

11-21-2008

Living Chassis: Learning from the Automotive Industry; Site Specific, Prefabricated, Systems Architecture

Christopher Emilio Emiliucci Cox
University of South Florida

Follow this and additional works at: <https://digitalcommons.usf.edu/etd>



Part of the [American Studies Commons](#)

Scholar Commons Citation

Cox, Christopher Emilio Emiliucci, "Living Chassis: Learning from the Automotive Industry; Site Specific, Prefabricated, Systems Architecture" (2008). *USF Tampa Graduate Theses and Dissertations*.
<https://digitalcommons.usf.edu/etd/192>

This Thesis is brought to you for free and open access by the USF Graduate Theses and Dissertations at Digital Commons @ University of South Florida. It has been accepted for inclusion in USF Tampa Graduate Theses and Dissertations by an authorized administrator of Digital Commons @ University of South Florida. For more information, please contact digitalcommons@usf.edu.

Living Chassis:

Learning from the Automotive Industry; Site Specific, Prefabricated, Systems Architecture

by

Emilio Christopher Emiliucci Cox

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

Major Professor: Michael Halfants, M.Arch.
Nathan Crane, Ph.D.
William Rapp, M.Arch.

Date of Approval:
November 21, 2008

Keywords: Modular, Prefabricated, Prefab, Chassis, System, Home, House, Residential, Architecture, Design

© Copyright 2008, Emilio Christopher Emiliucci Cox

DEDICATION

This thesis is dedicated to my mother, Linda Sue Cox, who is always one step ahead of wherever I am going.

ACKNOWLEDGMENTS

I would like to thank:

Professor Michael Halfants - for his refreshing honesty and dedication to design excellence.

Professor Stanley Russel - for teaching a rare combination of exploration and execution.

Carol Trent and Mary Hayward - for keeping the boat floating in choppy waters.

I am continually appreciative and amazed by my friends at the School of Architecture and Community Design.

My success is directly correlated to them.

Words can't describe the understanding and patience my family and friends have had with me during this time.

Special thanks all of them.

TABLE OF CONTENTS

LIST OF FIGURES	ii		
		Design Research	21
		Sizing and Grid	21
ABSTRACT	iv	US Census	22
		Precedent Studies	26
INTRODUCTION	1		
1.o THINK_iDEA	2	3.o DO_deSIGN	36
Introduction	2	Early Process	36
Inspiration	3	Language	39
		Spine	39
		Organs	40
2.o MOVE_reSEARCH	5	Bones	41
Introduction	5	Veins	42
Background	6	Infill	43
Current State of Affairs	6	Relic	44
Perception or Modular	8	Design Interations	45
Automotive vs Housing Workflow	9	Open Source	50
Precedents	11	Statesman	54
Automobiles Introduction	11	The Fish	57
Unimog	12		
Jeep	13	APPENDIXES	64
VW Beetle	14	Appendix A	65
Architecture Introduction	15	Appendix B	79
Pompidou Center	15		
Emotive Study	20		

LIST OF FIGURES

Figure 1.1. 2005 BMW z4 concept	2	Figure 2.19. Stories in new one family houses	23
Figure 1.2. Destroyed Home	3	Figure 2.20. Multifamily units by square feet per unit	24
Figure 1.3. IBM Blade	3	Figure 2.21. Multifamily units by number of bedrooms	24
Figure 1.4. Lego Tractor	3	Figure 2.22. Multifamily units by number of bathrooms	24
Figure 1.5. Structure and systems delivery on grader	4	Figure 2.23. Air-conditioning in houses	24
Figure 1.6. Rear differential on articulated truck	4	Figure 2.24. Loblolly House	26
Figure 1.7. Wheel loader	4	Figure 2.25. Loblolly House floor plan study	27
Figure 2.1. Eames House	5	Figure 2.26. Eames House floor plan study	29
Figure 2.2. Suburban track homes	6	Figure 2.27. Eames House section study	30
Figure 2.3. Mobile/Trailer home	8	Figure 2.28. Mobile Home floor plan study	31
Figure 2.4. PLM based, Catia software	9	Figure 2.29. Mobile Home section study	32
Figure 2.5. Above. Home construction workflow chart	10	Figure 2.30. Floor Diagram 1	33
Figure 2.6. Below. PLM, central data query workflow	10	Figure 2.31. Floor Diagram 2	33
Figure 2.7. Unimog in Dakar Race	11	Figure 2.32. Japanese Tatami	33
Figure 2.8. Unimog with detachable street sweeper	12	Figure 2.33. Tatami Diagram	33
Figure 2.9. Willys Jeep	13	Figure 2.34. Ceiling height study	34
Figure 2.10. VW Beetle Section	14	Figure 2.35. Plenum grid study	35
Figure 2.11. Pompidou Center Plaza Elevation	15	Figure 2.36. Plenum grid study	35
Figure 2.12. Pompidou Center Detail	15	Figure 2.37. Plenum grid study	35
Figure 2.13. Pompidou structural detail.	16	Figure 2.38. Plenum grid graphic	35
Figure 2.14. Section diagram	17	Figure 2.39. Plenum grid study	35
Figure 2.15. Grid Study	21	Figure 3.1. Structure graphic	36
Figure 2.16. Square feet of new one family houses	22	Figure 3.2. FASH graphic	37
Figure 2.17. Bedrooms in one family houses	22	Figure 3.3. Process Graphics idea	37
Figure 2.18. Bathrooms in new one family houses	23	Figure 3.4. The Hump diagram	38

Figure 3.5. The Plenum diagram	38	Figure 3.37. Fish east elevation	60
Figure 3.6. Spine Collage	39	Figure 3.38. Fish main perspective	61
Figure 3.7. 3/4" = 1' Plenum wall model	40		
Figure 3.8. Organ, plug and play	40		
Figure 3.9. Bone - spine connection	41		
Figure 3.10. BOSH extruded aluminium profiles	41		
Figure 3.11. Structural bay for vein panel	42		
Figure 3.12. Vein panel diagram	42		
Figure 3.13. Structural base with infill panels	43		
Figure 3.14. Mock up joint, hex infill panel	43		
Figure 3.15. Relic section perspective	44		
Figure 3.16. Relic collage	44		
Figure 3.17. Design iteration collage	45		
Figure 3.18. D001 Board	46		
Figure 3.19. D002 Board	47		
Figure 3.20. D003 Board	48		
Figure 3.21. D001 Graphic	49		
Figure 3.22. Open source diagram	50		
Figure 3.23. Bag of parts given to open source team	51		
Figure 3.24. Chipboard sites given to open source team	51		
Figure 3.25. Open source handout 1	52		
Figure 3.26. Open source handout 2	53		
Figure 3.27. Statesman south elevation	54		
Figure 3.28. Statesman section perspective	54		
Figure 3.29. Statesman floor plans	55		
Figure 3.30. Statesman perspective	56		
Figure 3.31. Fish exploded systems	57		
Figure 3.32. Fish interior perspective	58		
Figure 3.33. Fish floor plan	58		
Figure 3.34. Fish section perspective of floor system	59		
Figure 3.35. Fish spine and bone structure	59		
Figure 3.36. Fish section perspective interior space	59		

**LIVING CHASSIS:
Learning from the Automotive Industry; Site Specific, Prefabricated, Systems Architecture**

Emilio Christopher Emiliucci Cox

ABSTRACT

Suburban Americans suffer from homes built with: a low standard of craftsmanship, poor efficiency of construction, excessive use of material resources and a disregard for their site. Architectural diversity is at a low, driven by a consolidation of homebuilders and fewer floor plans. The current home production workflow from commission to build pales in comparison to the automotive industries solutions.

Influenced by heavy machinery and hot swappable computers, ideas are born for a better way to build houses. These ideas evolve through understanding the principles of several successful vehicles, analyzing census data, and studying floor plans.

The flexible autonomous systems house (FASH), involves a 900mm x 900mm framework and a kit of parts that engages our industrial ability and maintains architectural values of space, form, materiality and site specificity. FASH is about bringing a logic and simplification of technique to building that allows quality and reuse to become reality.

INTRODUCTION

This document is broken down into three main Sections:

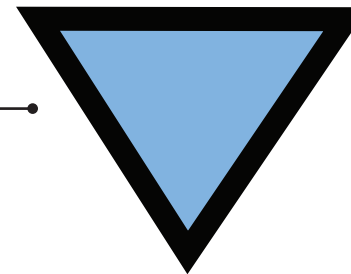
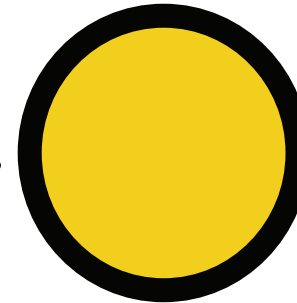
THINK, outlining the ideas and inspirations

MOVE, documenting the research and processes at work

DO, visualizing the execution of this thesis process

Appendix A - open source gallery

Appendix B - model gallery



1.0 THINK_IDEA



Introduction

“I think that only daring speculation can lead us further and not accumulation of facts.” Albert Einstein

This process started with an appreciation for the efficiency and beauty of automotive design and production. Since Ford’s Model T in 1908, cars have pushed the limits of design and production, while maintaining a high level of performance, reliability and safety. Manufactures like Toyota and BMW spend millions on research and development in order to streamline production, find niche markets, increase quality and understand the role of cars in the future. Meanwhile, Suburban Americans are suffering from homes built with: a low standard of craftsmanship, poor efficiency of construction, excessive use of material resources and a disregard for their site. The housing market still relies on a labor intensive model, inflexibility and limited reusability.

By focusing on developing a new language for the construction of single family homes, we can harness our industrial ability and maintain architectural values of space, form, materiality and site specificity.

Figure 1.1 2005 BMW z4 concept



Inspiration

Inspiration can be drawn from many places, but it all starts with the decision to make things better. After seeing enough homes destroyed with almost nothing salvaged, it's obvious that there is a better solution.

There is a lot to learn from purely purpose driven designs, like a steam roller, front end loader or server computer. Through observing heavy machinery, photographing connections and understanding part interactions, ideas were born.

The current influx of plug and play ability in the computer industry was of special interest. Trends toward flexibility and “Hot Swappability”, allow computer parts to be exchanged, added or removed without delay. These plug and play concepts have direct implications to the way homes can be built.



Figure 1.2
Destroyed
Home



Figure 1.3
IBM Blade



Figure 1.4. Lego Tractor



Figure 1.5. Left. Integrated structure and systems delivery on grader

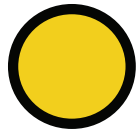


Figure 1.6. Bottom. Rear differential on articulated truck detailing a swing arm

Figure 1.7. Right. Wheel loader tells an honest story with clear structural articulation



2.0 MOVE_reSEARCH



Introduction

Research is broken into three main areas: background, precedents and design.

Background research investigates the current home building market. This background created a setting for other research to stem. Next, a 50 person survey was conducted on the perception of modular and prefabrication in home construction and automobiles. This comparison of home construction and automobile production was carried further in a workflow study.

Precedent research starts with three automobiles; the Unimog, Jeep and the VW Beetle; then is followed by several houses.

The next stage of research is design oriented. Design research is conducted with specific goals, so that conclusion reached are directly translated to design decisions.



Figure 2.1
Eames House
Steele, James, Charles
Eames, and Ray Eames.
*Eames House : Charles
and Ray Eames.* Lon-
don: Phaidon, 1994.



Figure 2.2 Suburban track homes.
“Markham Suburbs.” <<http://upload.wikimedia.org/wikipedia/commons/thumb/1/14/Markham-suburbs.id.jpg/jpg/800px-Markham-suburbs.id.jpg/jpg>>.

Background

Current State of Affairs

“Most of the roughly 1.5 million houses built every year are pieced together in a wasteful, antiquated way that has changed remarkably little in 150 years”, says Tedd Benson of Fine Home Building Magazine. According to US census data, 95 percent of 1,654,000 US single family homes completed in 2006 were site built (Characteristics of New Housing). Site built homes are entirely built at the building site. They conform to all state local and regional building codes at the site location.

2 percent of American single family homes constructed where modular (Characteristics of New Housing). Modular homes are built in sections in a factory. They are built to all state, local and regional building codes at their destination. Sections are then carefully transported from the factory to the site and assembled by local contractors. Well built modular homes should have the same longevity of site built homes, increasing in value overtime.

Site built homes take more time than modular homes to be constructed. “Our factories will be able to produce and deliver the home within four to 12 weeks”, said Palumbo of Custom Modular Designs (Smith). While a traditional site built home would take 8-12 months. This time advantage helps investors by shortening the time they pay interest. Developers benefit by having the ability to respond to market demands faster than their competitors using on-site construction.

Good labor is hard to find, especially when it's 95 degrees and raining. According to the 2006 Construction Quality Survey by Portland, Maine-based consulting company Criterium Engineers, the number of new homes with “significant problems” rose to 17% in 2006 (Roney). In October of 2003, University of Central Florida conducted a study on 406 site-built houses in the Orlando area (Tracy). The study found 386 of the homes had serious defects, including; faulty foundations, dangerous moisture intrusion, and inadequate framing (Tracy). Much of this is caused by unskilled labor and poor site conditions. Tedd Benson says, “From experience, I know it’s hard to do good work when you can’t feel your fingers, or when you’re ankle deep in mud, or when it’s been raining for five days straight and you’re spending most of your time tying down tarps” (Benson). Site constructed buildings open themselves up to common problems like sick building syndrome from rain and moisture. Factory built homes are constructed in a controlled environment. This allows for fewer accidents less mistakes and more

predictable time frames.

Material use in on-site construction is much less frugal than factory built. With Modular Construction, “You typically have 30 percent more material that goes into the home with 30 percent less waste” (Smith). You have a much more ideal work environment and more means to recycle.

