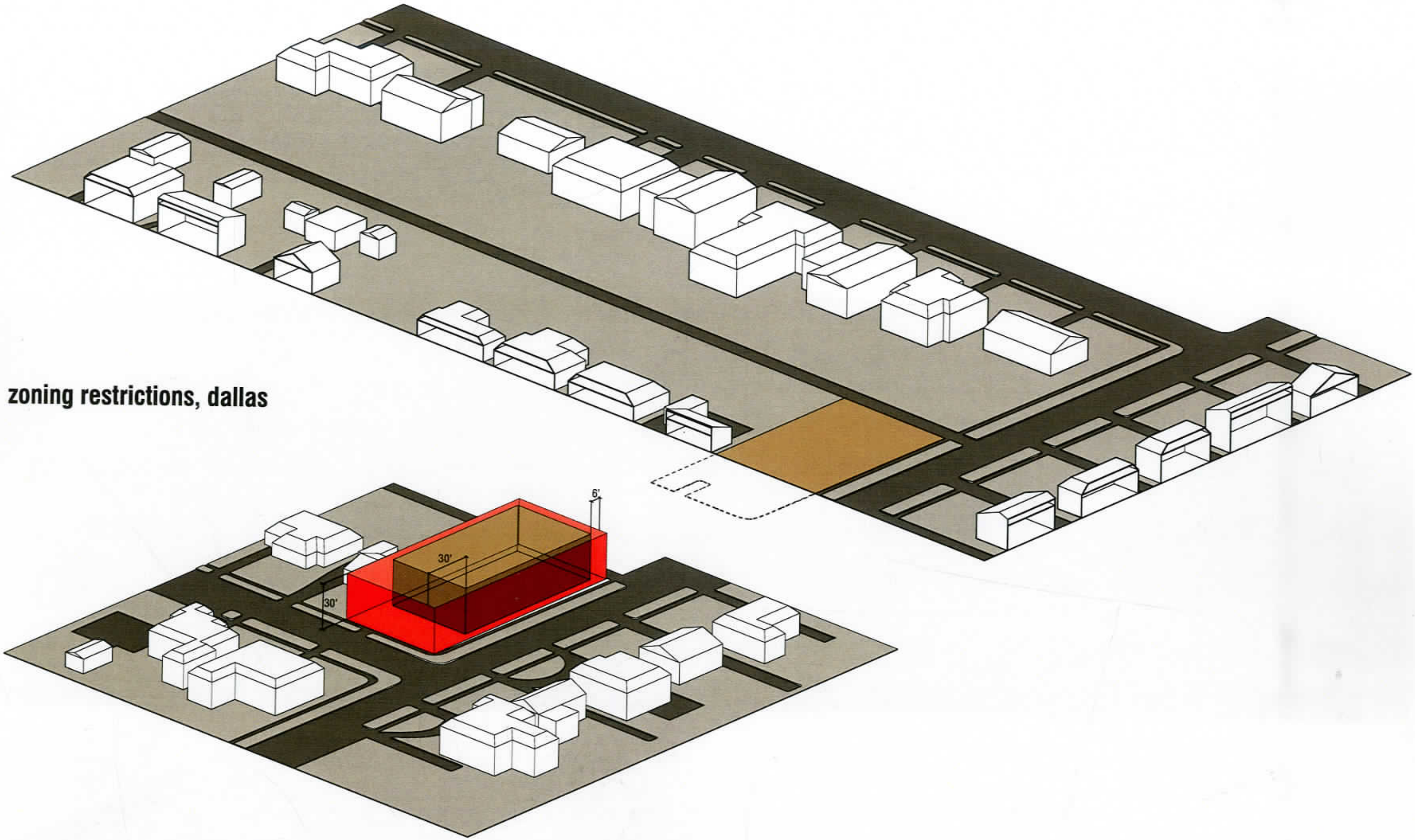
the neighborhoods:



zoning restrictions, syracuse



zoning restrictions, dallas



site documentation :

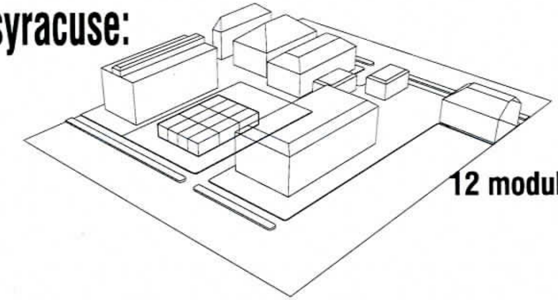
gifford steet, syracuse

site documentation :

cowan ave, dallas

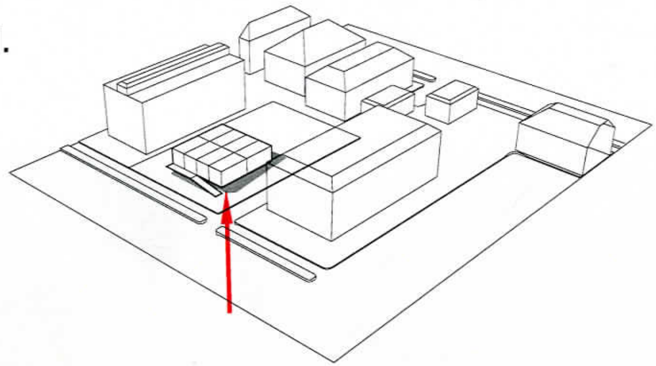

DON'T
DUMP
IN
DALLAS
Fine

deforming the prefab module, syracuse:



12 modules, 1,500 sq ft

1.



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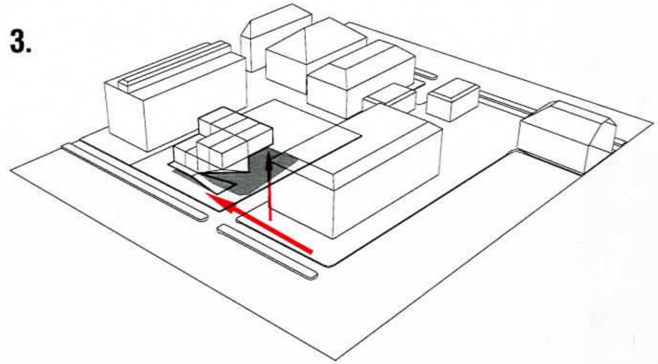

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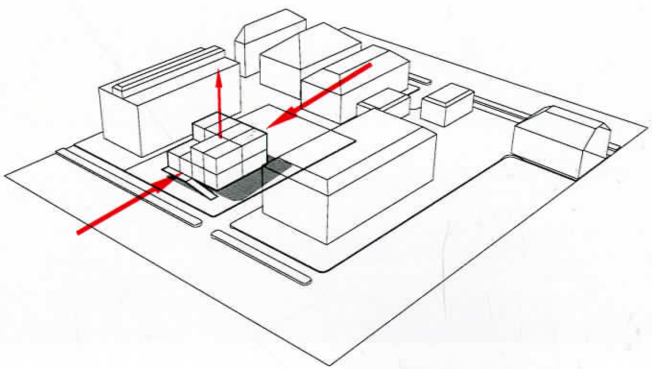

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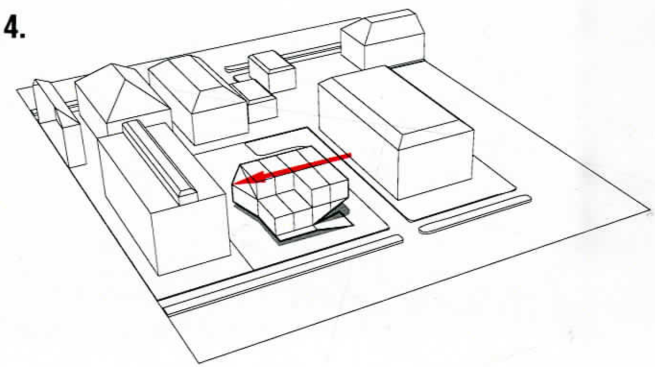
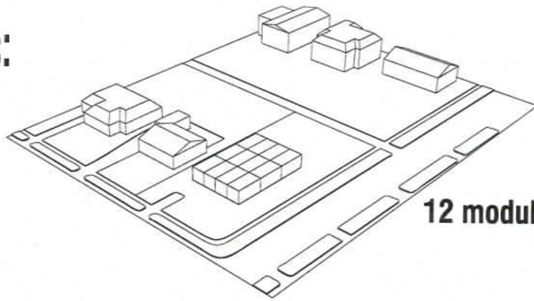


deforming the prefab module, dallas:



12 modules, 1,500 sq ft

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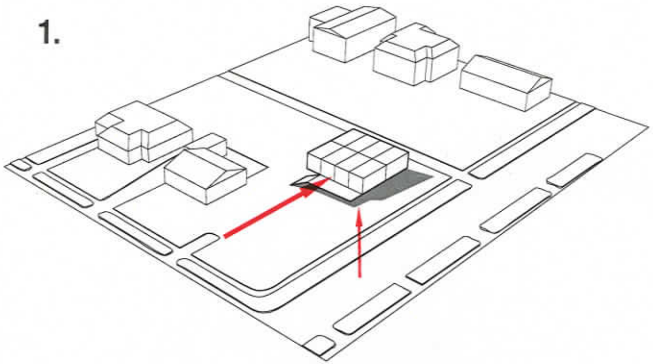

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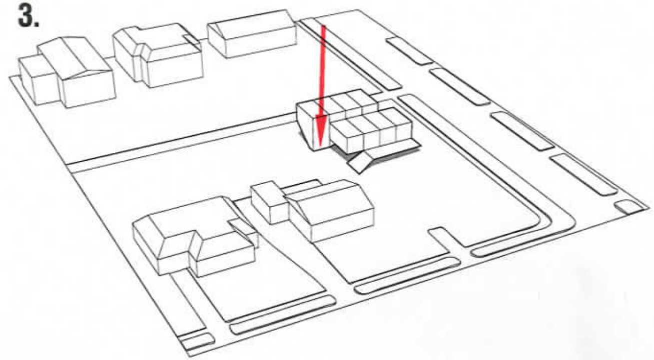

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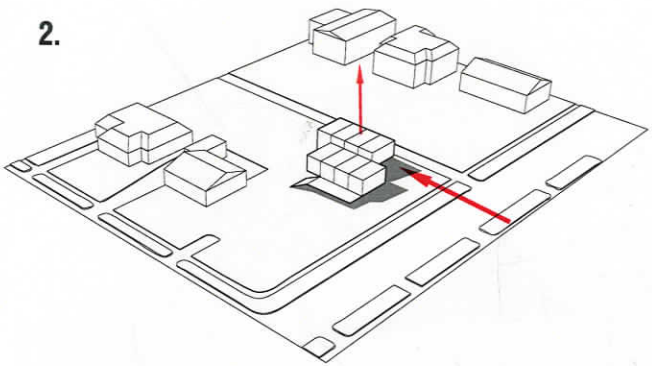

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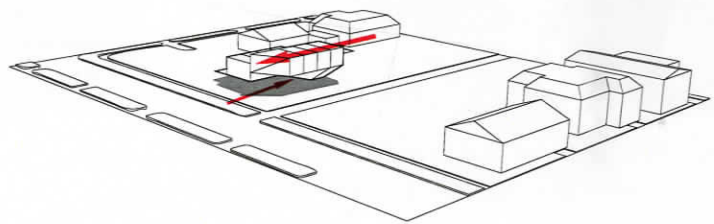
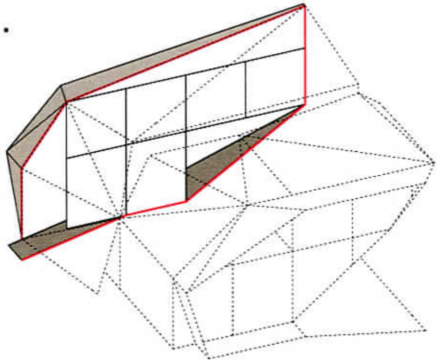


the scripts, syracuse:

***sectional manipulation of form to dictate how the building responds environmentally**

1.