Today’s track homes are constructed with little regard for their site. Newness is encouraged as a way of life, at the expense of reuse, frugality and quality. Their orientation doesn’t respond to an efficiency of use, but rather efficiency of economy. With the consolidation of the home builders fewer floor plans are available in an effort to make more money. Homes are sited with unprotected southern facades because of repeated floor plans. Local ecologies are disregarded and wetlands are filled disrupting complex ecosystem and watershed alignments. “We can raise the standard of home building as high as we want. We could increase the average life expectancy of homes fivefold. We could reduce energy requirements by 50% to 100% and all but eliminate waste of time and materials in the building process.” Modular/Prefab construction has its many advantages, which have not yet fully translated to the market. It will take entrepreneurs willing to take risks, and manufacturers with the knowledge and technology to back them. The auto industry is best aligned to take on a modular housing project of this nature.

Perception or Modular

Perception is reality. People react more toward their perception of reality than reality itself. Therefore the perception of modular and prefabricated construction in America has a great effect on its success or failure.

People have been jaded by bad examples of prefabrication...trailers. The majority of people are uninformed.



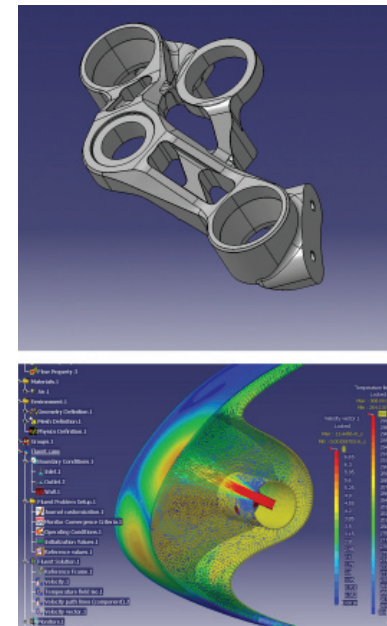
Figure 2.3 Mobile/Trailer home
“Abandoned Mobile Home.” <<http://south-floridadaily.com/?p=223>>.

Automotive vs Housing Workflow

78% of all new single-family homes completed were speculatively-built [house and land are sold together as part of the same transaction], up from 65% in 1986 (Characteristics of New Housing). Speculative builders rely on a limited number of floor plans and a repetitive construction technique to reach economic efficiency. Contractor to Subcontractor relations are a commonly associated with inefficiency. Keeping 20 subcontractors organized expensive, time consuming and exhausting. It is impossible to control delays caused by nature and almost as hard to control that many subcontractors. A study done over several years in the Phoenix area showed that 25% to 40% of a site built houses construction time is spent on building operations (Benson). Howard Bashford says, “The activity that occurs most often on a building is nothing” (Benson). With all these trades fighting for space on a job, in all kinds of weather, it looks crazy! Kent Larson from MIT’s open source building alliance said, “Building homes entirely on site now makes as much sense as building a car in your driveway” (Benson).

With more sophisticated costumers and greatly more complex products comes a need for greater knowledge and expertise for developing products. Car manufactures are quick to adopt new ideas. From the Henry Ford with the assembly line, to Toyota with the lean production model, car manufactures are constantly evolving with market needs and technologies. With the creation of Computer Aided Design [CAD] systems in the early 1980’s engineering reach a new era (Ameri). Each new release offered more than the previous. In the mid 1980’s came Product Data Management [PDM] (Ameri). PDM proved effective as a

Figure 2.4 PLM based, Catia software is capable of calculating part stress and strain in real-time, streamlining coordination efforts and empowering designers with accurate structural analysis. “Park Machinery.” <http://www.fer-mec.com/cart_eng/parco_macchinari_eng.htm>



database for engineers, but did not include any other disciplines. In the later 1990's came Product Life Management [PLM] with the goal of moving beyond the design and engineering aspects of a project creating a, "shared platform for the creation, organization and dissemination of product related information [cradle to the grave] across the extended enterprise" (Ameri). Car manufactures are taking advantage of PLM [product life management] solutions, allowing a more streamlined process from design to manufacture. PLM is the process of streamlining the flow of information about a product from concept to manufacture to service and disposal. At the core of PLM is a central knowledge base. From the knowledge base all questions are answered and solutions realized. Benefits include: Reduced time to market, improved product quality, reduced prototyping costs, savings through reuse of original data, reduced waste and savings through complete integration of engineering workflows (Ameri).

The adoption of these ideas and technologies is urgent. Our current system of information management from client to building is antique. Most firms are still collaborating drawings in 2d! With currently available technologies today's architect is more equipped than ever to tackle any project.

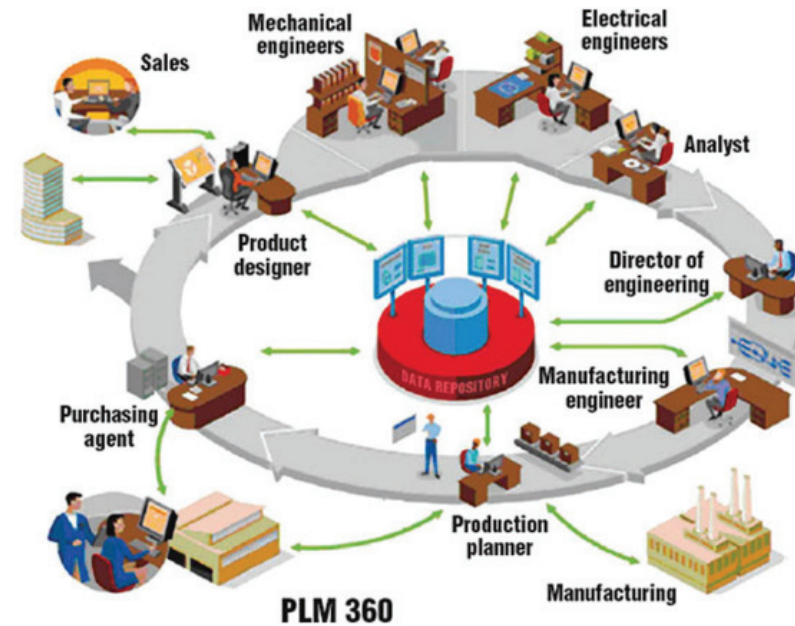
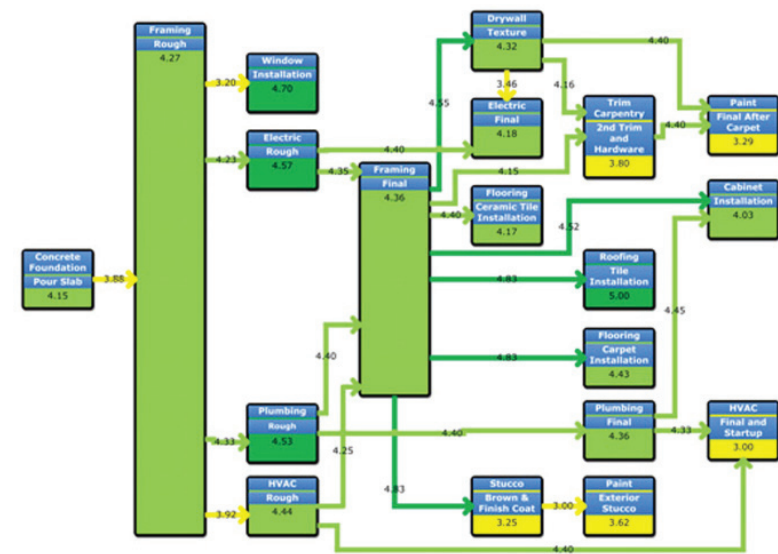


Figure 2.5. Above. Home construction workflow chart. "Process Performance Solutions." <http://fiq360.com/Solutions_Builder.htm>.

Figure 2.6. Below. PLM, central data query workflow. "Seven steps to complete PLM." <<http://machinedesign.com/ContentItem/69211/SevenstepstocompletePLM.aspx>>

Precedents

Automobiles Introduction

Websites, cars shows, conventions, endless press coverage and competitive races have all created a culture of enthusiast for cars. Cars are more accessible than houses, yet the cars that many enthusiast lust for are hopelessly out of reach. These enthusiast cultures create more informed consumers and motivate others to learn more about their hobby. Single family homes have not created enthusiast cultures similar to the automotive industry. This lack of enthusiast is in part related to the complexity, inflexibility, scale and cost of changes to a home. One of the only enthusiast groups for architecture is with skyscrapers and this enthusiast group relates more the hopelessly out of reach car fans of the car world. When looking at the automotive industry, a few cars stand out among enthusiast, consumers and time; like the Unimog, Jeep, and VW beetle. These three vehicles hold the longest production lives of any vehicle type (Wand). Through understanding their history, design intent, and enthusiast cultures a new outlook can be brought to home design.

Figure 2.7 Unimog in Dakar Race.
"2008 Dakar Rally Canceled."
<[http://howdywilcox.org/
?m=200801&paged=2](http://howdywilcox.org/?m=200801&paged=2)>.



Unimog

What is the Unimog? People have described the Unimog as, “A cross between a tractor, a tank – recovery truck and a tug boat”; others call it the “Swiss Army Knife of Trucks.” George Wand, of OffRoad.com calls it, “the European version of a Hammer, John Deere Gator, Oshkosh truck and several others – all blended into one pretty, powerful, precision-built vehicle.” Relatively unknown by Americans, Unimogs are now becoming available at limited truck dealerships. The Unimog holds the third longest production life of any type of vehicle.

The name “Unimog” was identified at the beginning of its life as a “motor-power universally adaptable machine for agriculture.” Its current name is a contraction of Universal Motor Gerat. The German word “gerat” translates to; apparatus, equipment, gadget, implement, machine and more (Wand). The Unimog defines beauty through technical appropriateness. The product line, has models ranging in size, power and use. It has been said that the Unimog can be configured eight million different ways (Wand). The Unimog's origin lies in post World War II Europe. After the war, European car manufacturers Porsche, Lamborghini, and Mercedes, in an effort to capitalize on war torn Europe's need for agriculture turned to making farm tractors. It was Albert Friedrich, a top designer and chief engineer for engine development at Mercedes Benz that first studied the idea of an all wheel drive agriculture vehicle.

Design Intent: It was to be a four wheel drive, vehicle with equal size tires and two lock differentials. The design specified high ground clearance portal axels, a small loading platform, a cab with a folding roof, and second seat for a helper. The vehicle was

to be driven at low speed in the fields, and high speeds on road for transporting. All models included a front center and rear power take off (PTO) as well as front and rear 3 point hitches.

This vehicle is important because of its unmatched flexibility. It can do anything and has. From plowing the fields to fighting fires, no vehicle has seen so many roles. The flexibility, is from an early design decision to include 3 standard connections allowing implements to be simply attached. It is also durable enough to pass down for years.

Figure 2.8 Unimog with detachable street sweeper.
“Schwarze Industries.” <<http://www.schwarze.com/PressReleases/A7UNIMOG.html>>.



Jeep

The “jeep” was commissioned for the United States Army. The first prototype Bantam BRC was created by American Bantam and then followed by two other prototypes by Ford and Willys. American Bantam was the first to produce the vehicle to specification, but its engine was underpowered, additionally the Army decided that American Bantam was too small of a company to handle the production needs of the War. There were 1500 of each prototype produced for exhaustive field testing, then a competitive bid.

The Jeep’s original design intent was clear:

- Carry men and Equipment through all kinds of Terrain.
- Weigh less than 1300 pounds so that it can be easily freed from terrain by a few men.
- 4 wheel drive
- 80” wheelbase

This vehicle’s success is in its mass production, customization and availability. Where the Unimog saw flexibility through attachments, the Jeep’s strength is mass standardization. Its standardized parts and economic accessibility have allowed large numbers of people to become enthusiasts.

Figure 2.9 Opposite.
Original Willys Jeep.
“Old Jeep Photos and Advertising.”
<<http://blogs.4wdandsportutility.com/6286200/miscellaneous/old-jeep-photos-and-advertising/index.html>>.



VW Beetle

The beetle idea dates back to Ferdinand Porsche and his vision for a mass produced vehicle that was affordable for the average citizen. This idea was mirrored by then young car enthusiast Adolf Hitler. In 1933 at the Berlin auto show, Hitler showed his intention to build the vehicle and choose Ferdinand Porsche to design it.

Hitler gave Ferdinand Porsche these specifications:

- designed for two adults and three children
- operate at 100 km/h
- get 33 mpg
- sell at the price of 1000 Reichmarks
- be as simple as possible (Dean).

The Beetle hit the US at time when horsepower and chrome ruled the land. This new beetle was a very small car and comedians were constantly making fun of it. The car was slow, it had trouble climbing steep hills, but it was reliable. This car made transportation available for those who couldn't afford the larger alternatives. The car was spot-on; it was a great democratic concept, from a very un-democratic mind. The beetle success lied in its simplicity and availability. This why it was adopted by a generation.

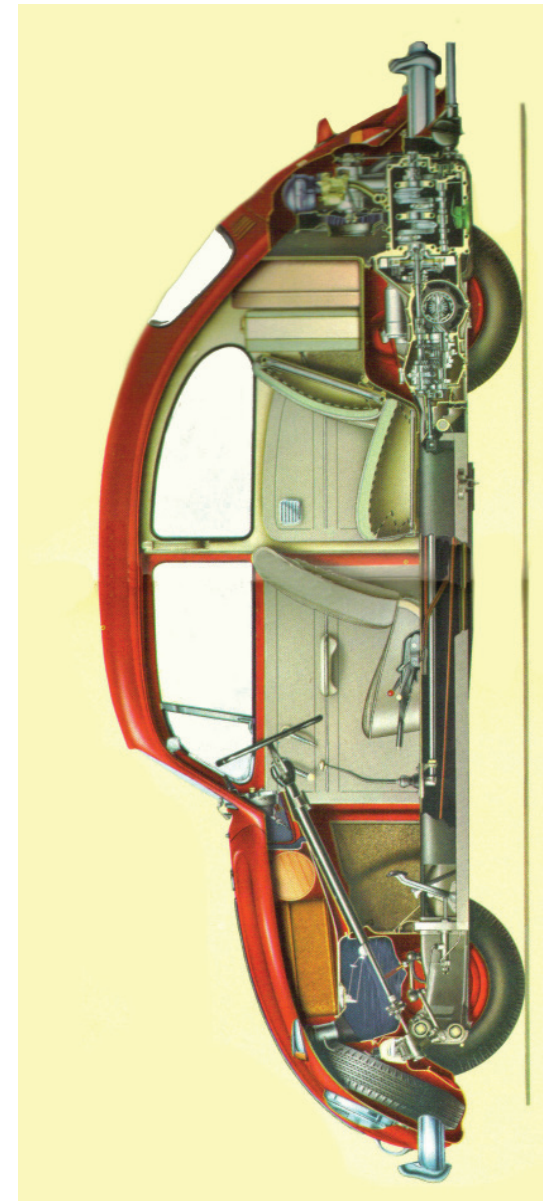


Figure 2.10
VW Beetle Section.
"1966 VW
Beetle." <[http://
www.1966vwbeetle.
com/](http://www.1966vwbeetle.com/)>.