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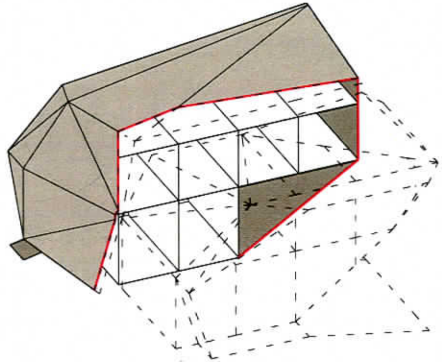

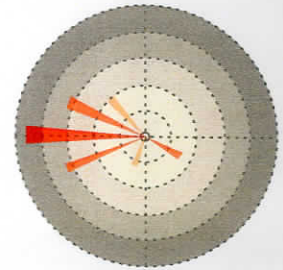

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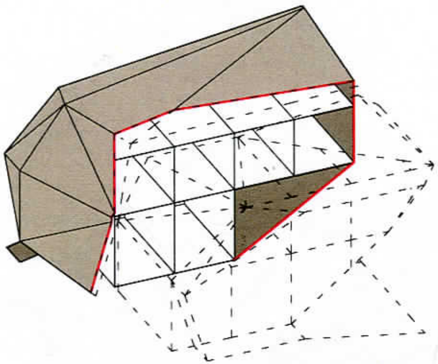

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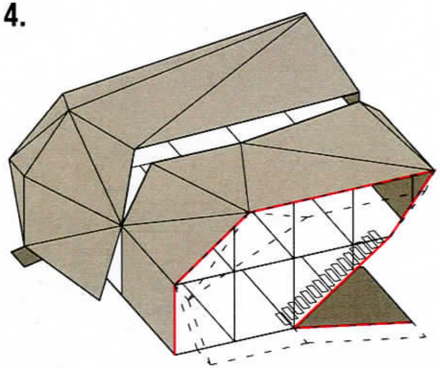
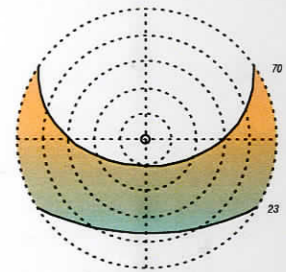
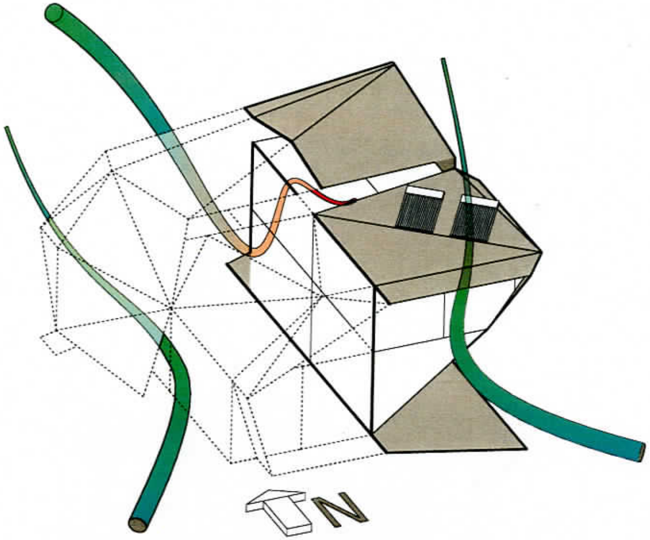
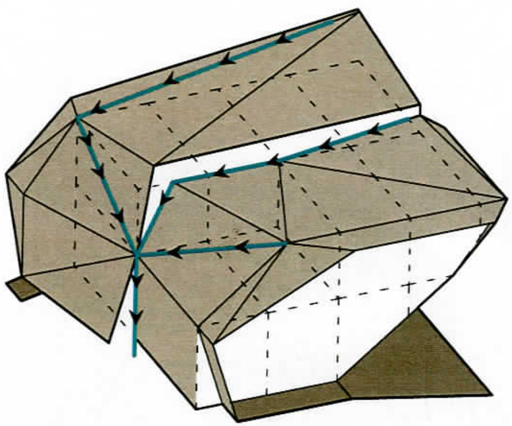
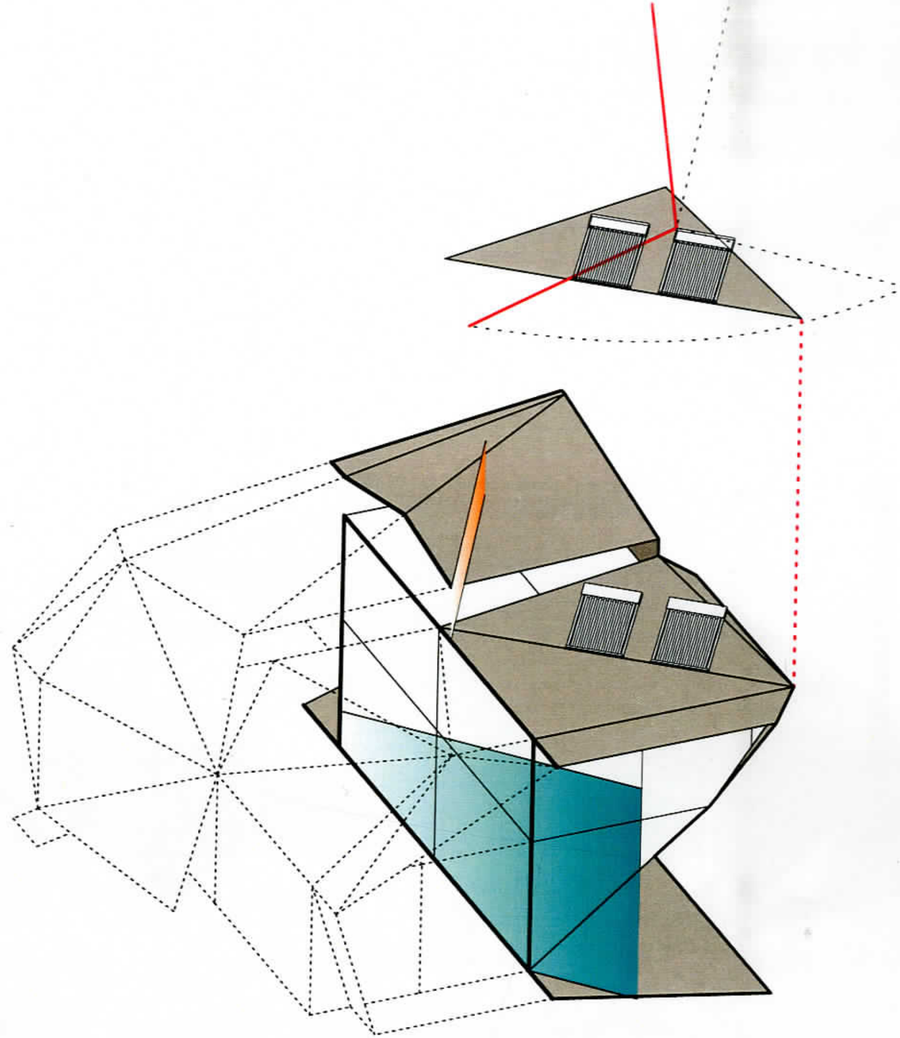




environmental response, syracuse:



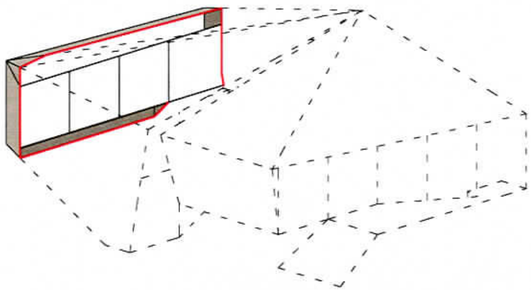




the scripts, dallas:

***sectional manipulation of form to dictate how the building responds environmentally**

1.



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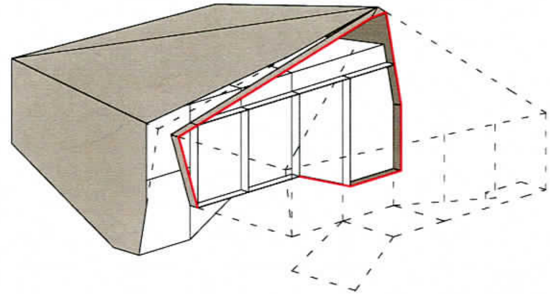

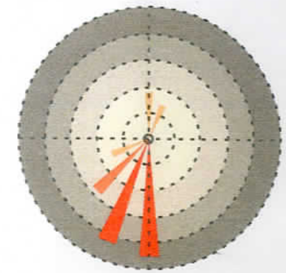

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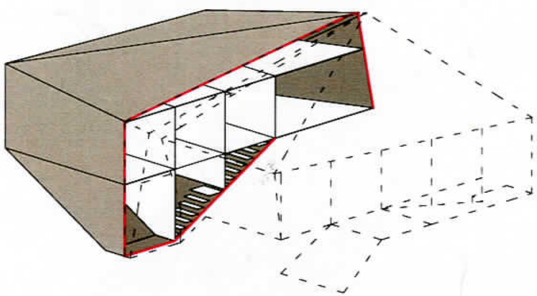

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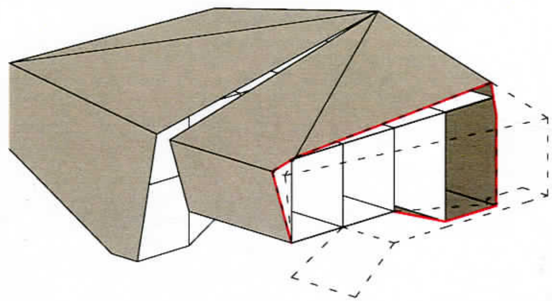
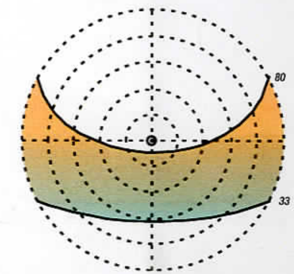
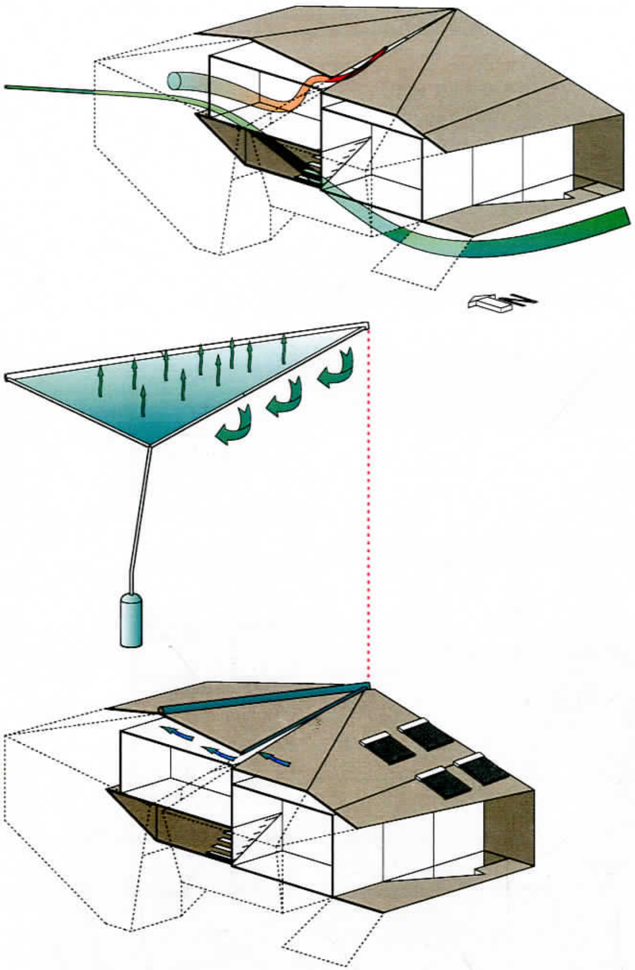
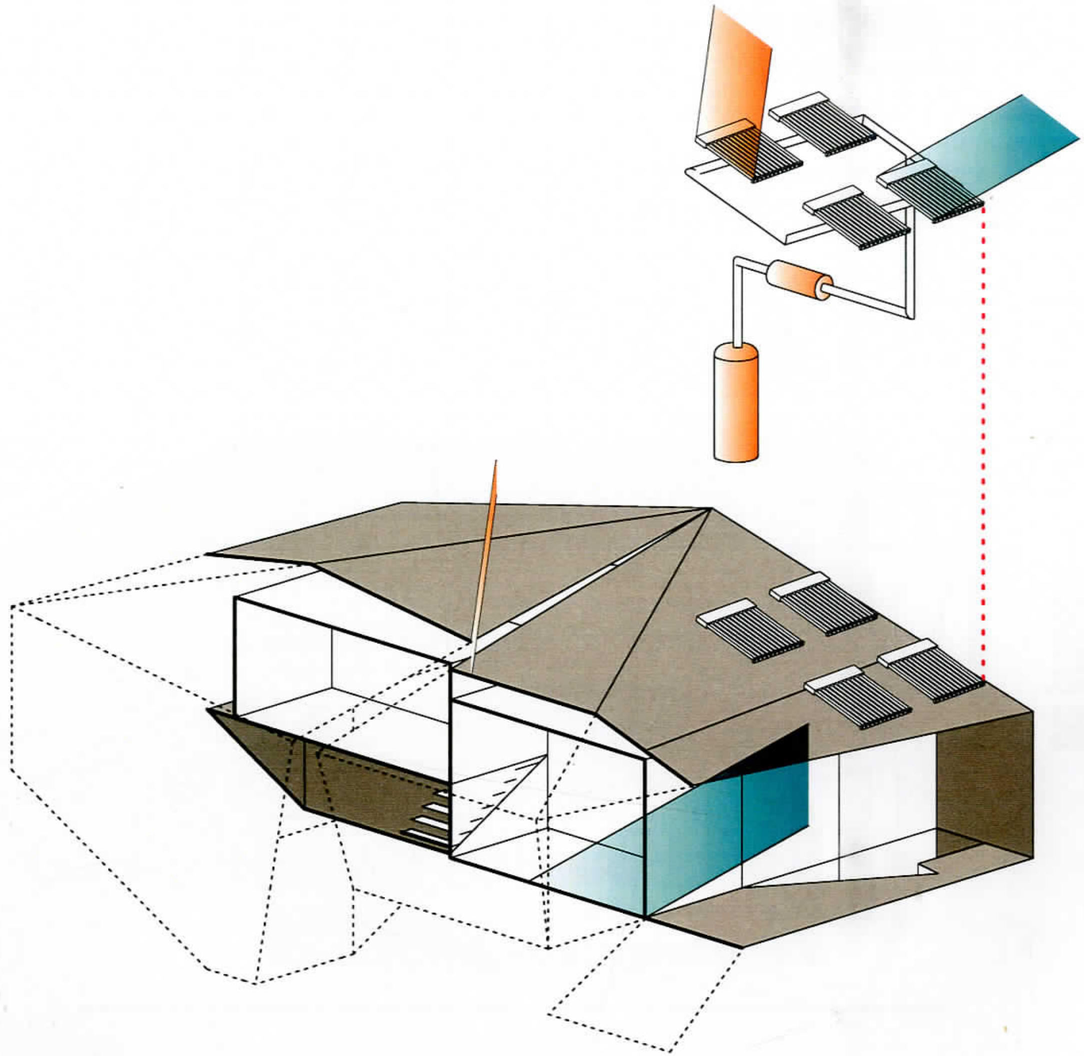