Architecture Introduction

Today Americans are changing residence more than ever and their homes are as inflexible as they have ever been. An estimate 22 million people moved to new residences between March 1999 and March 2000 (Characteristics of New Housing). This need for flexibility is also evident in the 226.4 billion dollars spent on residential repairs and improvements (Characteristics of New Housing). This mobile lifestyle will only become more common in our ever changing global economy.

Pompidou Center

Why should one study a massive museum when trying to design, a house? The answer is actually quite simple; Changeability. Museums are in constant change, a sort of hotel of the arts. Curators must change spaces to accommodate each new exhibit. Not to unlike future homes under constant change from new residents, technologies and weather patterns.

Renzo Piano' and Richard Roger's Pompidou Center (Beaubourg) captured the spirit of change best. The building was programmed to be a center for the concentration of cultural information. Beaubourg was conceived as the ultimate flexible space. Did Beaubourg's flexibility aid it in accommodating art humanity and its unforeseen path?



Figure 2.11. Above.
Pompidou Center Plaza
Elevation.



Figure 2.12. Below.
Pompidou Center Detail

Silver, Nathan. *The Making of Beaubourg : A Building Biography of the Centre Pompidou*, Paris. Cambridge, Mass.: MIT Press, 1994.

Beginning

Two ideas came from President Pompidou: to hold an international competition and to build a museum. On December 11, 1969, the President of France, Georges Pompidou decreed that Paris was to have a “Centre erected in the Heart of Paris, not far from Les Halles, devoted to the contemporary art” (Silver). In July of 1970, the competition became a reality. Ted Happold, an execu-

Figure 2.13 structural detail.
Silver, Nathan. *The Making of Beaubourg : A Building Biography of the Centre Pompidou*, Paris. Cambridge, Mass.: MIT Press, 1994.



tive partner at Arup [engineering firm] in charge of structures 3, read about the cultural center competition in Paris and immediately sent in for the design package (Bosma). Happold discussed the competition with his colleagues then decided to lure Richard and Su Rogers on the project. After deliberation the group, including Peter Rice, Ted Happold, Richard Rogers and Renzo Piano entered the competition for Beaubourg, Centre de Pompidou.

Design

Rogers and Piano started to assemble their design team. The design team sought, “a right to suppose that invention, resourcefulness, and reason were the proper sources of architectural beauty, or truth” (the ethic rather than the aesthetic) (Silver 22). The flexibility began from the start involving a core of engineers and architects. Peter Rice and Ted Happold, from Ove-Arup [engineering firm] joined in on the brainstorming, contributing a page dedicated to the steel in the competition entry (Silver 29). Rogers and Piano had an unflinching belief in rational design as the only secure guiding principle. The team outlined fundamental considerations, including easy accessibility, and flexibility (Silver) “The Centre’s flexibility should be large [great] as possible. In living in a complex organism such as the Centre, the evolution of needs is to be especially taken into account” (Silver). The idea evolved into pushing out all the interfering things so that the inside would remain as flexible as possible. Out of the 681 valid submissions, their design was selected. It was decided on a vote, 8 of 9 jury members selecting Rogers’ and Piano’s scheme. As Listed by the jury, the top reason for selection was the designs “functional, flexible, polyvalent construction that is as adaptable as possible to needs, means, and tastes that are changeable and unforeseeable” (Silver 45).

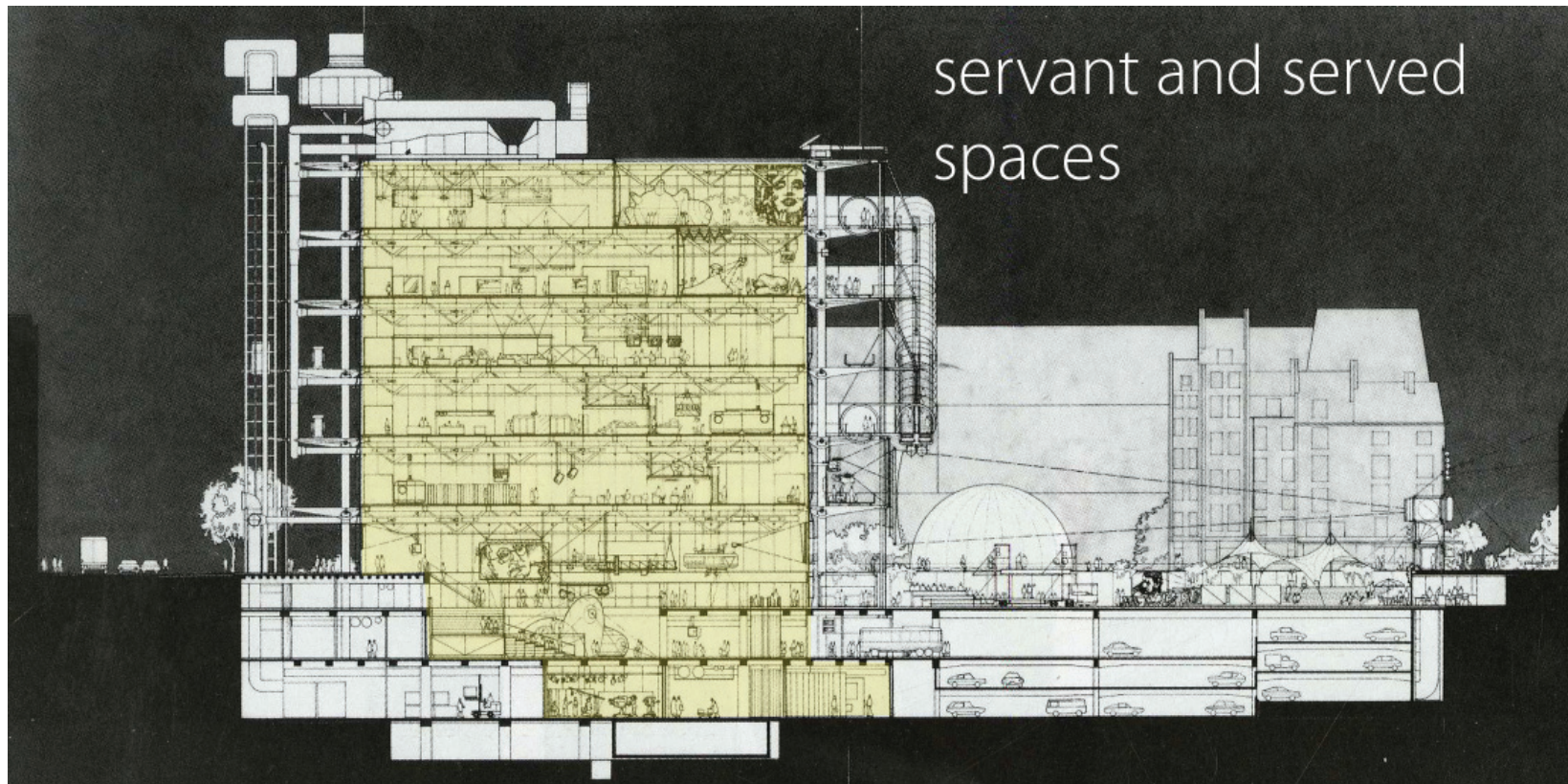
Construction

The construction was a tremendous enterprise occurring in factories and workshops far from the site (Silver 129). It was estimated that 2-3 times more makers, supplies and trades were employed because of the construction type (Silver 129). These

Figure 2.14 Section diagram showing servant and served space (yellow). Silver, Nathan. *The Making of Beaubourg : A Building Biography of the Centre Pompidou, Paris*. Cambridge, Mass.: MIT Press, 1994.

inefficiencies are to be expected when created a first of its kind building. Ventilators and mechanical pieces that were designed specifically for Beaubourg had to be inspected and checked by fire authorities.

The site work was to be an assemblage of prefabricated parts. The structural steel was conceived as a giant toy kit, each piece relating to another in a simple way. Site welding was to be avoided requiring that some pieces be very big (Silver 131). The pieces went up fast and without major problems, taking eight



months to erect the entire steel frame including floors (Silver 132).

Original ideas of two movable mezzanine levels, changed to one interchangeable level as a cost savings. Two years after the project was completed the client was asking for more mezzanine levels, showing the successful flexibility of the building (Silver 158).

In retrospect the design team would have further benefited from more time developing the plans and a less frantic construction. However, the building was completed within budget and on time (Silver 169).

Conclusion

The flexibility of Beaubourg can be looked at two scales. First, at the scale of the expansive column free floors which were designed to allow full flexibility of exhibit design. Benefits of this system in comparison to traditional museums are not well documented; however large scale flexible spaces in the Tate Modern not only changed the way we display art, but also the way art is created. Similar characteristics can be noted for Beaubourg.

At the larger scale the success of the building is not currently through its physical flexibility, but rather the spirit of the idea. In 1997, the Pompidou Center called on Rogers and Piano to update Beaubourg. Renovations included the addition of mezzanine levels and repairs from overuse. The Mezzanine levels, although easier to install than on traditional buildings did not show time or cost savings over traditional construction.

“The inside out of Beaubourg’s mechanical equipment was exposed partly for fire safety, partly to keep the interior free and flexible, partly for expression, and partly through the recognition that it was the major building element likely to be soonest replaced, upgraded, adapted, or made more energy efficient” (Silver

148). Other long life buildings have shown the need for mechanical accessibility; however the exposure of mechanical equipment was a bad decision. Weather resistance on this equipment was a concern, electric lines had to be water tight, water lines had to prevent freezing and sheet metal ducts had to be finished to resist rust. Many of these problems were solved through readymade fixes; however the finishing was crucial and costly. These problems in addition to wear and tear from over success closed Beaubourg for 27 months in 1997 (BBC). The separation of servant and served spaces are well executed in the total inversion of the building. This decision gives curators the flexibility of massive column free floors to work with.

The spirit of Beaubourg is unflinching, from the young energetic architects who designed it to the street performers currently in the plaza. Beaubourg is a celebration of the arts, like the iPod is a celebration of personal music. They may not be the most economical, or most functional but they embody the spirit more than any of their predecessors. That is why we love them.

It may take 200 years before we realize the potential of this design. A time when we see traditional buildings torn down and replaced wasting precious materials and costly labor; and Beaubourg continually growing with each generation.

Translation to the home

Ideas learn from the design and construction of Beaubourg can be translated into designing and constructing a home. Collaboration with different disciplines early is a must. Rice’ and Happold’s early involvement benefited the project in many ways. It was crucial to them winning the competition and constructing the project. The Ove-Arup [Rice and Happolds firm] collaboration

gave the comity confidence in the relatively unknown Piano and Rogers to build the project (Silver 42).

The strong bond and clarity of concept created early between the design team allowed them to stay true to their design through tough times in construction.

The complexities of the Beaubourg design were not able to be understood by one person. It wasn't a heroic architect creating a masterpiece; it was several likeminded people learning to make rational decisions. This method of working was effective and efficient, considering the complexity and newness of the design. The separation of servant and served space is especially applicable to housing. The idea of potential a wall or service core would lend well to ideas of prefabrication while allowing infill or the incorporation of a relic.

Lessons Learned:

Keep dreaming - a good idea lasts forever

Collaborate – not one person can fully grasp today's modern buildings

Surround yourself with good people – Ted Happold, enlisted the brilliant Rice, and sought after Rogers. Rogers enlisted Piano.

Great ideas may not be fully realized till long after they are created.

Emotive Study

John Habraken is a Dutch architect, educator, and theorist. The focus of his career was not from the view point of architect as an artist, but rather a designer for the millions of ordinary people. In the 1960's Habraken studied mass housing in the Netherlands, finding monotony and a lack of occupant participation. After seeing this he devised a system of support and infill that would essentially split the construction of mass housing into two parts; the communal [support] and the part of private responsibility [infill]. "A support structure should be interpreted as an autonomous, durable structure, comparable to a highway" (Bosma 92). The support structure should contain connections for electric, sewer and other general connections (Bosma 92). The support structure is extremely durable and will outlive the infill. The infill is created and commissioned by the occupant allowing each infill to be unique.

Habraken says that the first step is to consult with the authorities and all parties involved, requiring cooperation from municipalities (Bosma). The second step involves the creation of a prototype, along with clear regulations and high quality standardized parts (Bosma 106). After these steps are taken the most difficult part will be changing the opinions, and clearing up misconceptions (Bosma 106). "Housing does not require a masterpiece of design; what it needs are freedoms to grow and change" (Bosma 92).

Habraken's ideas are very important issues for inhabitants of the house. It takes a humble designer to incorporate human needs and desires so well, in such a large context. Though this thesis will deal with repetitive elements, it will be at a smaller scale than many of Habraken's studies. The idea of support and infill is

essential tied to the creation of an enthusiast for the home. Just like Jeep owners modify their trucks, to their needs and style, the Live-In Chassis will support aftermarket parts and user add-ons. People like to personalize their VW Beetle after all.