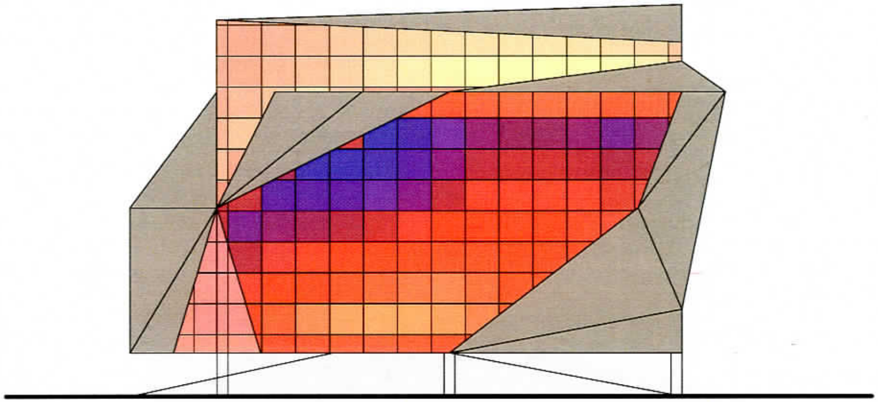
environmental response, dallas:

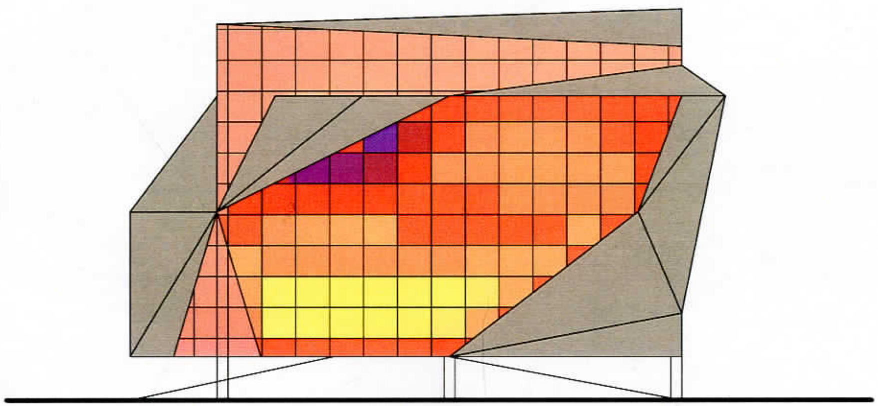


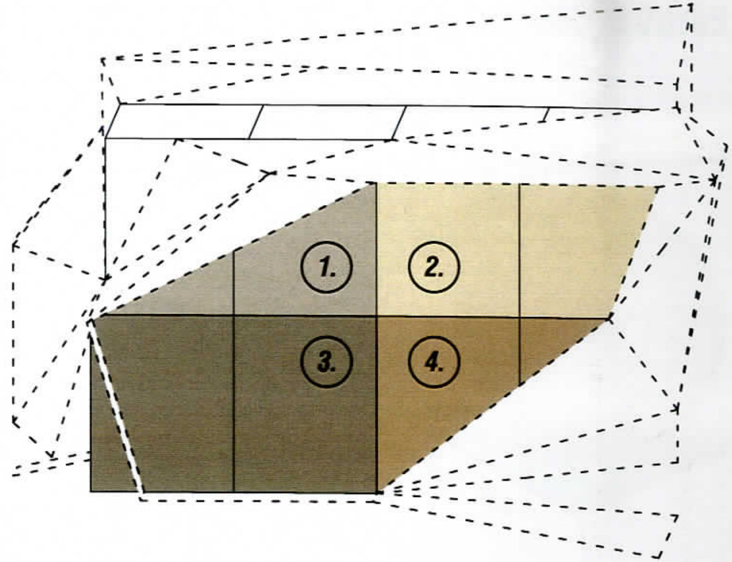


ecotect as facade generator, syracuse:

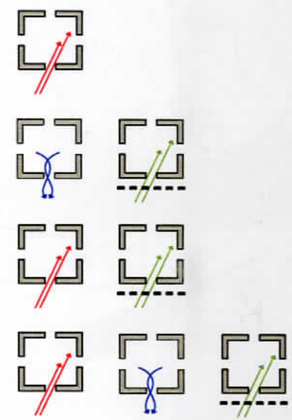
***southern facade**



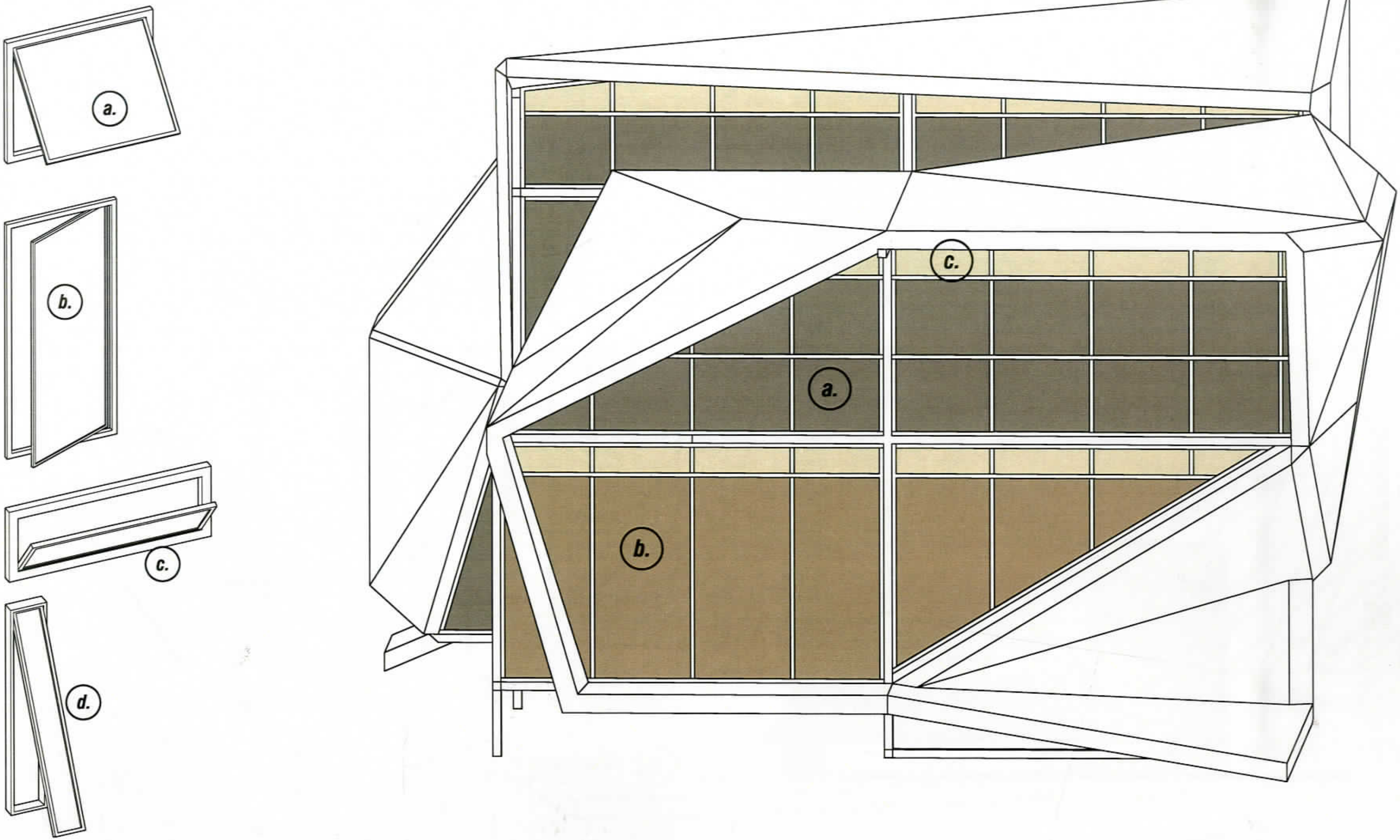




1. *expandable/outdoor space*
2. *bathroom/circulation*
3. *entry/dining*
4. *kitchen*