The studies outlined above have already begun to carve a path toward a more clear thesis. Understanding the background of an object's design and the original intent, is paramount to understanding a process. In looking back, many of the case studies highlight the need for rules of design; from Hitler's command for the beetle, to the Unimogs connections of necessity. When looking at the ideological workflow of home construction, the need for a paradigm shift is evident. Other industries are paving the way, the building industry must first learn, then act. Most importantly, the human must be at the center of all of this. After all that is who we design for.

Design Research

Sizing and Grid

To design the most flexible system you don't design objects, you design rules. Objects are designed through arrangement and adornment, rules can be designed within. This case study focuses on setting a grid [rule] for the FASH house. First looking at US Census data, then precedent studies to understand the scale of homes.

Conclusion: The home should not be designed to a standard size but rather have a standard set of pieces that accommodate a variety of conditions. The Plenum wall acts as an expandable spine. The flexibility possible in a FASH system will allow homeowners to scale their house as needed. Instead of buying a large home in expectation or a large family, inhabitants will be able to quickly add on as needed. The scalability will bring an economy to living, where we are using what we need. Conceptually similar to the scalability of computing found in the IBM Blade Center, where modular computer "blades" are exchanged and updated as needed into a larger chassis.

A base grid of 900mm x 900mm will be used as a base dimension for many building components including the; floor system, plenum wall, and infill system.

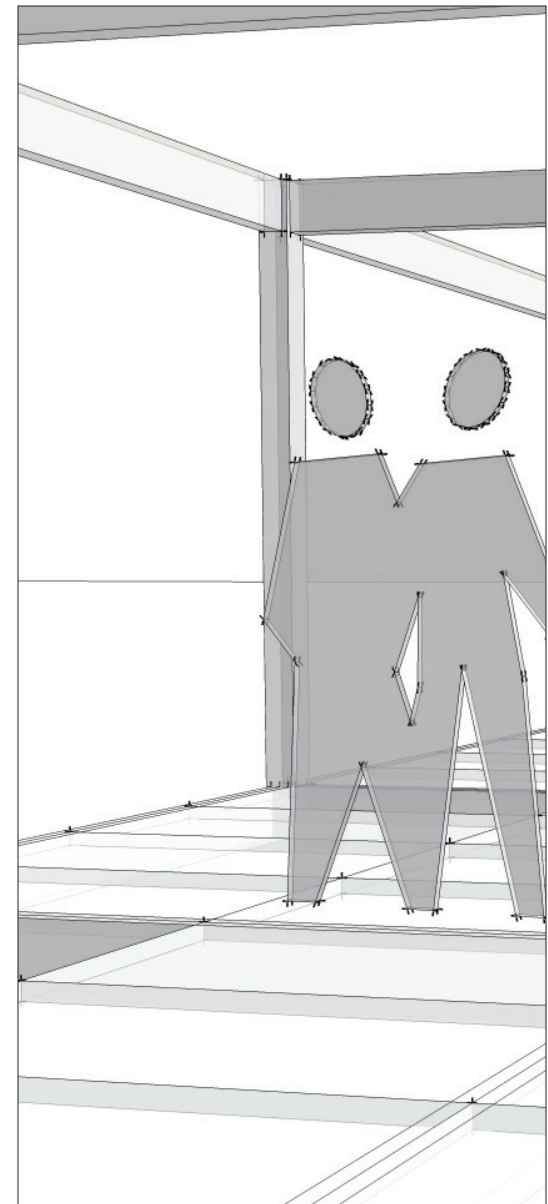


Figure 2.15. Grid Study.

US Census

The most common single family home since the 70s has been the 3 bedroom 2 bath. This configuration is marketed to both the low and high income brackets. There are noted trends moving toward more square footage, more rooms and more bathrooms. These trends are not linear; it seems that there are two markets in housing as show by the double bell curve in figure 1. This gives a 1600 sq. ft. module the ability to take part in both the 1600 – 1999 sq. ft. and 3000 or more sq. ft. markets by simply modulating two units. The trend toward more space, rooms, and bathrooms will be affected by the housing crash of 2007 and the energy crisis. These two factors could produce a shift away from larger homes back toward a more clearly defined double bell curve. The most universal house for single family America is a 3 bedroom, 2 baths, approximately 1600 sq. ft. core with potential add-ons for more square footage and the ability to work two units in tandem.

There are several trends to note in figure 2.16. First, the double convex curve forming around 1600-1999 sq. ft. and 2400-2999 sq. ft. showing the most common square foot ranges. This double hump is showing two distinct square footage groups in 1976 [dark blue], that slowly are becoming less severe in 1981, and 1986. The next trend starts in 1991, when the 1600-1999 sq ft curve is maintaining and the second hump levels off showing a change toward larger square footage homes. This trend become more evident through 2006, when a defined hump is seen at 1600-1999 sq ft transforming to a progressive rise toward homes 3000 sq ft and more.

The 1600 ft home has historically proved itself as lasting trend in housing. By doubling the 1600 sq. ft. module (3200 sq. ft.) this system is positioned to capture the growing trend for larger

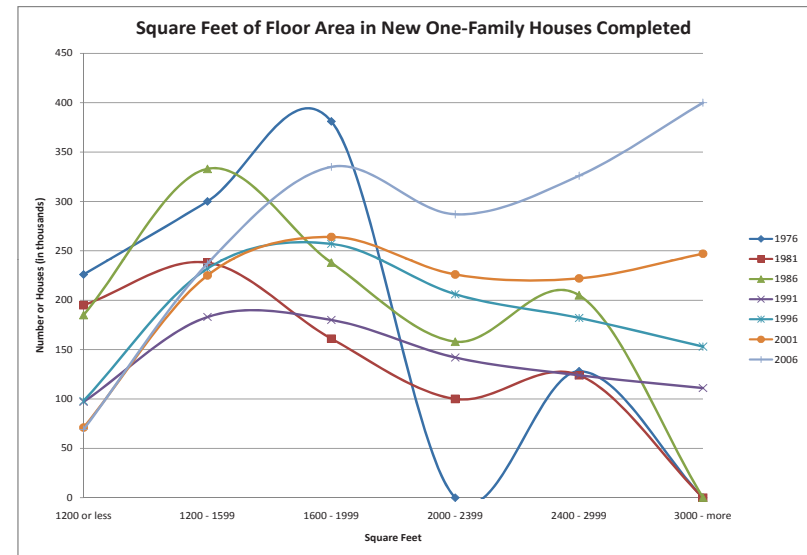
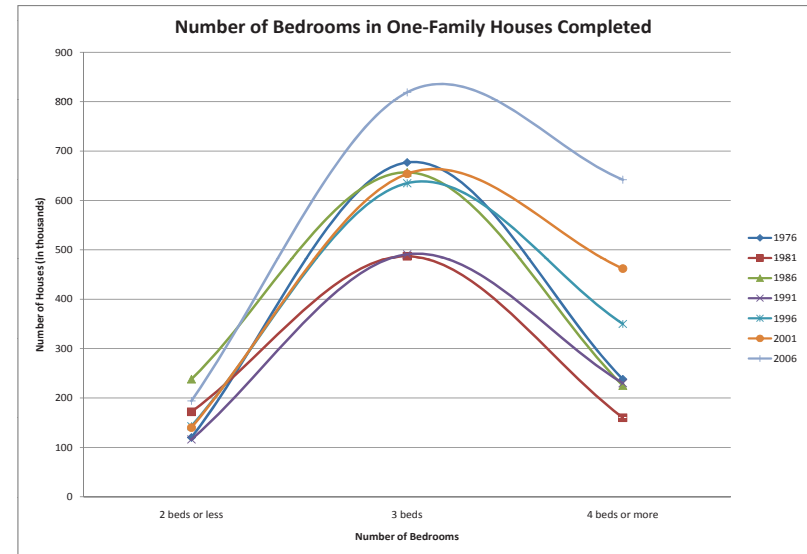


Figure 2.16. Square feet of floor area in new one family houses completed.

Figure 2.17. Number of bedrooms in one family houses completed.



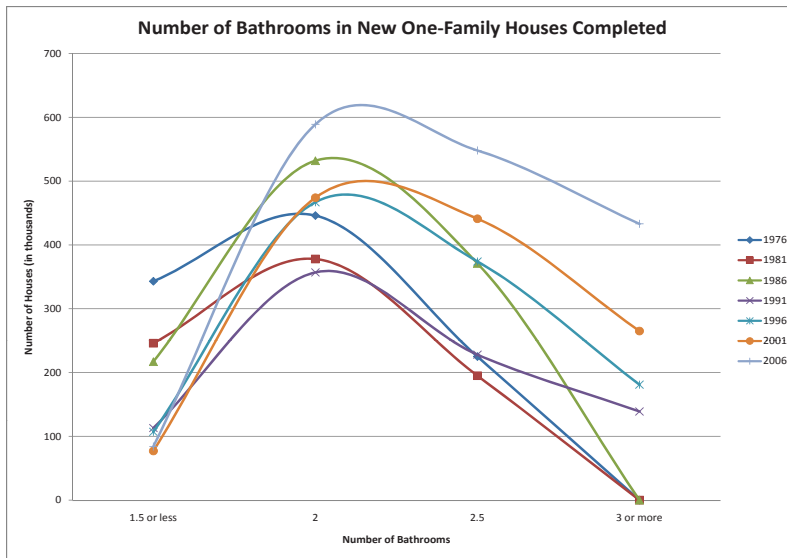
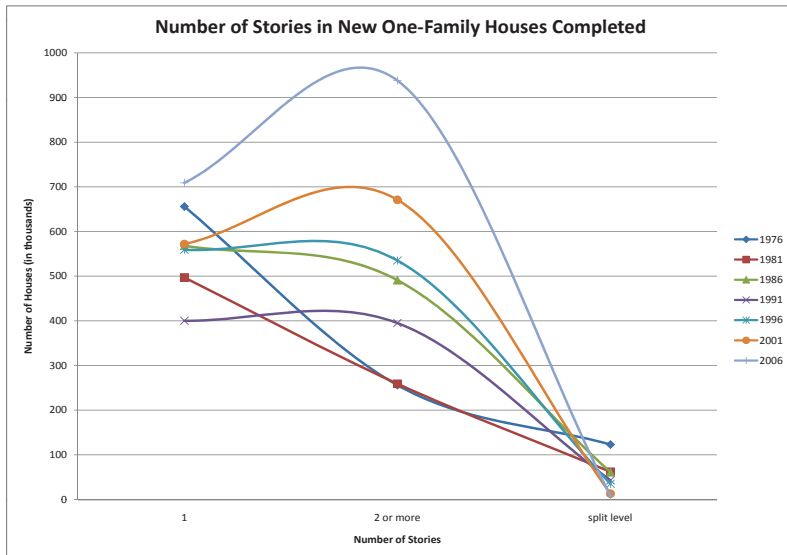


Figure 2.18. Number of bathrooms in new one family houses completed.

Figure 2.19. Number of stories in new one family houses completed.



homes.

Figure 2.17, shows an evident peak at 3 bedrooms, and a growing trend toward 4 bedrooms or more becoming more evident in 2006.

Figure 2.18, displays a clear peak at 2 bathrooms and a growing trend toward 2.5 and 3 or more as the graph gets closer to 2006.

Figure 2.19, shows the growing trend for multi story homes. This can be for a few reasons. One might think the rise in land value has caused the trend. But US Census data highlights that there has been a consistency in land size for single family homes. If we are building on the same size land and our homes are getting bigger there is only one way to go, up. The average size home built in 2006, before the housing crash of 2007, was 2,469 769 sq. ft. up 769 sq. ft. from 1976.

Figure 2.20 highlights several trends in multifamily housing. The great rise in multifamily housing in 1980, focused on units sized between 800 and 999 sq. ft. This 800-999 square foot trend was growing since 1976. Starting in 1991, the square footage curve starts to flatten out, as larger units become more popular. In 2006, units took a sharp toward the 1200 and larger bracket showing the first convex curve. This trend is noted before the housing bust of 2007, but can be expected to be on the rise with the rising energy costs, and the eminent growing cities.

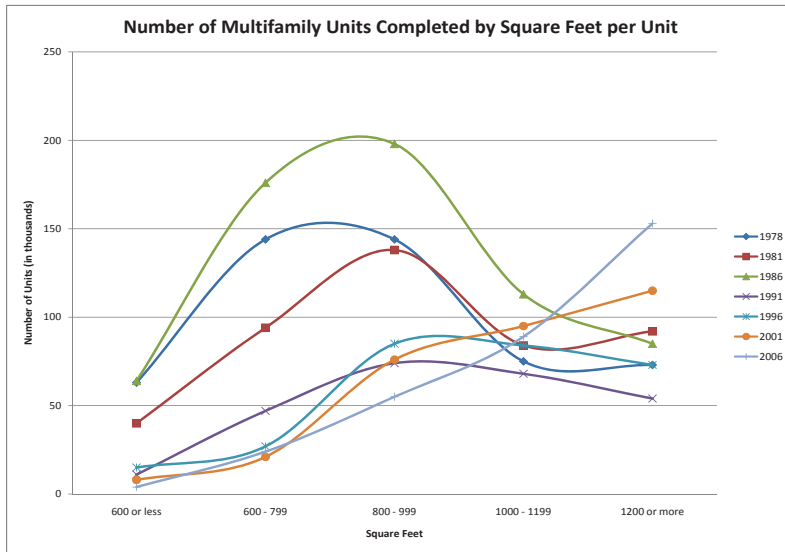


Figure 2.20. Number of multifamily units completed by square feet per unit.

Figure 2.21. Number of multifamily units completed by number of bedrooms per unit.