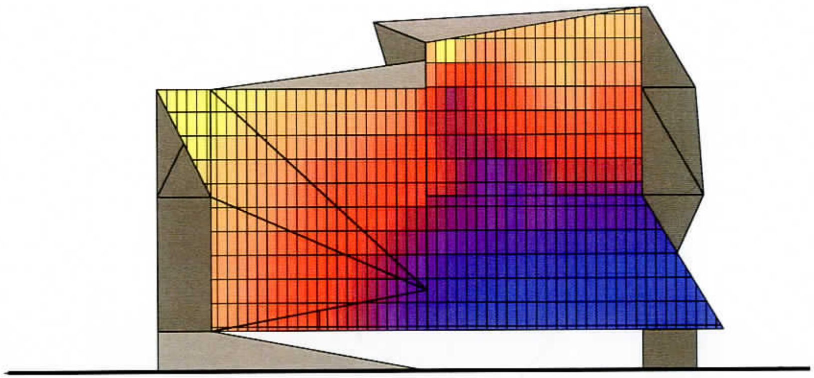


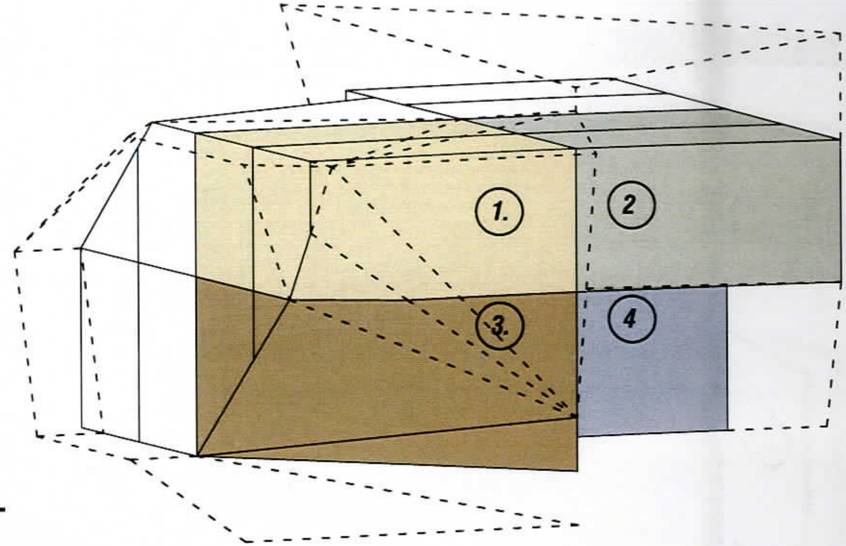
realized facade:

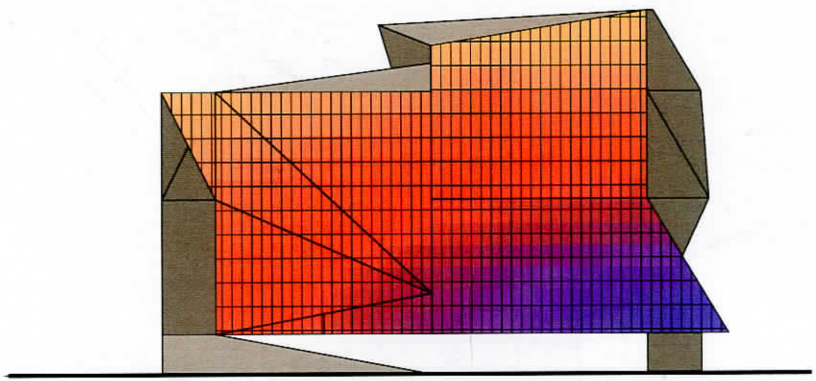


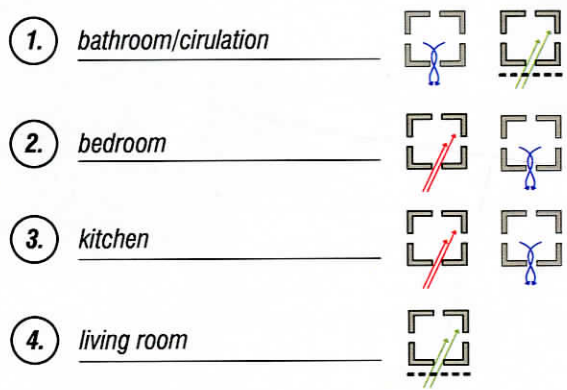
ecotect as facade generator, syracuse:

*eastern facade

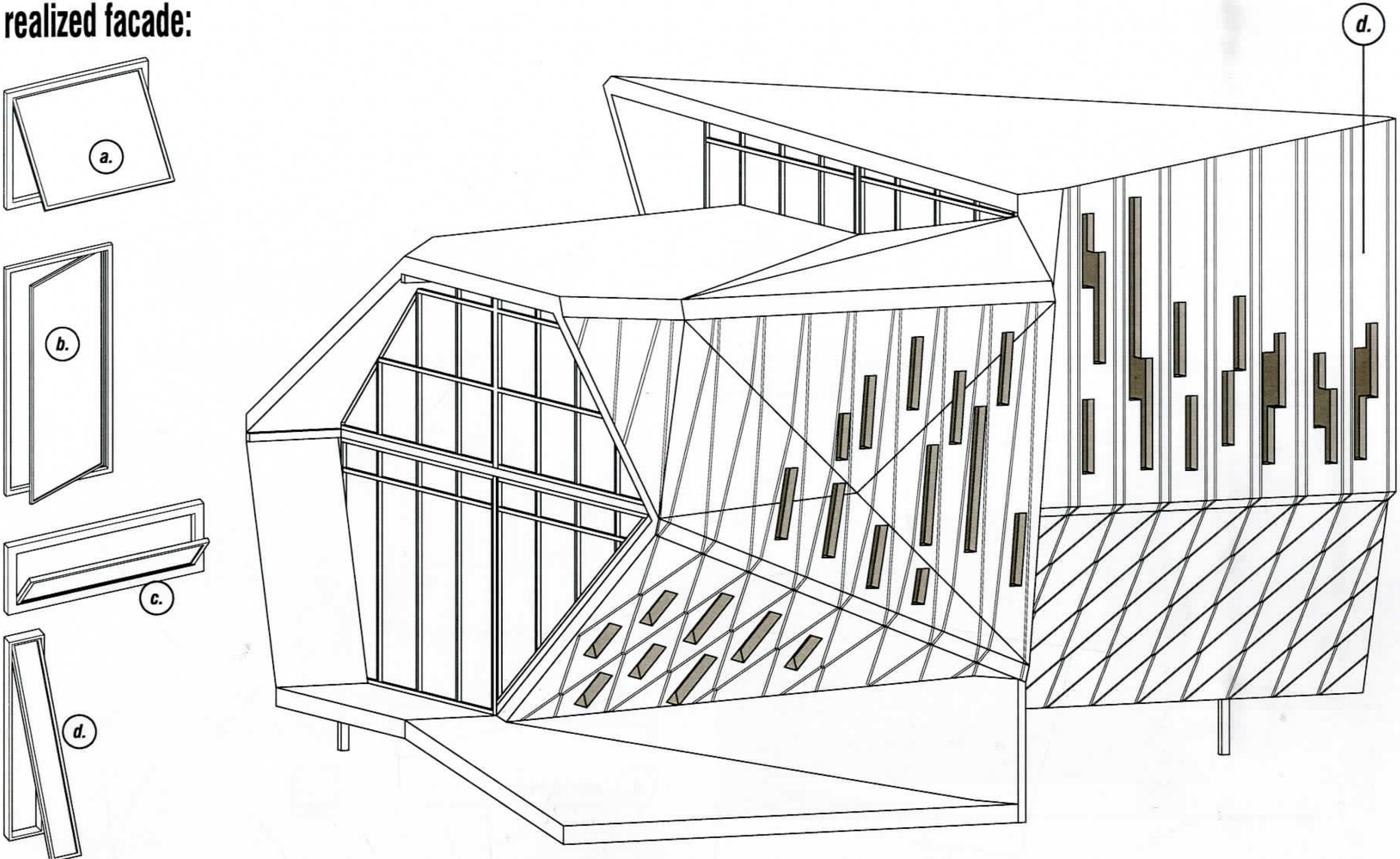






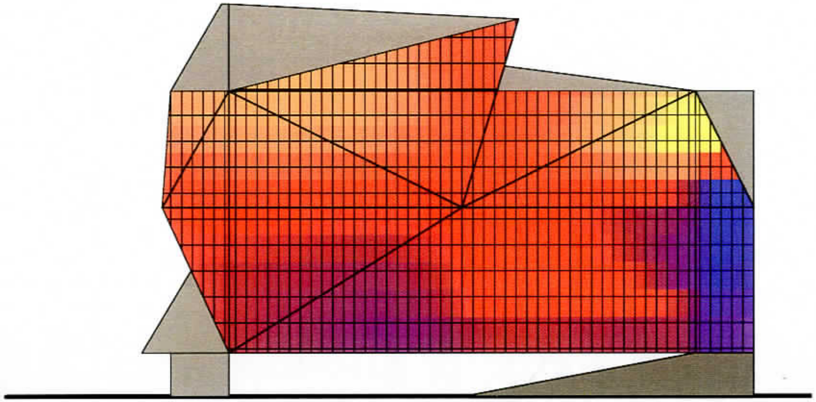


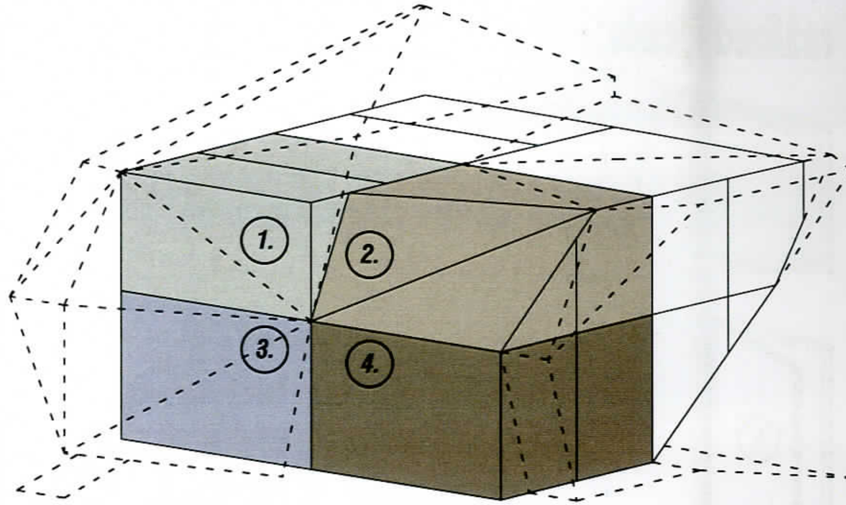
realized facade:

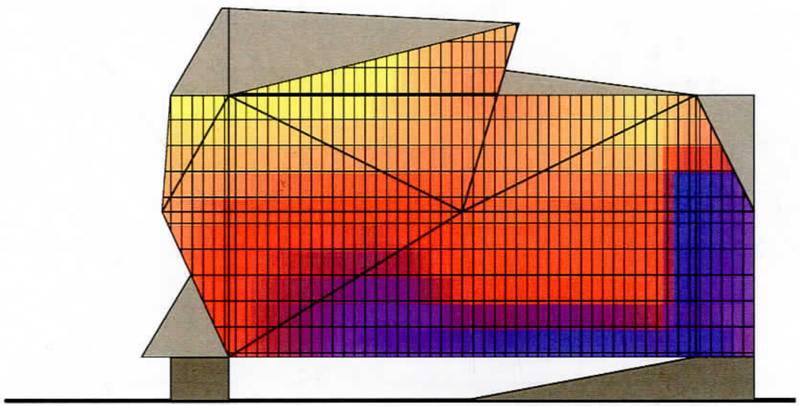


ecotect as facade generator, syracuse:

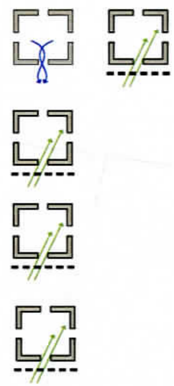
***western facade**



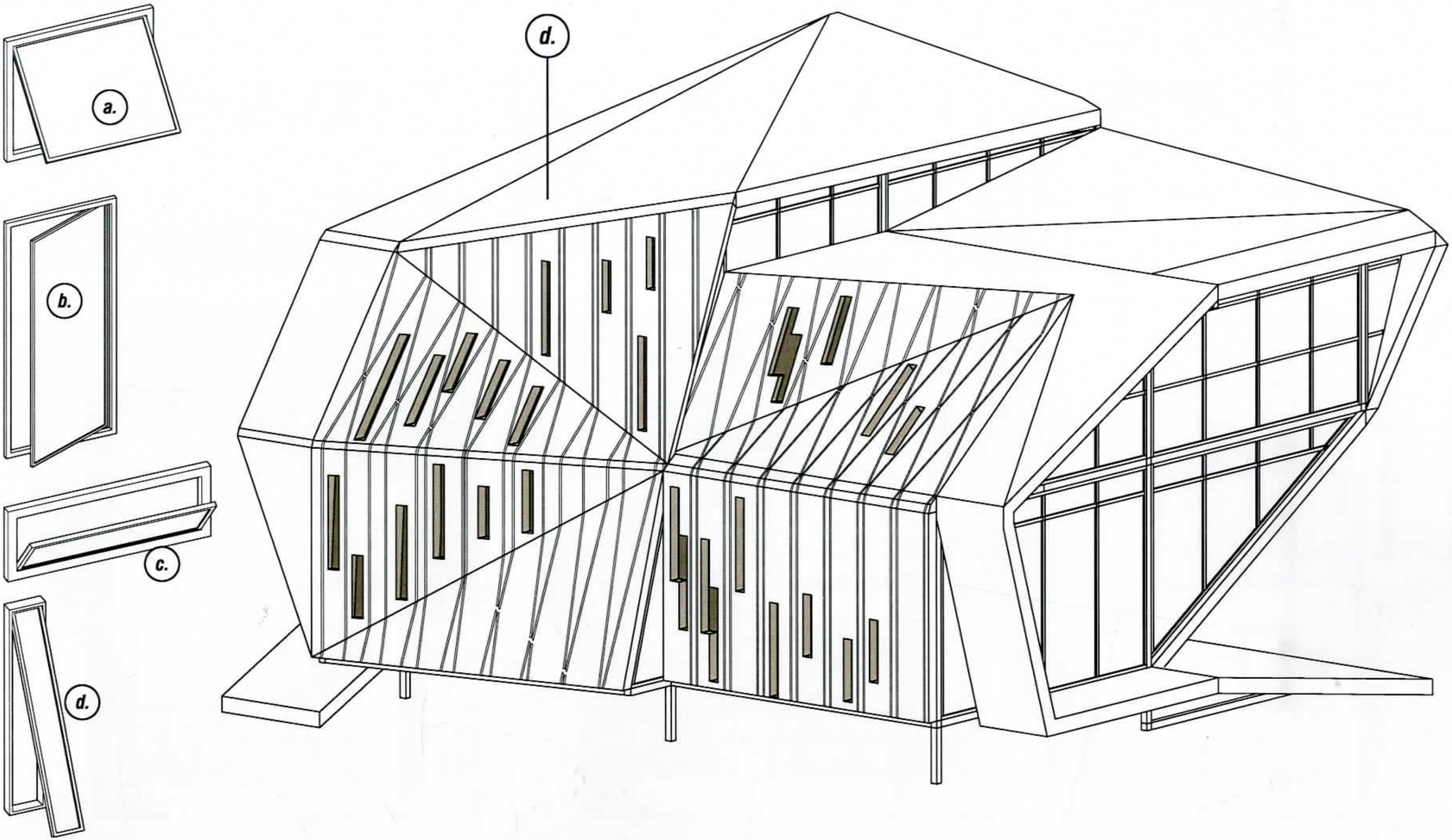


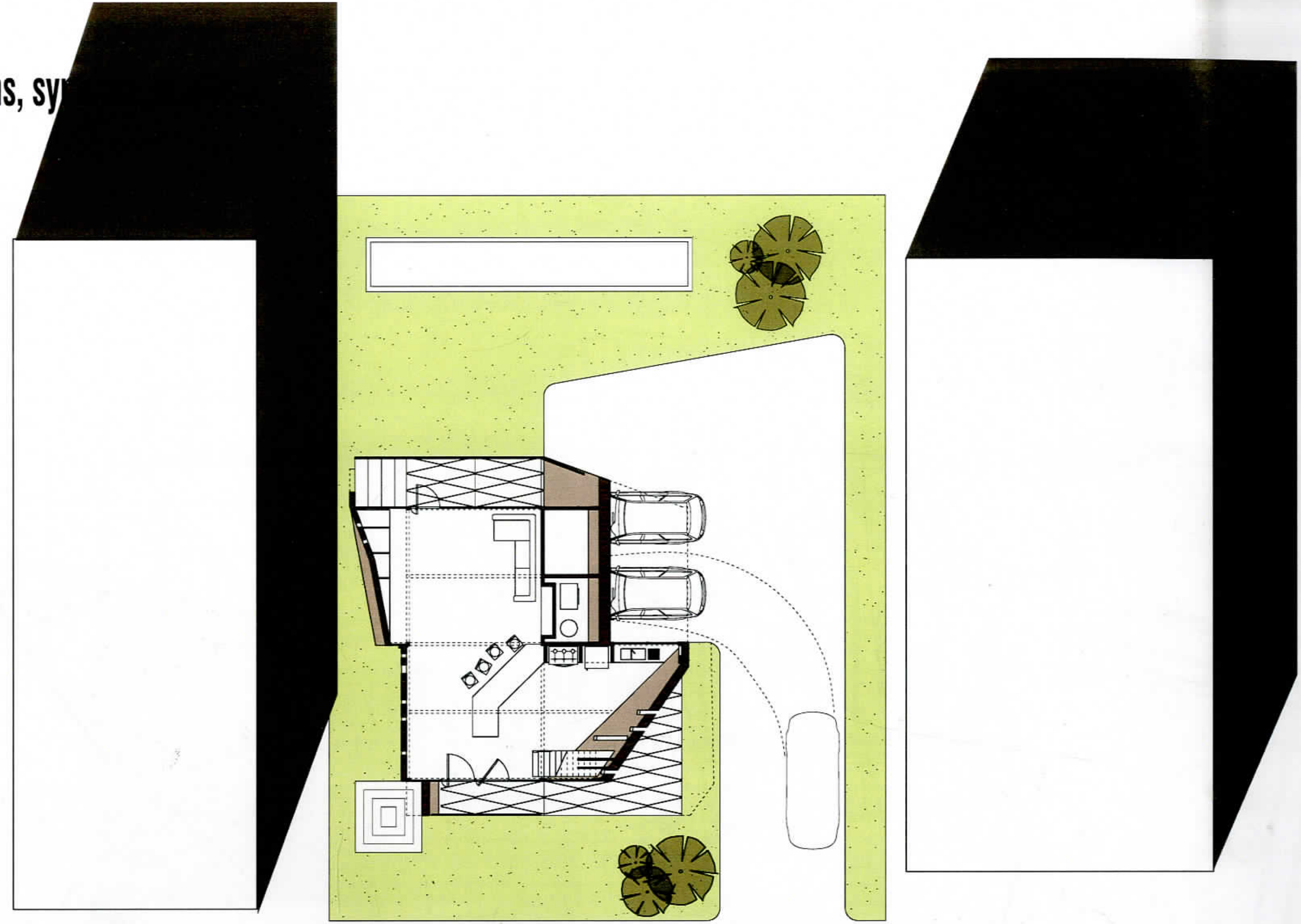


1. *bedroom*
2. *expandable/outdoor space*
3. *living room*
4. *entry/dining*



realized facade:

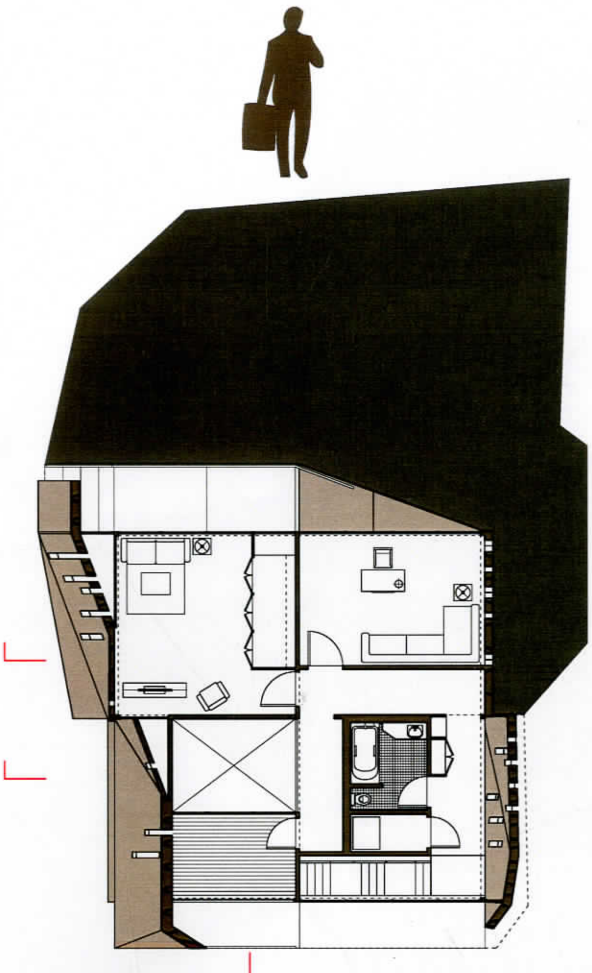


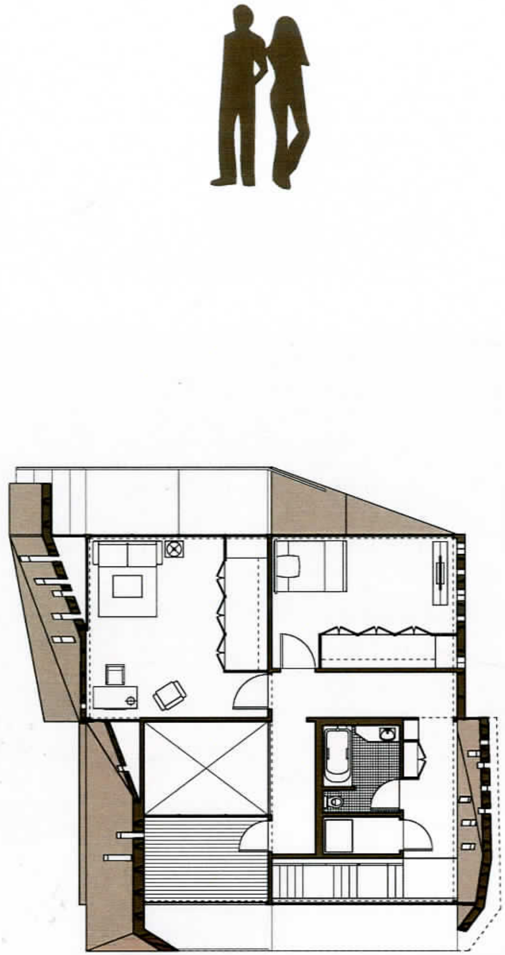


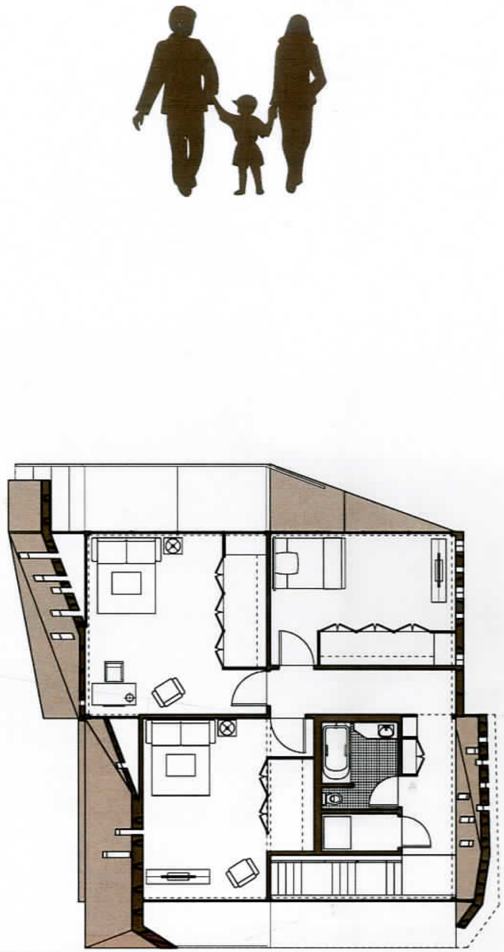
ground floor plan

upper floor plan configurations:

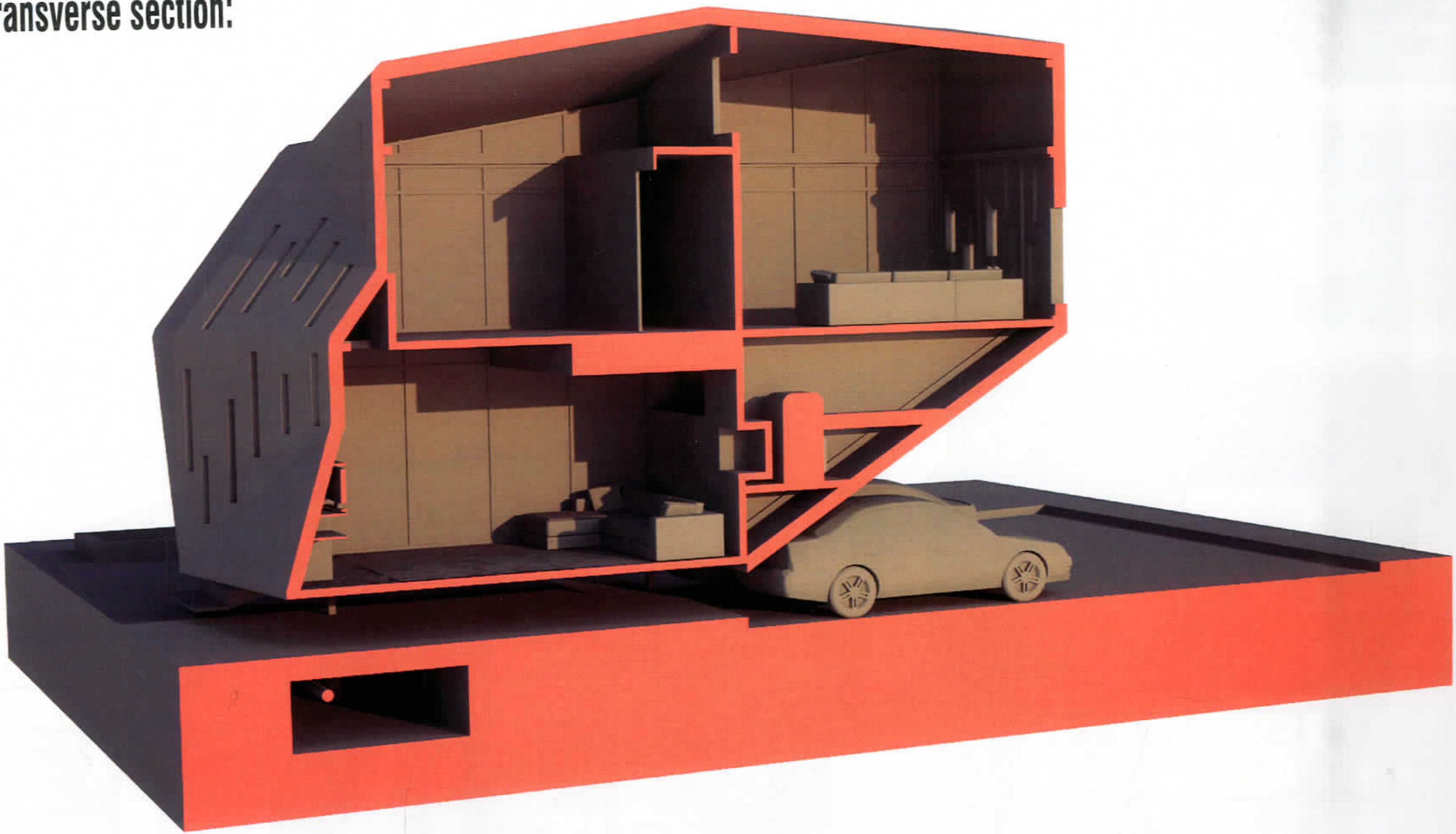
***floor plans are flexible depending on occupant/needs**



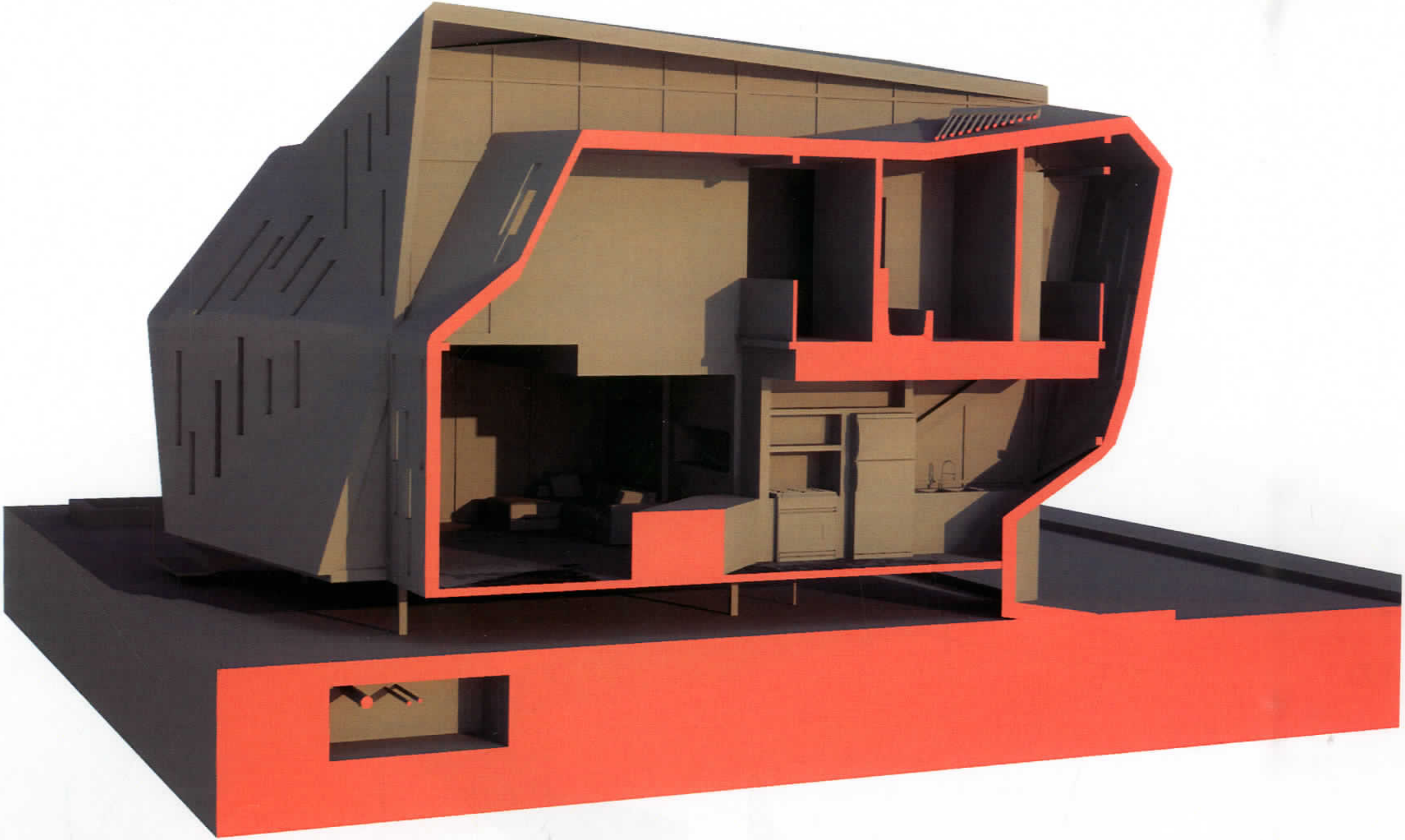




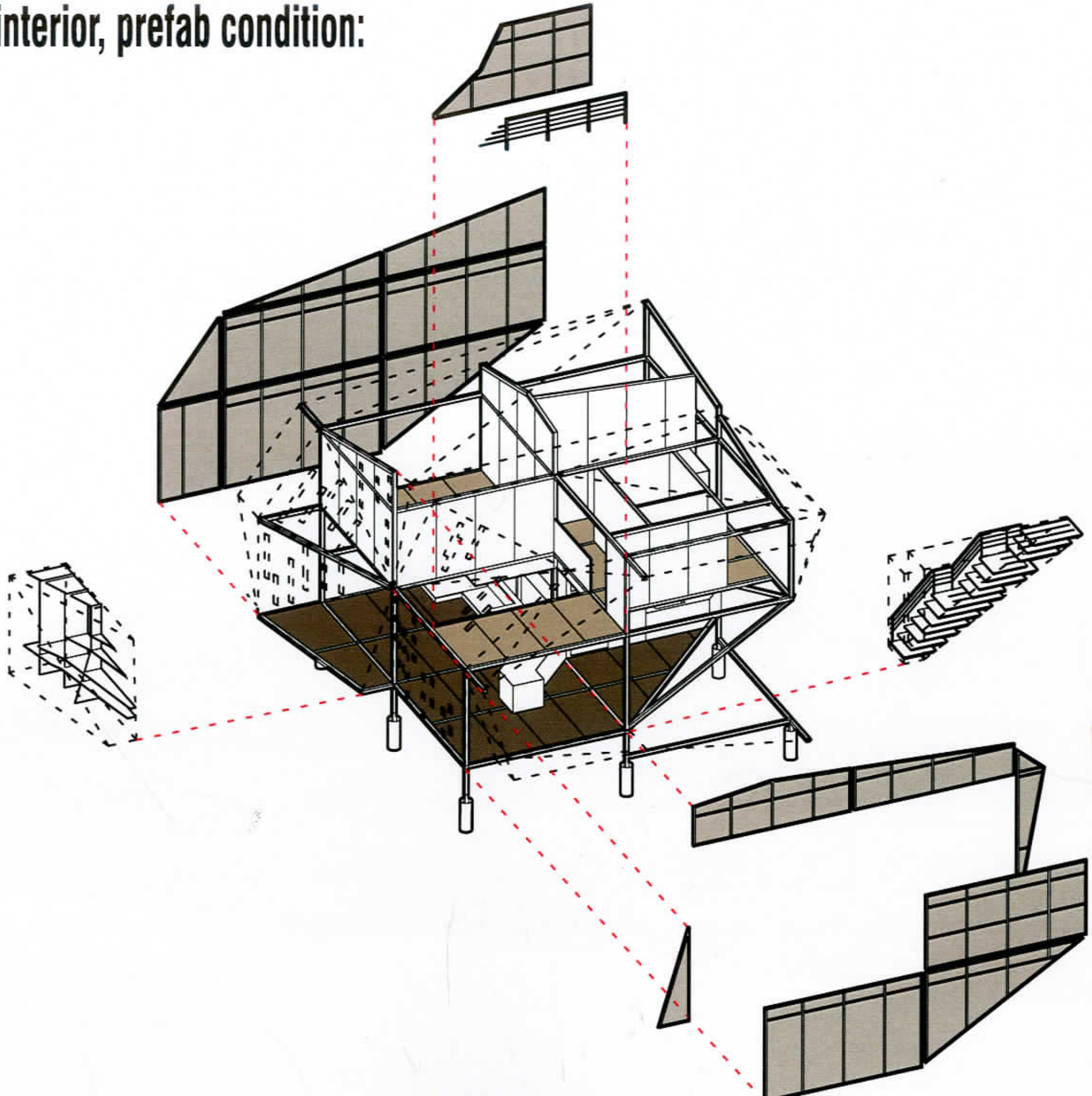
transverse section:

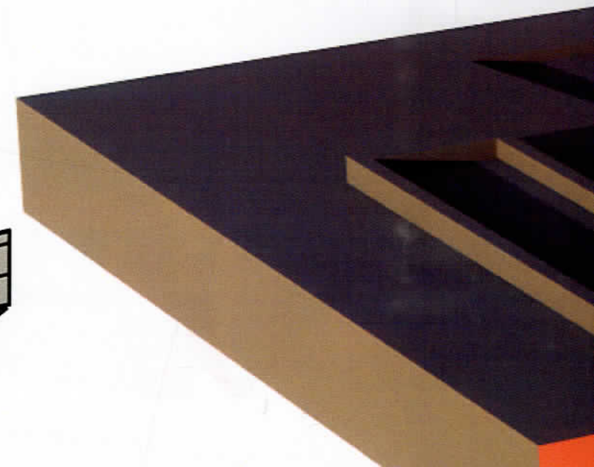


transverse section:

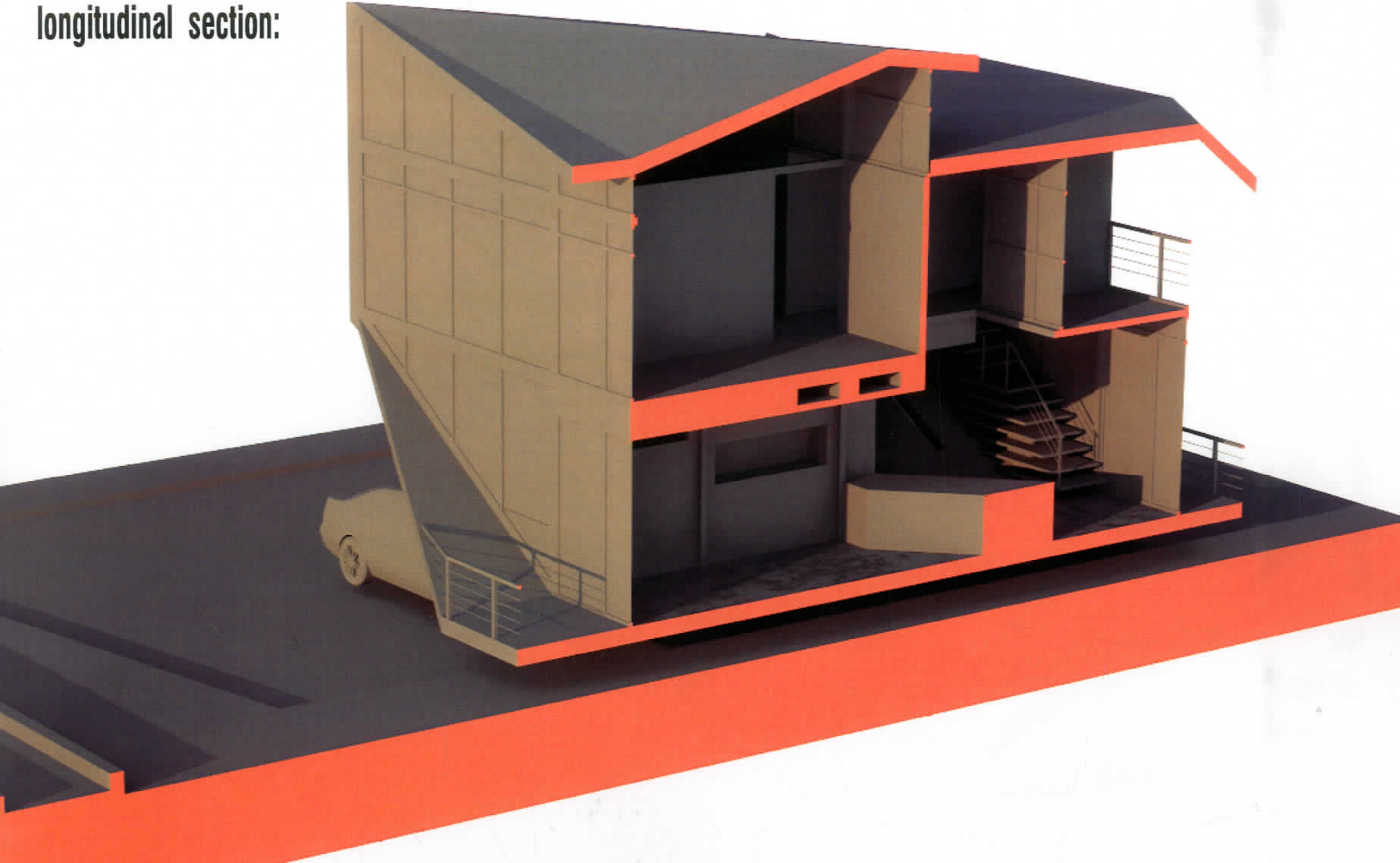


interior, prefab condition:

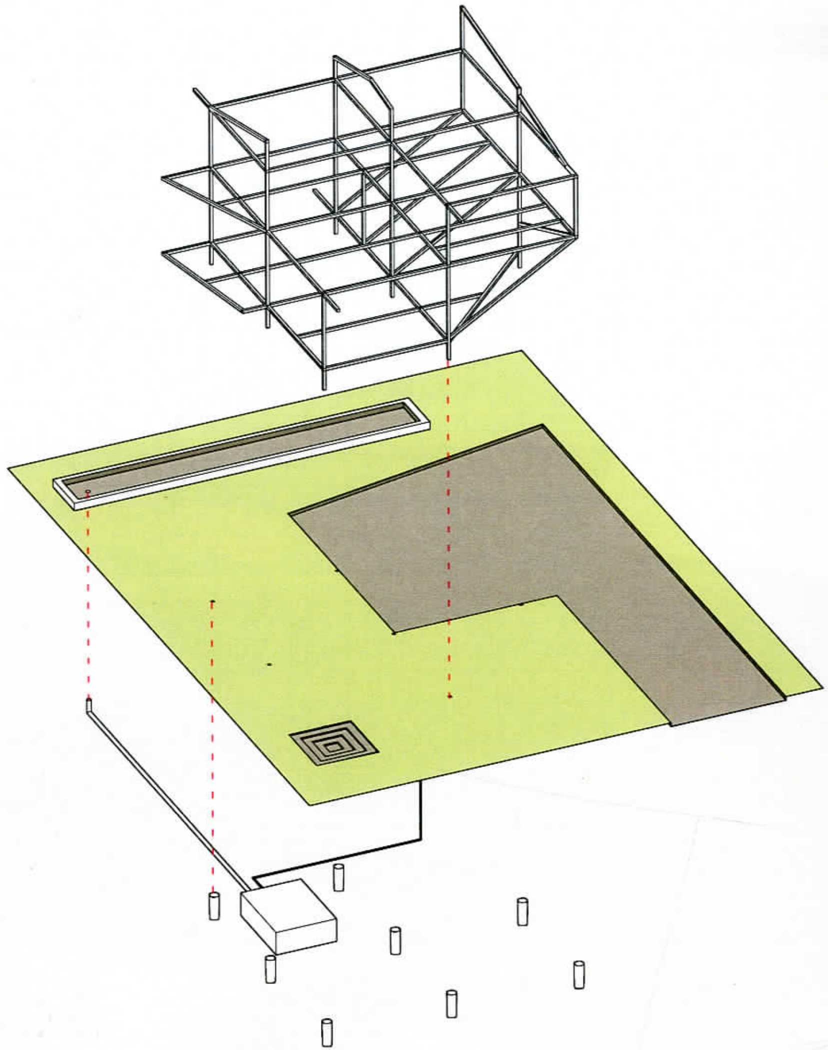




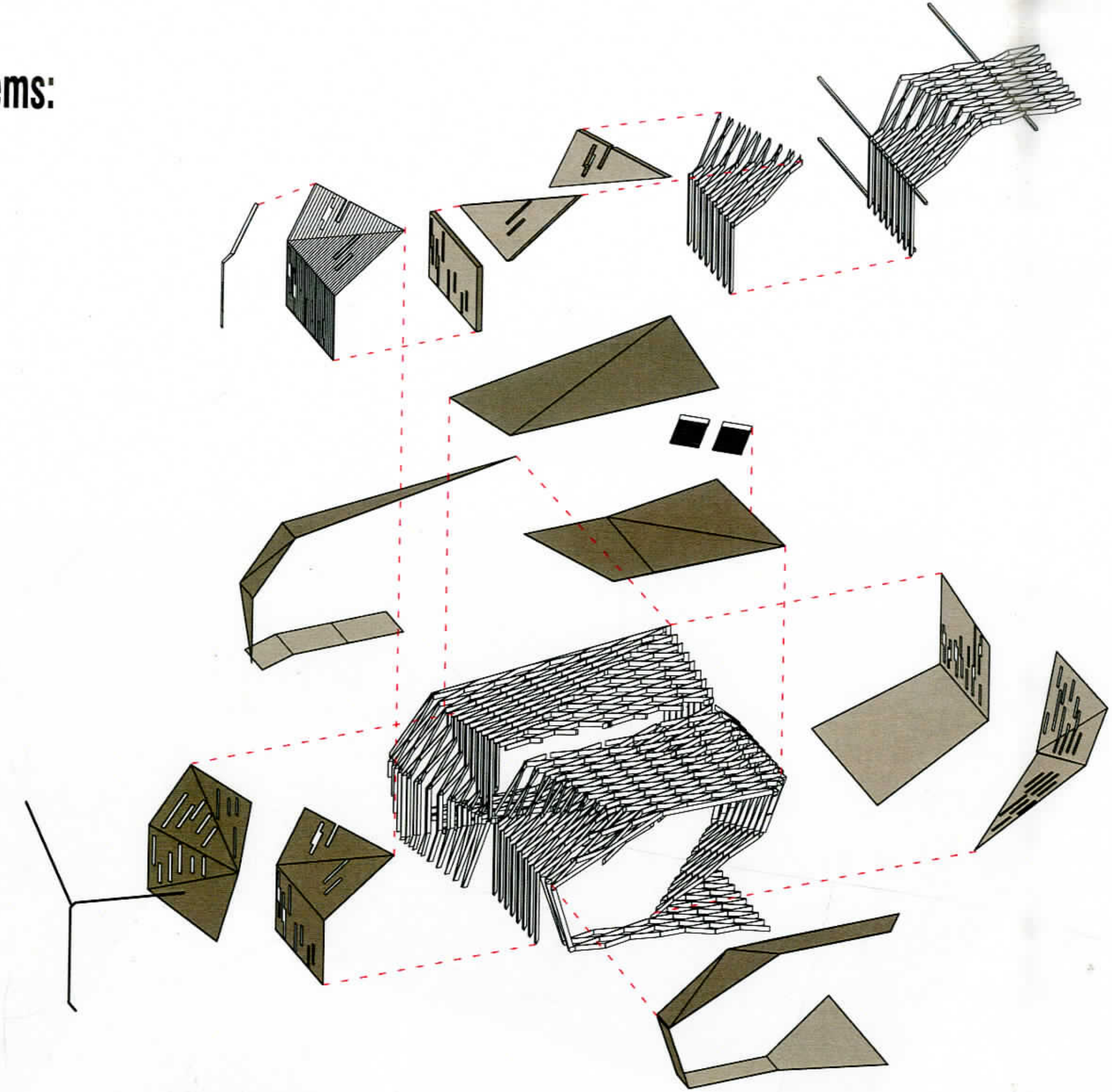
longitudinal section:



exterior, structural system/landscaping:

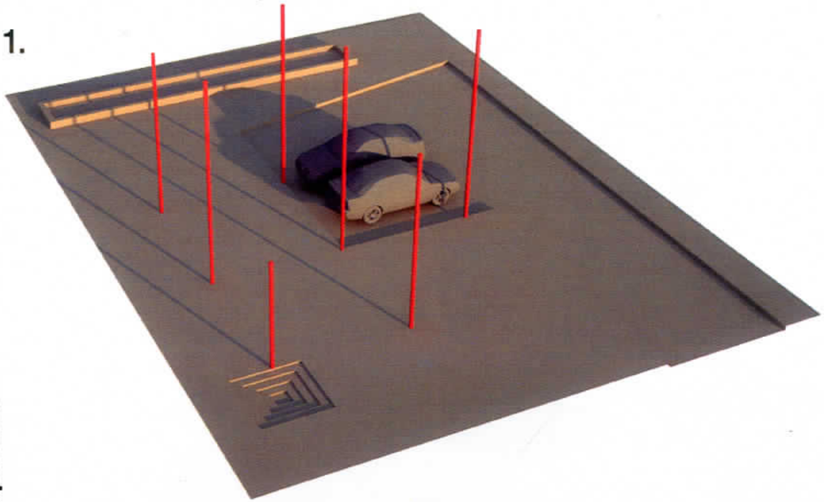


exterior, digitally fabricated systems:

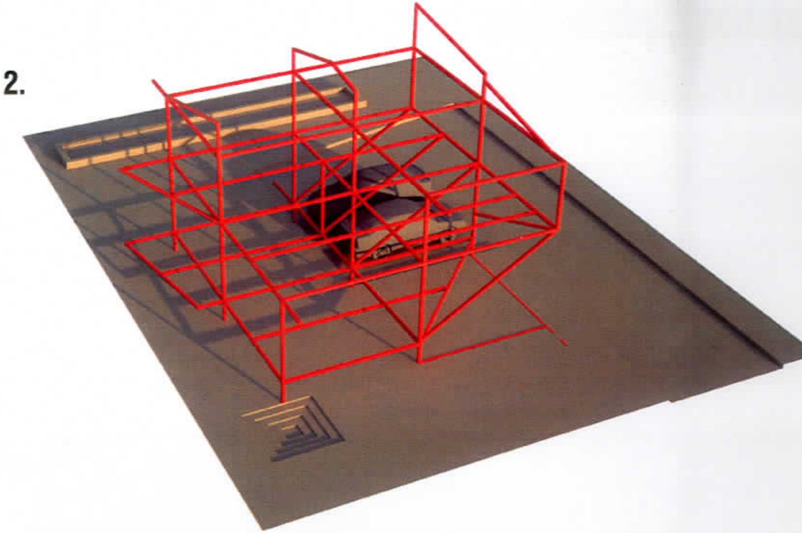


construction sequence:

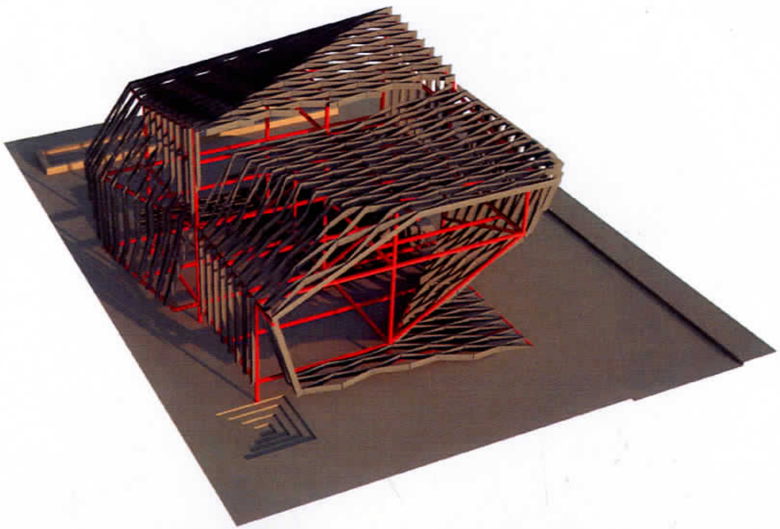
1.



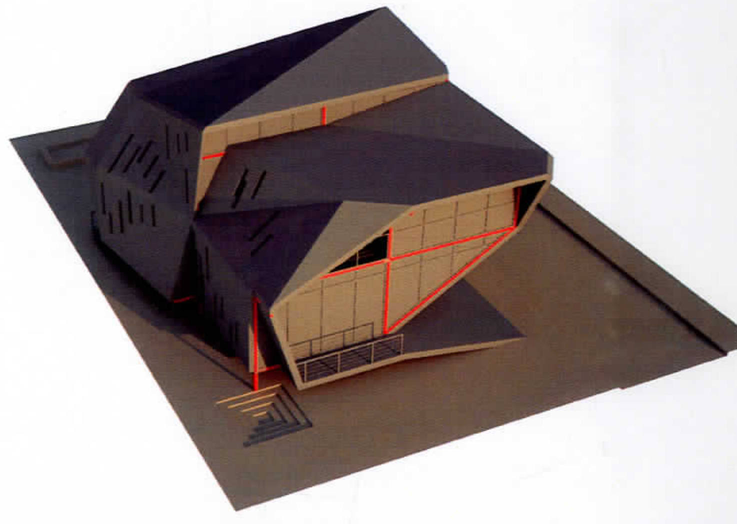
2.



3.

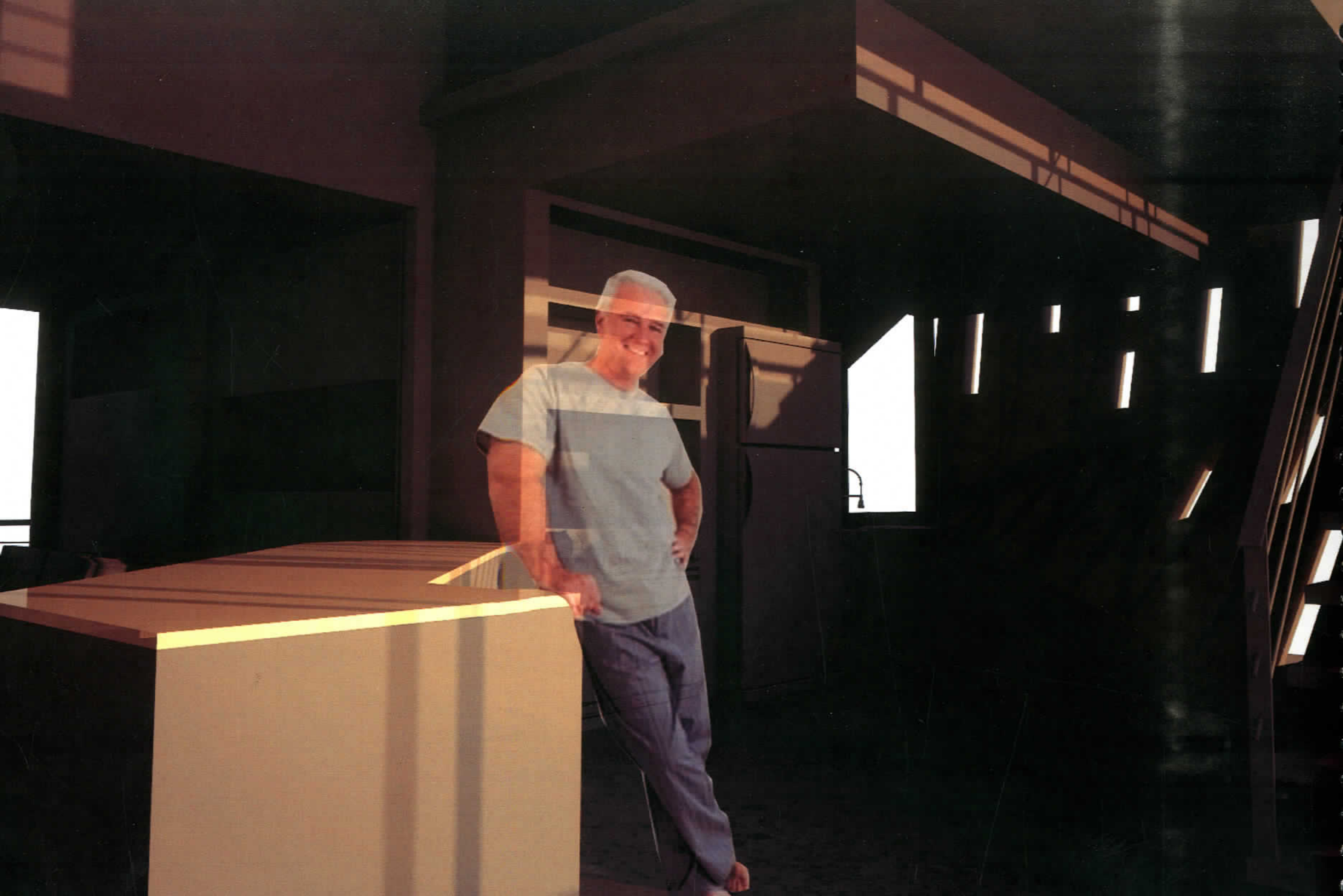


4.



5.

proposal in context, gifford street



works cited:

Abel, Chris. *Architecture, technology, and process*. Boston: Elsevier, 2004. Print.

Architectural Design + Research Collaborative. Web. 10 Dec. 2009. <http://www.epiphyte-lab.com/>.

Barrow, Larry R., Shaima Al Arayedh, and Shilpi Kumar. *Performance House 1 – A CADCAM Modular House System*. Web. 12 Nov. 2009. <www.shilpikumar.com/ACADIA_PH1.pdf>.

Broadhurst, Ron. *Next Houses*. New York: Abrams, 2009. Print.

Camera Obscura. SHoP Architects. Web. 12 Nov. 2009. <http://www.shoparc.com/#/projects/all/camera_obscura>.

Corbusier, Le. *Towards a new architecture*. New York: Dover Publications, 1986. Print.

Demchak, Gregory L. *TOWARDS A POST-INDUSTRIAL ARCHITECTURE: Design and Construction of Houses for the Information Age*. Massachusetts Institute of Technology, June 2000. Web. 1 Dec. 2009. <architecture.mit.edu/house_n/documents/Demchak00.pdf>.

Domestic architecture and the use of space an interdisciplinary cross-cultural study. Cambridge [England]: Cambridge UP, 1990. Print.

Ernst., Neufert,, Peter Neufert, Bousmaha Baiche, and Nicholas Walliman. *Architects' Data (3rd Edition)*. Grand Rapids: Blackwell Limited, 2002. Print.

Herbers, Jill. *Prefabmodern*. New York: HarperCollinsPublishers, 2004. Print.

Jacobs, Karrie. *The Perfect $100,000 House A Trip Across America and Back in Pursuit of a Place to Call Home*. New York: Viking Adult, 2006. Print.

works cited:

Jones, Dora E. *Walter Gropius and the (Not So) Endless Possibilities of Prefabrication*. Aiacc.org. Web. 25 Oct. 2009. <www.aiacc.org/site/docs/jones.pdf>.

Klinger, Kevin R., and Joshua Vermillion. "Visualizing the Operative and Analytic: Representing the Digital Fabrication Feedback Loop and Managing the Digital Exchange." International journal of architectural computing 04.03: 79-97. Print.

KLINGER, Kevin R. *Making Digital Architecture: Historical, Formal, and Structural Implications of Computer Controlled Fabrication and Expressive Form*. Web. 24 Nov. 2009. <www.tkk.fi/events/ecaade/E2001presentations/10_02_klinger.pdf>.

Kolarevic, Branko. *Architecture in the digital age design and manufacturing*. New York, NY: Spon, 2003. Print.

McCullough, M.: 1996, *Abstracting Craft: The Practiced Digital Hand*, MIT Press, Cambridge, MA.

Mies van der Rohe, L.: 1950, a speech to IIT, in Johnson, P.: 1953, Mies van der Rohe, second edition, Museum of Modern Art, New York.

Newton, Timothy. "The Chair |." YSOA | Yale School of Architecture. Web. 20 Sept. 2009. <http://www.architecture.yale.edu/drupal/courses/fall/study_areas/design_visualization/1224a>.

Ouroussoff, Nicolai. "*Machines for Living*." NYTIMES.COM/TMAGAZINE 16 Mar. 2008: 113-42. Print.

Pedreschi, Remo. "*The Innovative Lightweight Buildings and Systems of Jean Prouvé*." Advancements for Metal Buildings Congress 08 (2008). University of Edinburgh. Web. 15 Oct. 2009. <www.eppf.com/meetings/edinburgh/23102008RemoPedreschi.pdf>.

glossary of terms:

Design files/building information: Computer generated information that allows the architects of today, working alongside with technology and digital fabrication processes to move seamlessly from digital model to physical prototype.

Digital fabrication: The use of manufacturing processes to conceivably transform digital information to physical building components. Often associated with laser cutting, CNC milling and CAD/CAM software.

Rapid Prototyping: Digital fabrication processes allow for seemingly infinite recreations of various building components with the use of computer generated cutting or forming tools. Often associated with vacuum forming.

CNC & CAD/CAM: Computer Numerically Controlled systems often associated with CNC milling, a subtractive method of digital fabrication. CAD/CAM or computer aided design/computer aided manufacturing.

Vertical serial section: Cutting multiple vertical sections through a computer generated model in order to obtain two-dimensional information for the translation to cutting files for CNC milling or laser cutting.

Waffle Construction Systems: A common output of laser cutting and CNC milling processes. Notched structural ribs intersect with cross members running perpendicular in direction, interlocking and making a highly structural system.

NURBS: Non-Uniform Rational B-Spline. NURBS are mathematical representations of 3-D geometry that can accurately describe any shape. Most often associated with the 3-d program, Rhino.

Compromise angle: The optimum angle for building orientation in order to best benefit from solar gains. Calculated through incidence radiation on a vertical surface.

Eco-Tect: Autodesk software used to simulate sun-path diagrams, light analysis, acoustical responses, and various design parameters.

Adaptive building components: Elements that comprise [often the exterior] of a building or dwelling. They often reflect environmental analysis in relationship to program studies and have a profound impact on the physical appearance of the building. Digital fabrication and rapid prototyping allow for the mass-customization of adaptive building component systems.

Digital-[pre]fabrication: A hybrid typology [associated with the single family dwelling] that combines lessons learned from our pre-fabricated predecessors yet adopts the digital technologies of today in order to define a new, environmentally responsible housing typology.