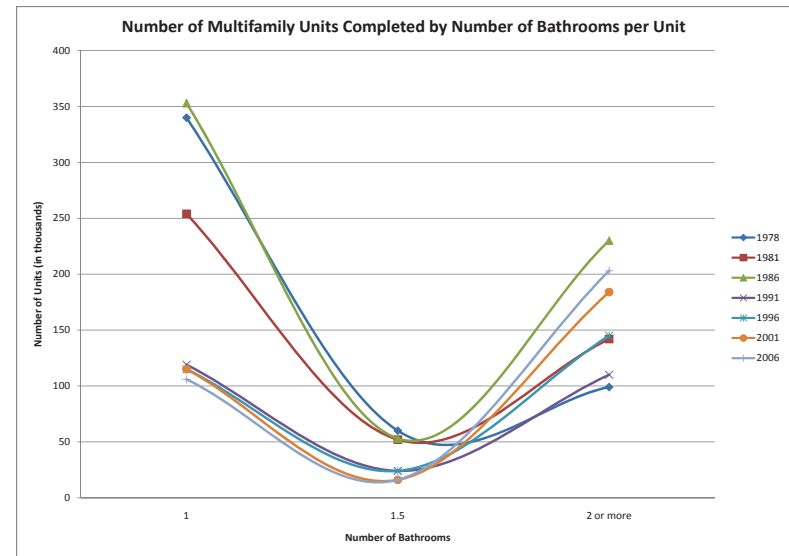
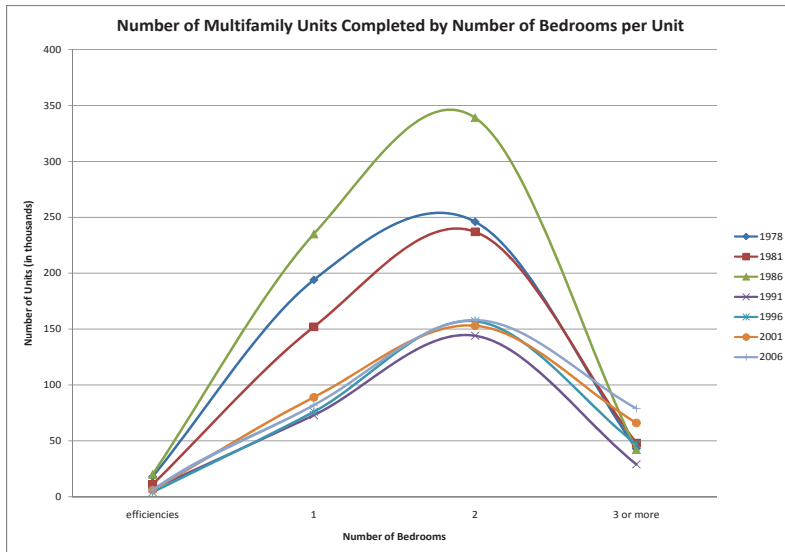
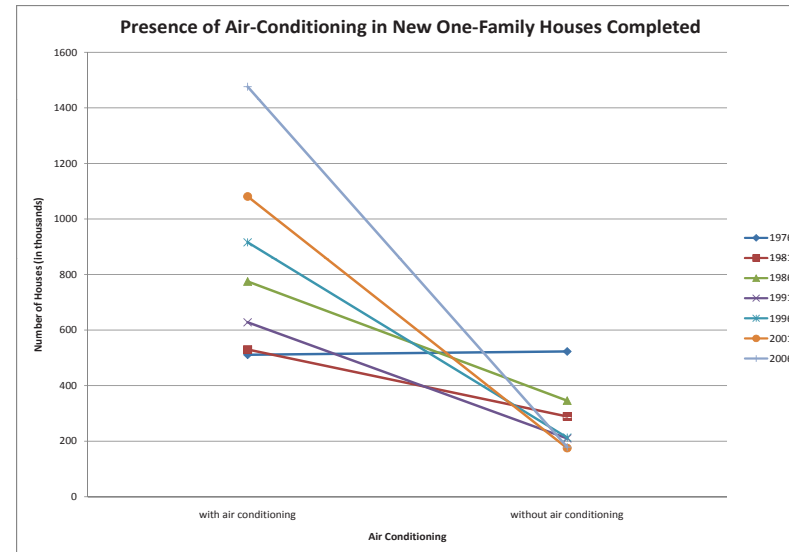


Figure 2.22. Number of multifamily units completed by number of bathrooms per unit.

Figure 2.23. Presence of air-conditioning in new one family houses completed.



The most common single family home since the 70s has been the 3 bedroom 2 bath. This configuration is marketed to both the low and high income brackets. There are noted trends moving toward more square footage, more rooms and more bathrooms. These trends are not linear; it seems that there are two markets in housing as show by the double bell curve in figure 1. This gives a 1600 sq. ft. module the ability to take part in both the 1600 – 1999 sq. ft. and 3000 or more sq. ft. markets by simply modulating two units. The trend toward more space, rooms, and bathrooms will be affected by the housing crash of 2007 and the energy crisis. These two factors could produce a shift away from larger homes back toward a more clearly defined double bell curve. The most universal house for single family America is a 3 bedroom, 2 baths, approximately 1600 sq. ft. core with potential add-ons for more square footage and the ability to work two units in tandem.

Conclusion: The home should not be designed to a standard size but rather have a standard set of pieces that accommodate a variety of conditions. The Plenum wall acts as an expandable spine. The flexibility possible in a FASH system will allow homeowners to scale their house as needed. Instead of buying a large home in expectation or a large family, inhabitants will be able to quickly add on as needed. The scalability will bring an economy to living, where we are using what we need. Conceptually similar to the scalability of computing found in the IBM Blade Center, where modular computer “blades” are exchanged and updated as needed into a larger chassis.

A base grid of 900mm x 900mm will be used as a base dimension for many building competents including the; floor system, plenum wall, and infill system.

Precedent Studies

Three precedent studies were selected to further understand the scale of inhabitants, ultimately seeking to design the grid through research.

Loblolly House

The first precedent study looked at Kieran Timberlake's Loblolly House. Kieran Timberlake's practice is run as a sustained research project, with over 50 architects in their Philadelphia office. The Loblolly House is aimed at rethinking architecture in regard to new industrial production techniques. Their research touches on the digital collaboration capable with new BIM, Building Information Modeling practices. Their approach deals with the creation of complex and diverse parts assembled into units before delivery to the site for assembly. They continue the modern tradition in separating frame and infill.

The Loblolly House is located in Taylors Island, Maryland. Summer time temperatures reach over 100 degrees Fahrenheit and 75% humidity. The house is designed to use as little mechanical air-conditioning as possible.

Figure 2.24. Loblolly House. Kieran, Stephen, and James Timberlake. *Loblolly House : Elements of a New Architecture*. 1st ed. New York: Princeton Architectural Press, 2008.



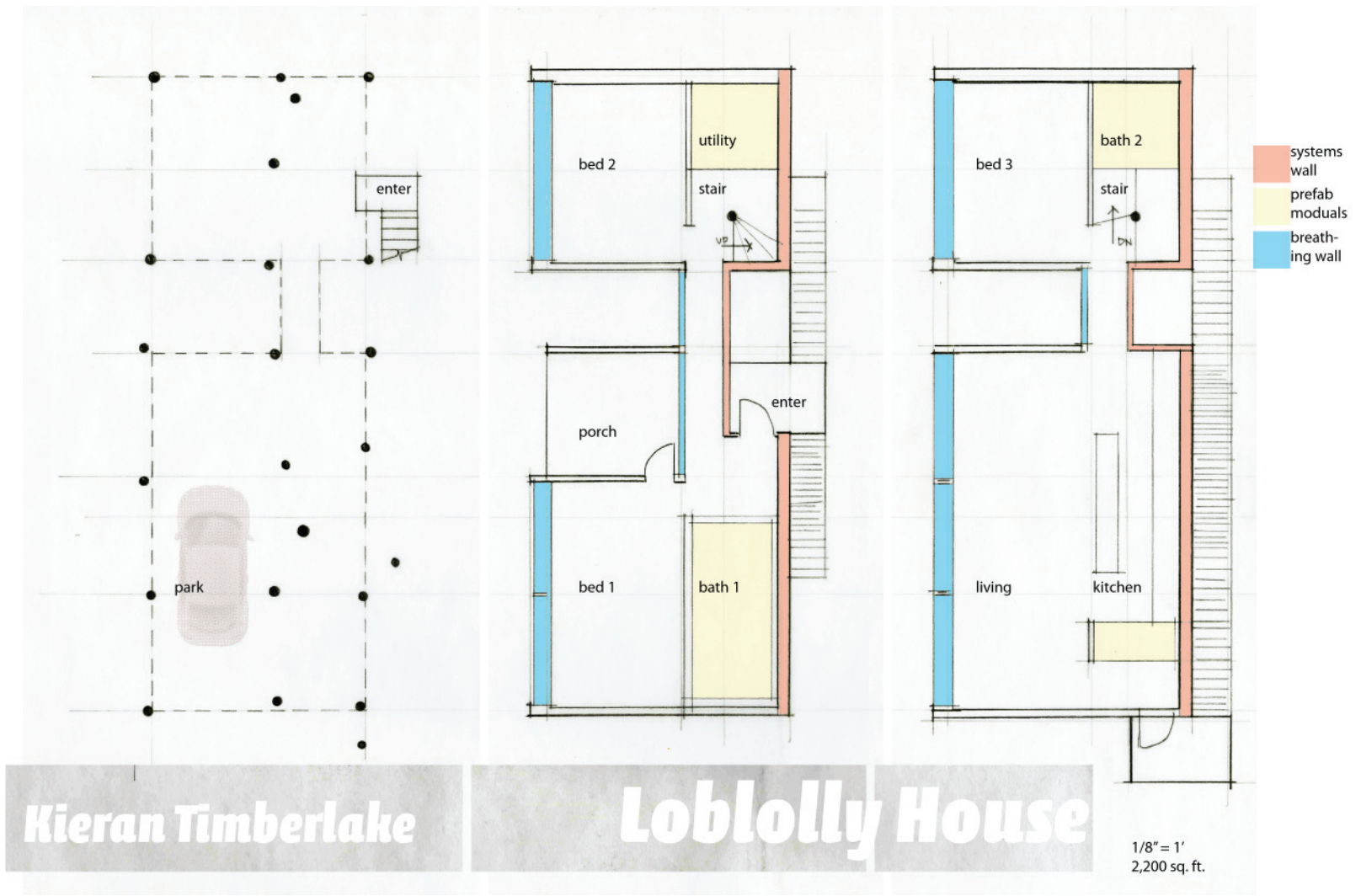


Figure 2.25. Loblolly House diagrammatic plans.

The house is crafted from aluminum, glass, poly carbonate and timber. The elements of a house are arranged into 5 areas, in contrast to CSI's 50 sections; site [piles and utilities], scaffold [structure of frame], floor/ceiling cartridges [wood-shethed floor, ceiling and roof panels with integrated mechanical and electrical systems], block [bathrooms enclosed in wood, with mechanical rooms and integrated fixtures, equipment, piping, wiring and ductwork], and wall cartridges [wood-shethed panels with integrated windows, insulated, cement board, and vapor barrier].

As seen in figure 2.25, the Loblolly House is broken down though an underlying 12' grid. This is evident in the overall room sizes 12'x16', 12' x24' etc. Another important dimension is the total width of the building, being 24'. This dimension allows for rooms and bathrooms to coexist horizontally, as seen in the first floor plan above. If the dimension were to get any smaller than 24', both the room and the bathroom would lose their proportional relationship, leaving an elongated room or cramped bathroom. The yellow portions of the plan show the fully prefabricated cartridges as sitting in the scaffolding.

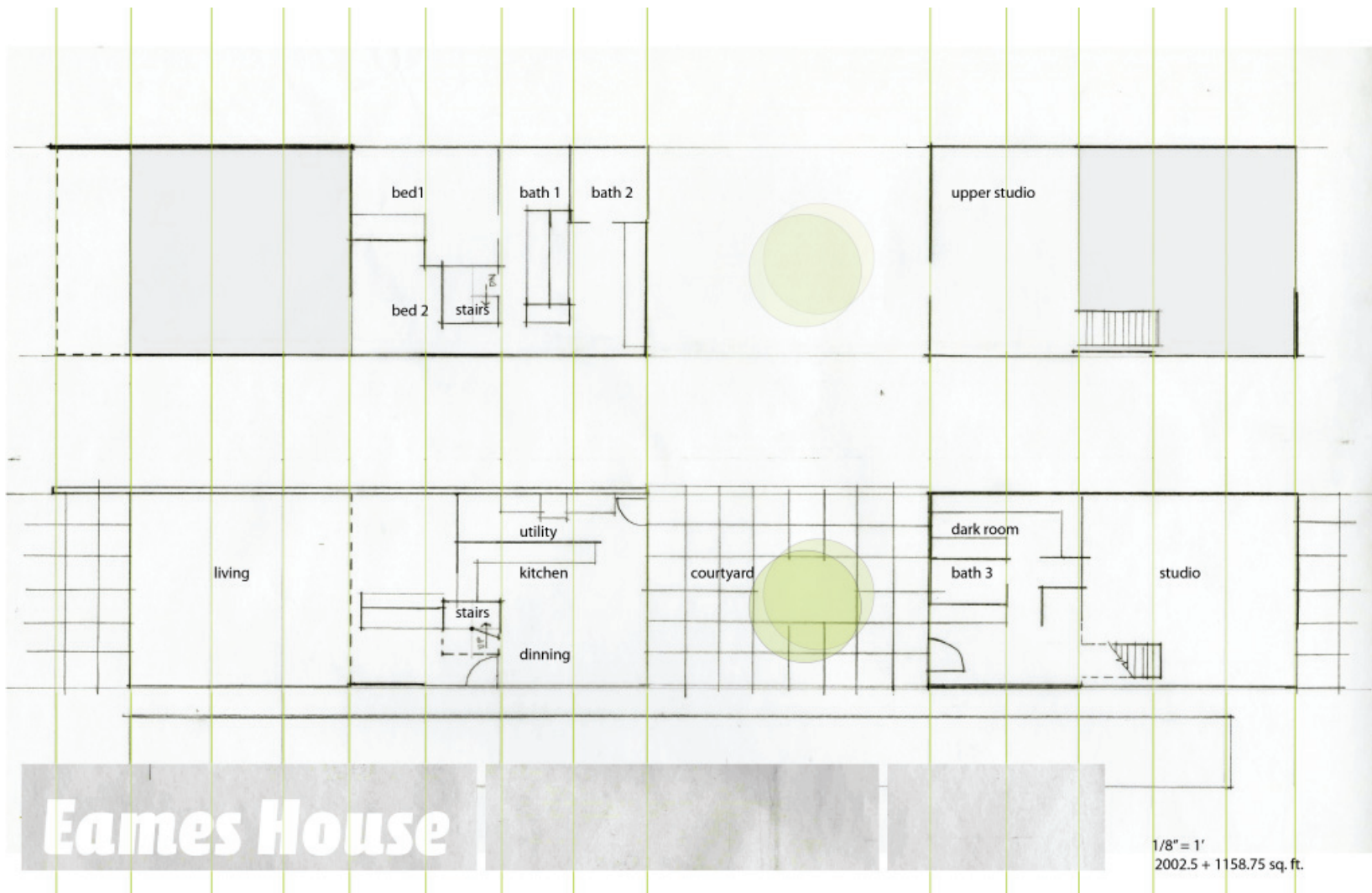


Figure 2.26. Eames House floor plan study..



Figure 2.27. Opposite. Eames House section study.



Construction - Entire building is prefabricated off site, then transported to site. Size is limited by transportation methods. Low ceiling heights due to height limitations on transportation.

Systems integration - Systems are routed similar to typical site built home. Space under house becomes plenum.

Target Market - Low to middle income. Limited to rural or suburban use.

Upside - Low cost. Fastest option. Very minimal site construction.

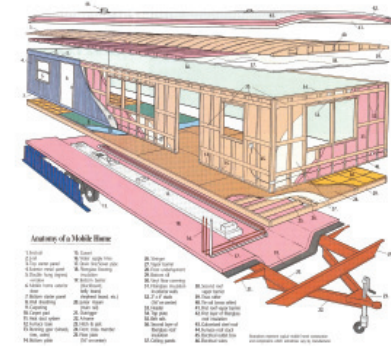
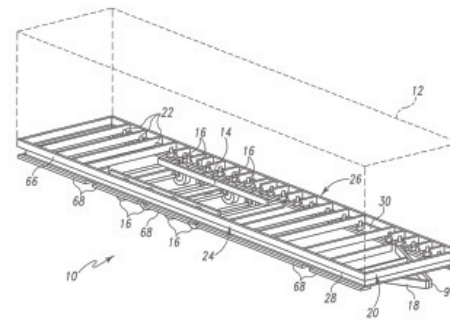
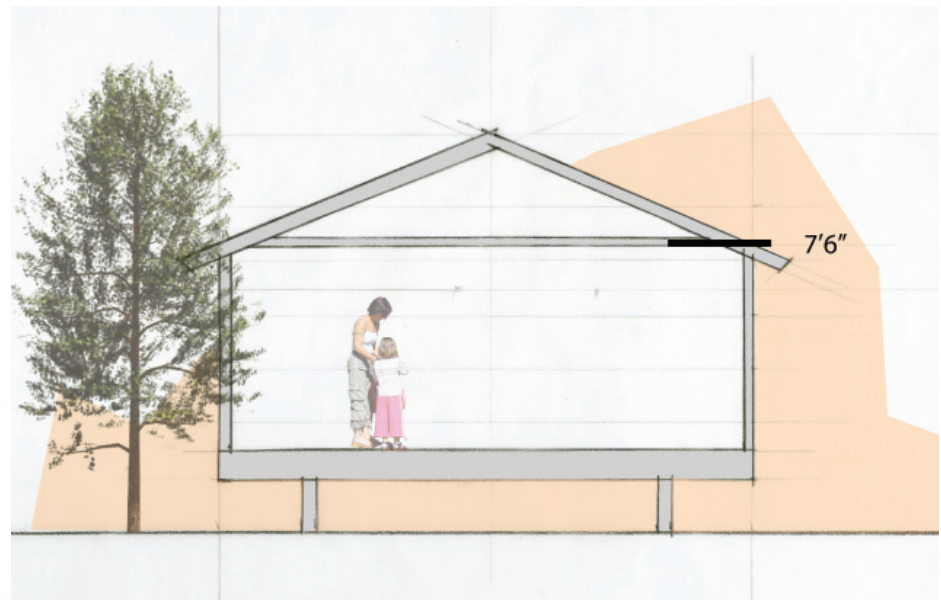
Downside - Limited configuration. Low ceiling heights. Similar configurations. Horrible public perception.. Doesn't stand up to inclement weather. Manufactured homes depreciate in value. Do not meet local building codes.



Mobile Home

1/8" = 1'
1120 sq. ft.

Figure 2.28. Mobile Home floor plan study.



Mobile Home

Figure 2.29. Mobile Home section study.



After looking at US Census data and precedent studies, the next step was to start designing the grid. Knowing that the approximate 24' width for a home was the best scale of space for economy and proportion, I started looking at the metric equivalent that would bring logic to the project. This logic needed to be evident at both the scale of the building and also the scale of the individual. 24' equals 7315.2mm. This dimension can be rounded up to 7400mm [3700, 1850, 925] or down to 7200mm [3600, 1800, 900]. The simplicity of 7200 at the large scale is equal at the small scale. Additionally 900mm equals 35.43", a workable size that is good for scaling space in a 2 dimensional floor plane and in a vertical plane, where 35.4" is equal to the standard working counter height. Ironically a 900mm x 900mm system is not new to the construction world. The Japanese have been working with 900mm x 1800mm Tatami for over a thousand years. This system has proved to be a great module for scaling rooms while keeping human proportion close at mind.

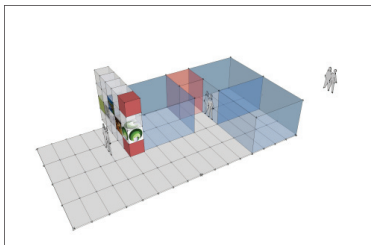


Figure 2.30. Floor Diagram 1

Figure 2.31. Floor Diagram 2

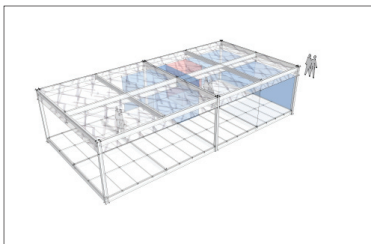
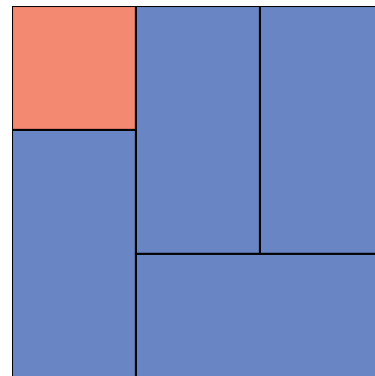


Figure 2.32. Above. Japanese Tatami. "Jack's Crisp." <<http://www.jackcrisp.com/store/productimages/tatami1900.jpg>>.

Figure 2.33. Below. Tatami Diagram.



Once the 2d grid of 900mm x 900mm was set, the next step was to determine a good ceiling height. Figure 2.34 shows, several common widths of space and how they are affected by different ceiling heights. The top row, 2300mm, shows a comfortable proportion at a width of 1750mm, but is cramped at the other widths. After analyzing the chart 2600mm, is determined to be the best ceiling height showing good proportions in larger widths with only a marginal loss of proportion in the 1750 width.

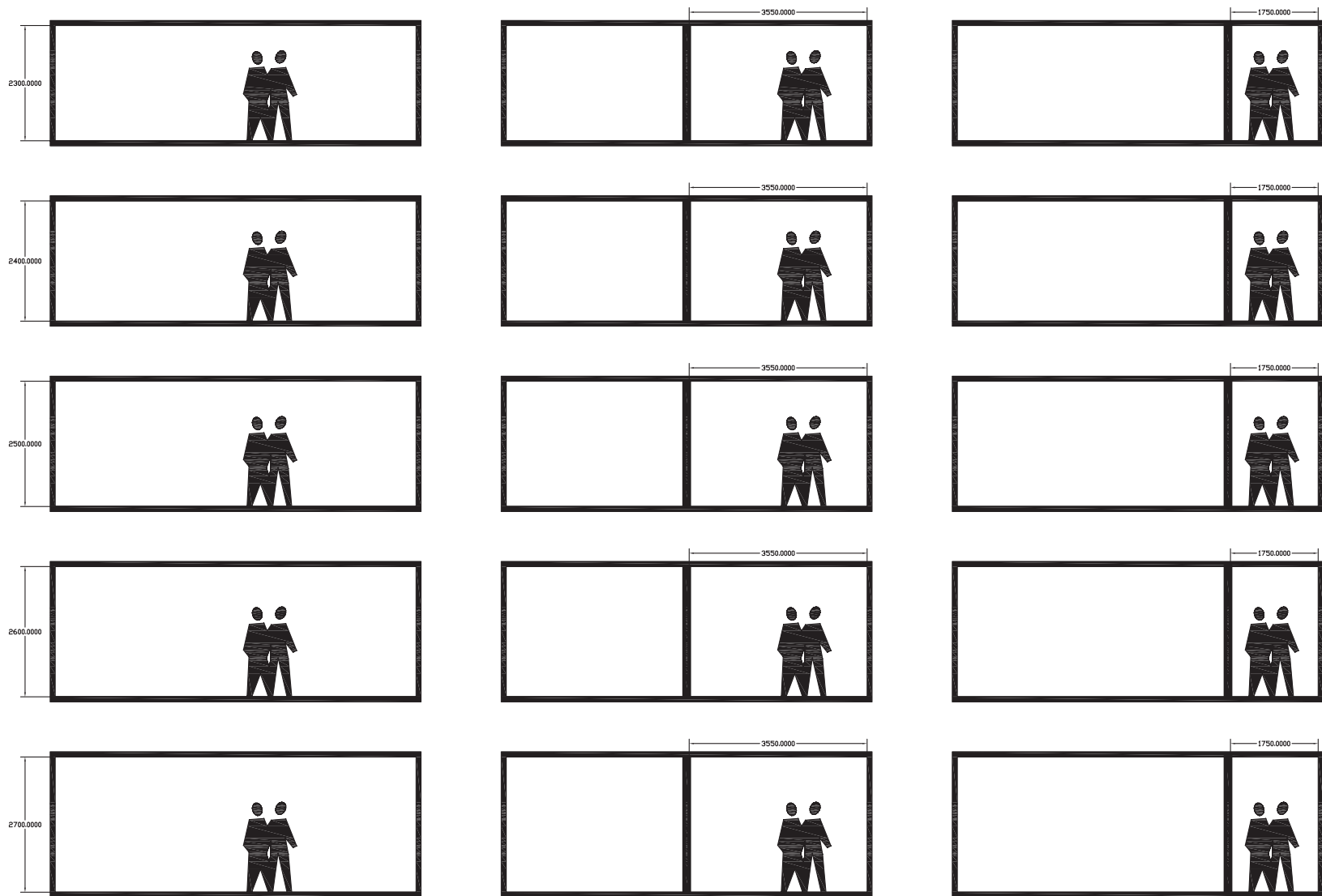


Figure 2.34. Ceiling height study.

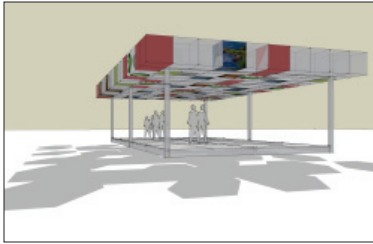


Figure 2.35. Plenum grid study

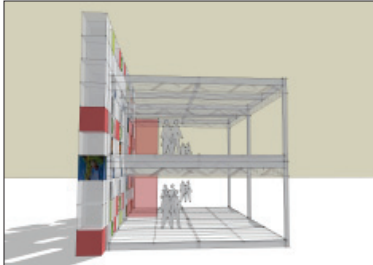


Figure 2.36. Plenum grid study

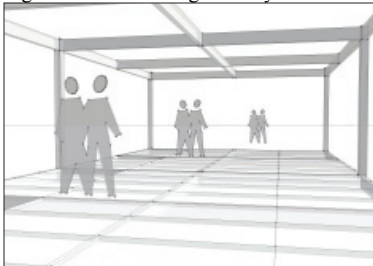


Figure 2.37. Plenum grid study

Figure 2.38. Plenum grid graphic

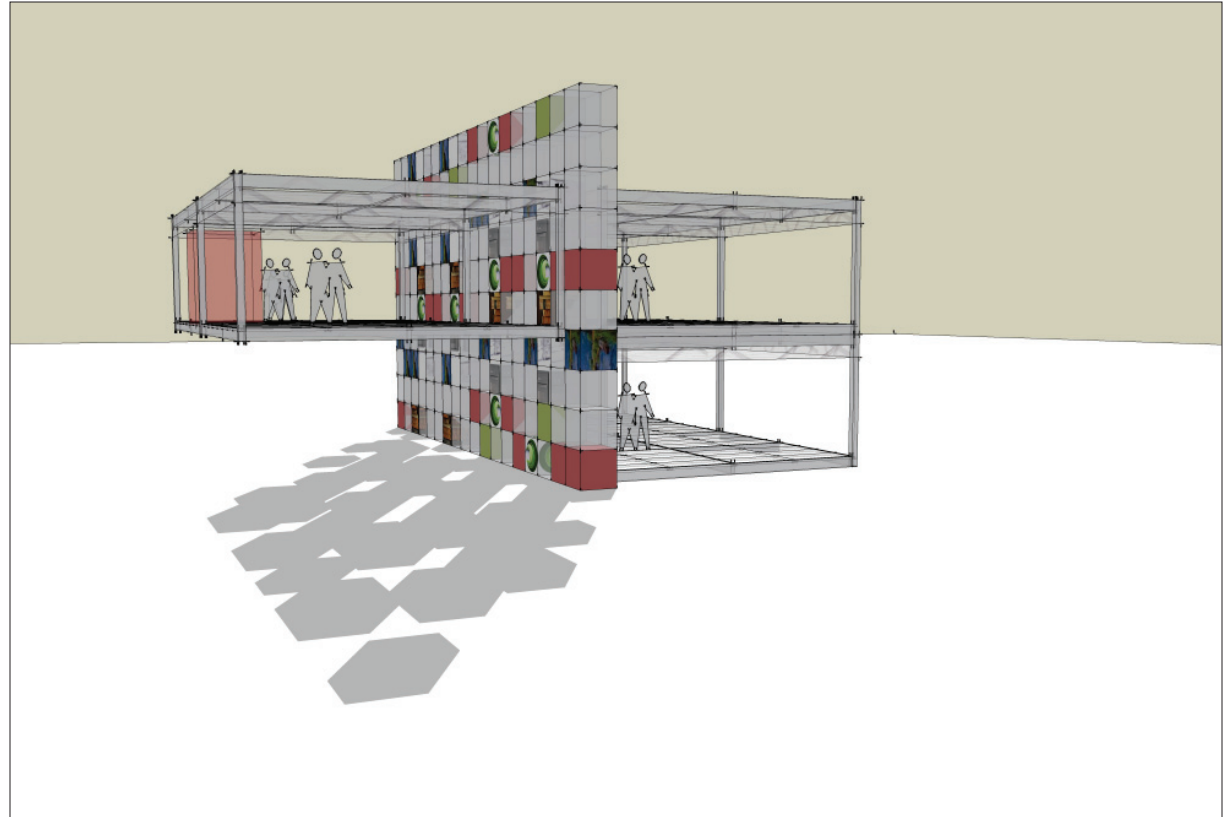


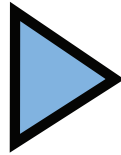
Figure 2.39. Plenum grid study



plenum wall

3.0 DO_deSIGN

Early Process



Design starts as soon as the problem is identified. In order to let the project properly evolve from its influences, the designer must be clear of preconceived notions. The process of disconnecting from preconception is difficult and near impossible. In attempt to disconnect from these notions, early visioning sketches take place. These sketches models and ideas are recorded for the purpose of mind cleaning. After a mind clean the designer is ready to move on to other ideas. This mind clean gives the designer a proper mind set to create a controlled balance between intuitive design and analytical design. Allowing early intuitive process sketches to evolve into schematics through research.

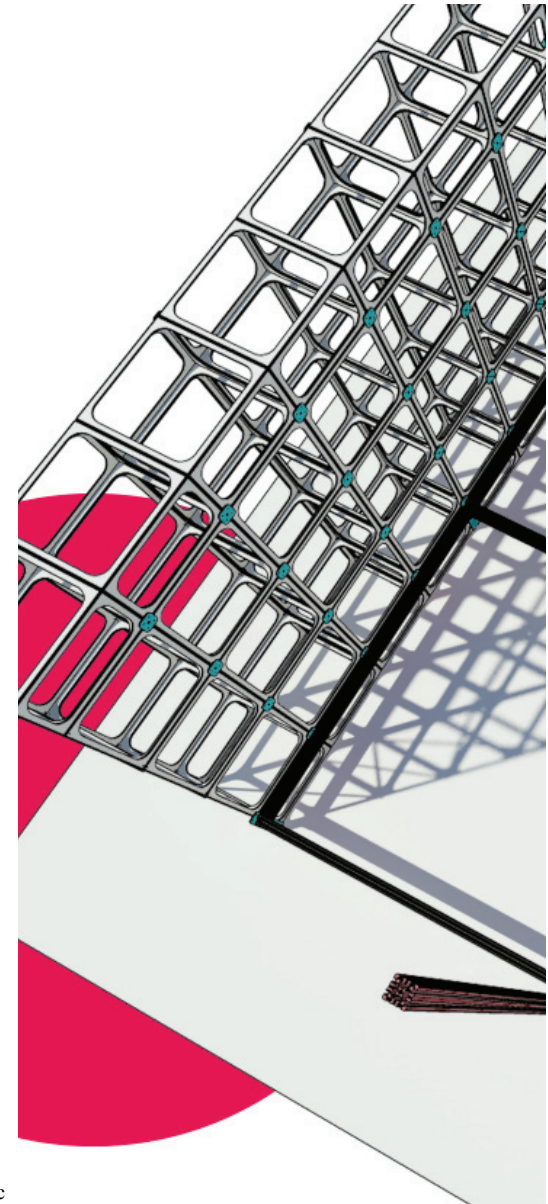


Figure 3.1. Structure graphic

A crucial part of design is identity. An easily identified name and graphic adds necessary continuity and closure to any design proposal. Early in the process the F.A.S.H. name was adopted, representing the goals of the project,

FLEXIBLE AUTONOMOUS SYSTEMS HOUSE.

This identity continually sparked interest amongst those who came in contact with the project.

Figure 3.3, is of early process sketches. The sketch circled marks the instant the design was born. The plug and play ideas clearly seen.

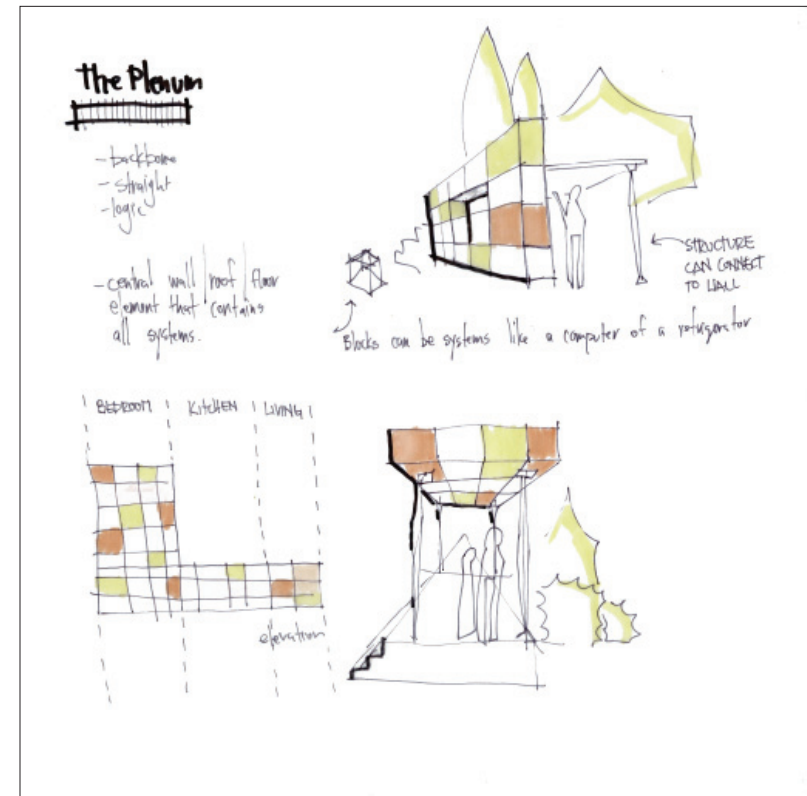
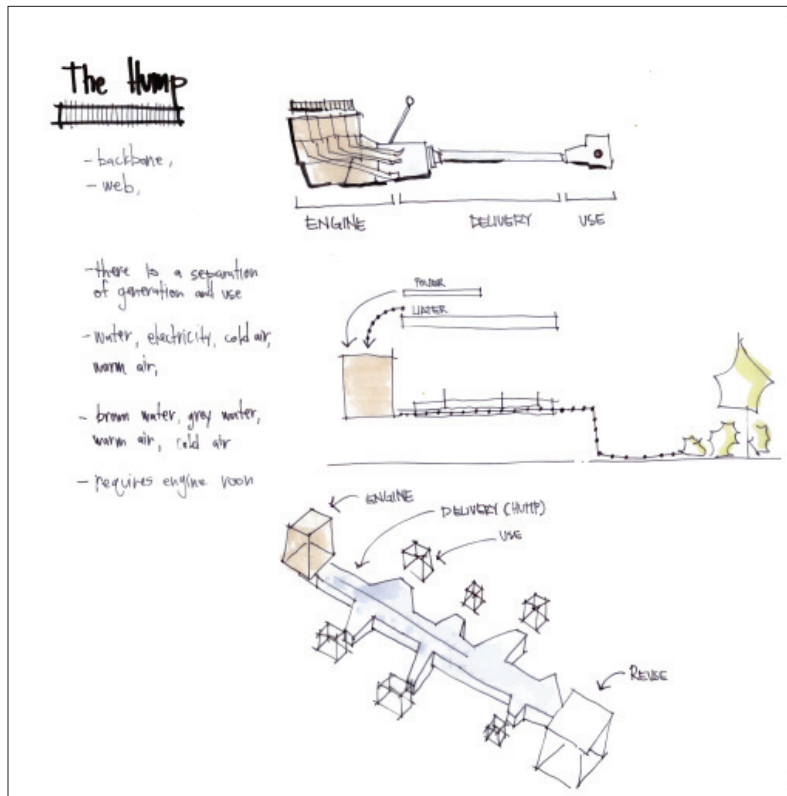
Figure 3.2. Below. FASH graphic
Figure 3.3. Right Process Graphics, idea.

Suburban Americans suffer from homes built with a low standard of craftsmanship, poor efficiency of construction, excessive use of material resources and a disregard for their site. Architectural diversity is at a low, driven by a consolidation of homebuilders and fewer floor plans. The current home production workflow from commission to build pales in comparison to the automotive industries solutions. Can a framework be created that allows us to harness our industrial ability and maintain architectural values of space, form, materiality and site specificity? In 1941, the Willis-Towland group produced a framework, which was modified as a medical center, gasshop, food vendor and advertisement. This platform became an object for users to modify and personalize, helping make it one of the most realized consumer products ever. This product now found all over the world is called the JEEP. The Jeep has proved itself as a highly adaptable and reusable platform for a wide range of cultures and needs. This vehicle has allowed users to become enthusiasts, through standardization of connections, easy of modification, and economic accessibility.

I hope to shed new light on how design and construction through case studies of the automotive industry, case studies of modular/prefab architecture, a comparative production workflow, and surveys on the perception of modular/prefab housing in America.

Living Chassis is about learning to translate the high level of craftsmanship, efficiency of construction, economy of material use, and reusability achieved in the automotive industry into architecture, while keeping the position of space, connection to site and materiality of supreme importance. A primary goal is in creating a chassis/kit of parts, for designing homes that is flexible enough to adapt to each site while allowing for future user modification. From the kit of parts homes will be designed for common American lifestyles, bringing a logic and simplification of technique to building that allows quality and reuse to become reality.





These two images depict different typologies for residential systems architecture. Figure 3.4, “The Hump”, is based on the diagrammatic function of a car; with the engine, delivery and use happening separately in a linear model. This highly efficient separation of functions loses strength when attempting to modulate space architecturally. Figure 3.5, “The Plenum”, was a major step in the project. The systems architecture now serves both as spatial module and systems module. This idea is at the heart of the FASH system.

Figure 3.4. Left. The Hump diagram
Figure 3.5. Above. The Plenum diagram



Language

The plenum wall idea evolved with research noted in the Move chapter into a clearly defined language. This language is the basis for understanding the FASH system.

The FASH is made from a kit of parts defined by:
Spine, Organs, Bones, Veins, Infill and Relic

Spine

The Spine:

- Base 900mm x 900mm grid
- Defined by stackable zinc coated steel cubes

The spine cubes have three sizes

- 900mm x 900mm - standard
- 900mm x 1800mm - large
- 900mm x 500mm - used for spinal cord

Figure 3.6, shows the teal connector plates located at the corners of the spine cubes. These corners are where other parts connect to the spine.

Figure 3.6. Spine Collage

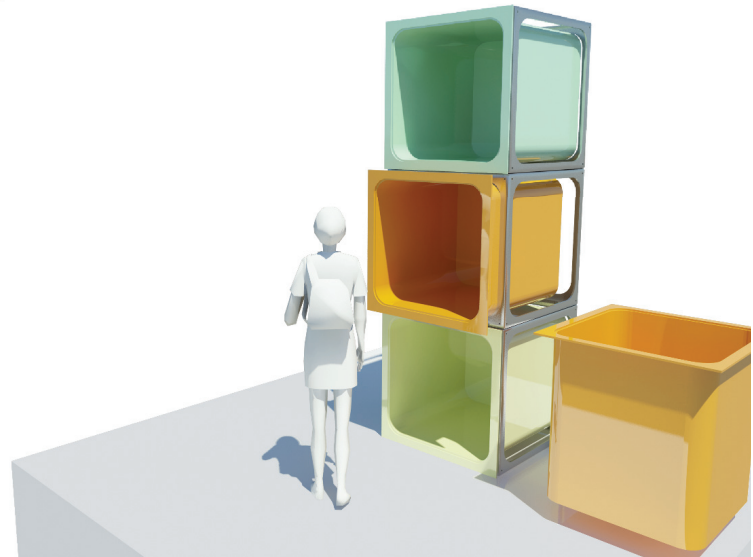


Figure 3.7. Top. 3/4" = 1' Plenum wall model

Figure 3.8. Right. Organ, plug and play

Organs

The organs plug into the spine. These organs can be appliances, HVAC, water purifier, cabinets, mainframe computers or anything.

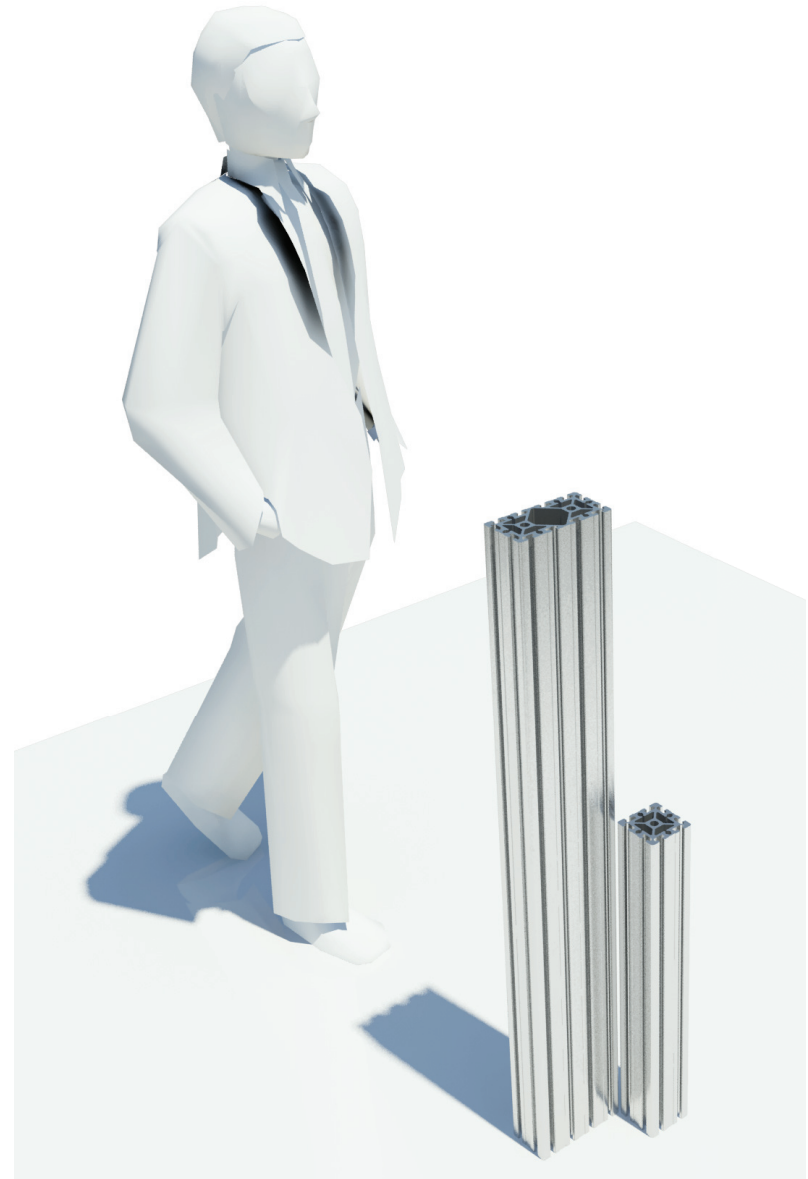
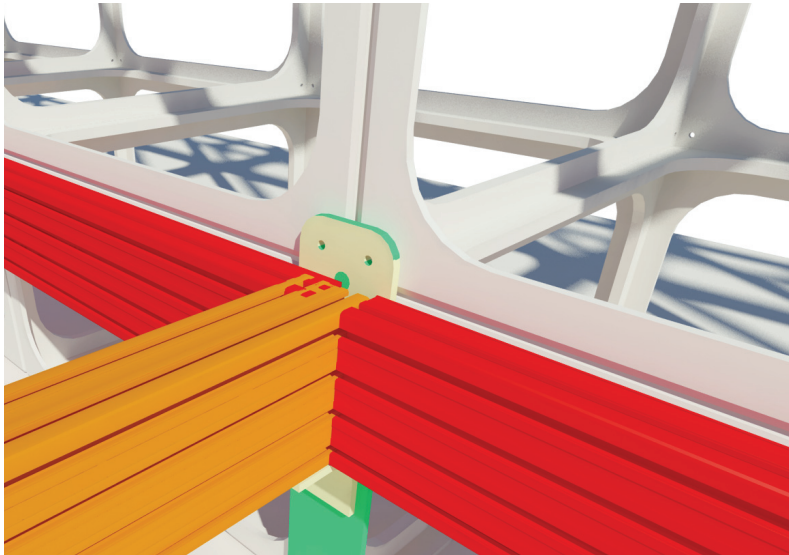


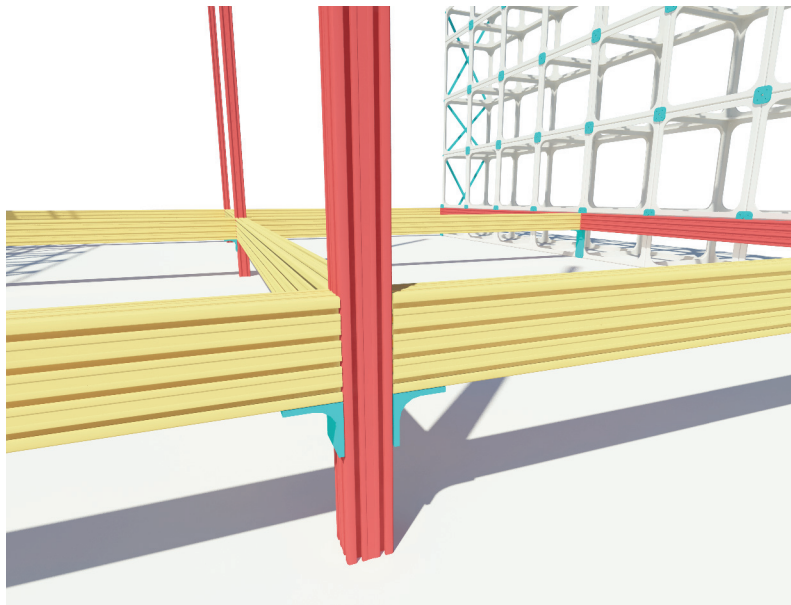
Bones

The bones are bolt together extruded aluminium forms, that provide flexibility and longevity. These bones are a manufactured form by BOSH. This system is commonly used in the construction of manufacture processes. It has proven itself as a strong flexible system that out weights its initial cost. This extruded aluminum framing is the same system seen in Kieran Timberlake's, Loblolly House.

Figure 3.9. Below. Bone - spine connection

Figure 3.10. Right. BOSH extruded aluminium profiles, 90x90, 90x180





Veins

Veins are a hollow space frame floor system that allow delivery of hvac, electricity and water. This system is similar to raised floor plenums seen in offices.

Veins panel sizes:

- 7200mm x 3600mm
- 3600mm x 3600mm
- 1800mm x 3600mm

The vein panels plug into the bays formed by the bones.

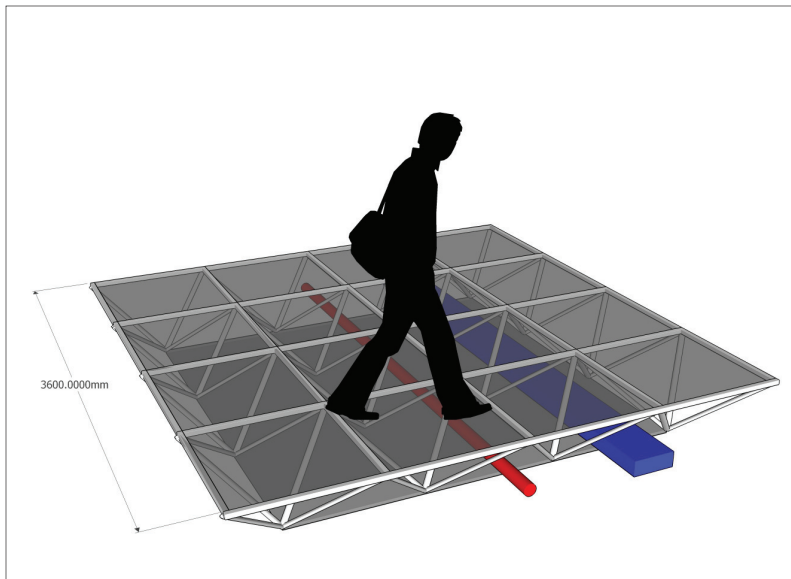
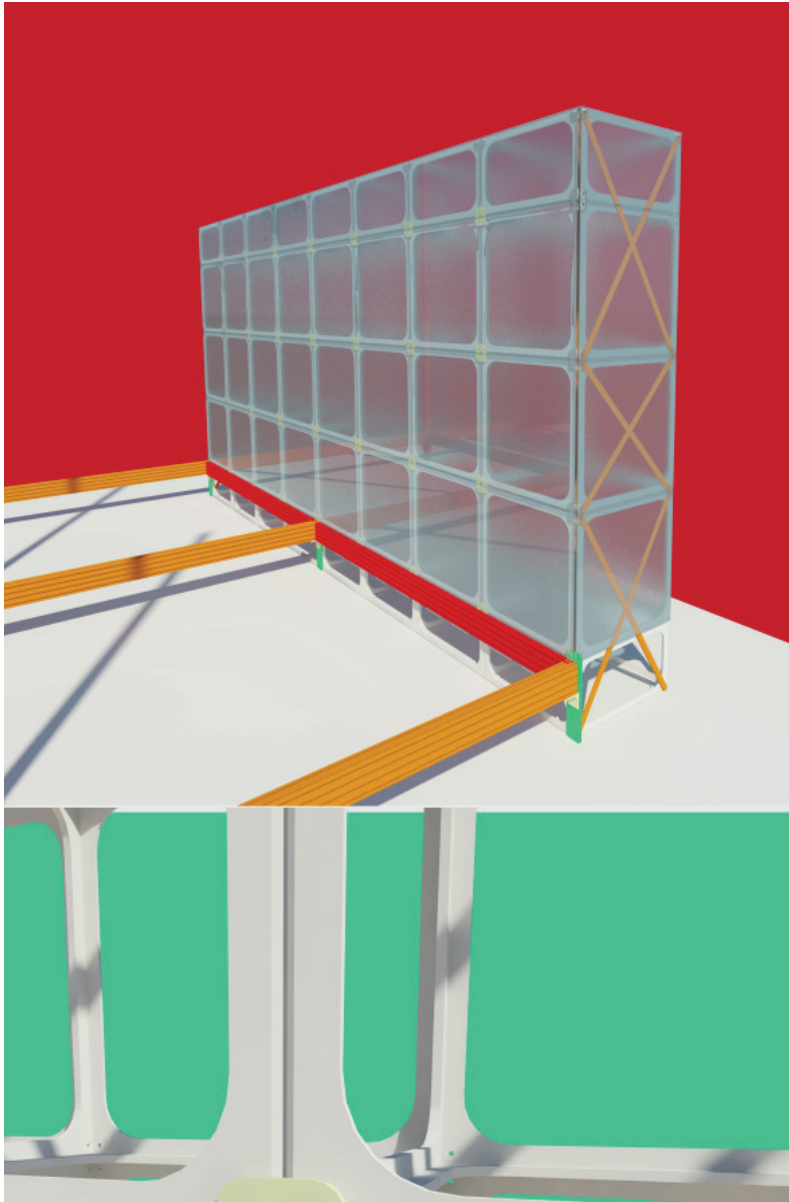


Figure 3.11. Left. Structural bay for vein panel
 Figure 3.12. Bottom Left. Vein panel diagram



Infill

The system is enclosed through modular infill panels. SIP [structurally insulated panels] are used to counter shear and enclose the building in the most common application, however the 900mm x 900mm grid suits itself to local material adaptations.

Figure 3.13. Left. Structural base with translucent infill panels

Figure 3.14. Bottom. Mock up joint, hex infill panel



Relic

The relic is an element that physical and mentally anchors the structure to the site. The relic can be made from a site specific find or can be designed as a site cast pour.

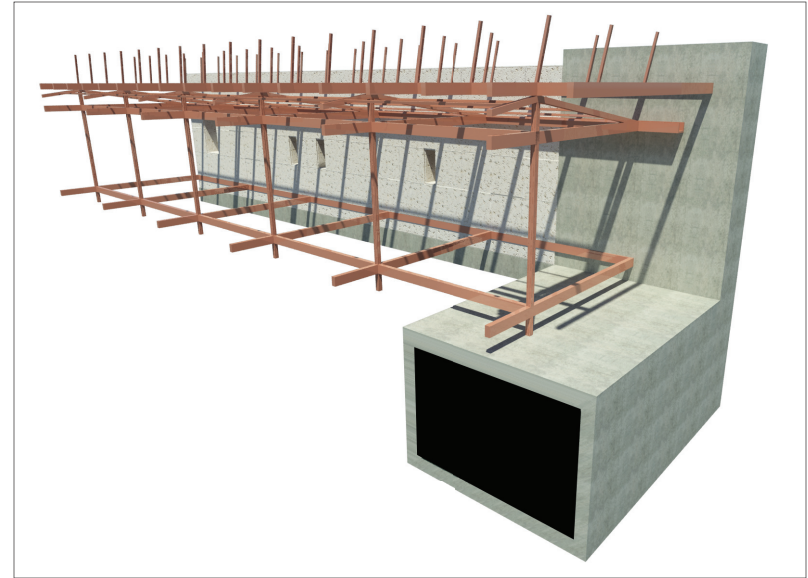


Figure 3.15. Top. Relic section perspective showing cistern

Figure 3.16. Right. Relic collage

Design Iterations

Once the system's language was set, quick 3d models were produced. Each model started with a simple idea in order to test the kit. It was clear that the roof, was going to be a place where customization per resident and climate wanted to happen.

The next several pages outline the first design pursued for the Florida Cottage Competition, fall 2008. The project submitted was presented in Miami at the Emerging Professionals Conference, tying for first prize.

Figures 3.18, 3.19 and 3.20 show the evolution of house D001. The series starts out with a couple in a 1 bedroom house, Figure 3.18. D001 evolves to a 2 bedroom house when the couple's first child is born.

By designing flexibility into the house, you empower inhabitants to meet their needs much more specifically.

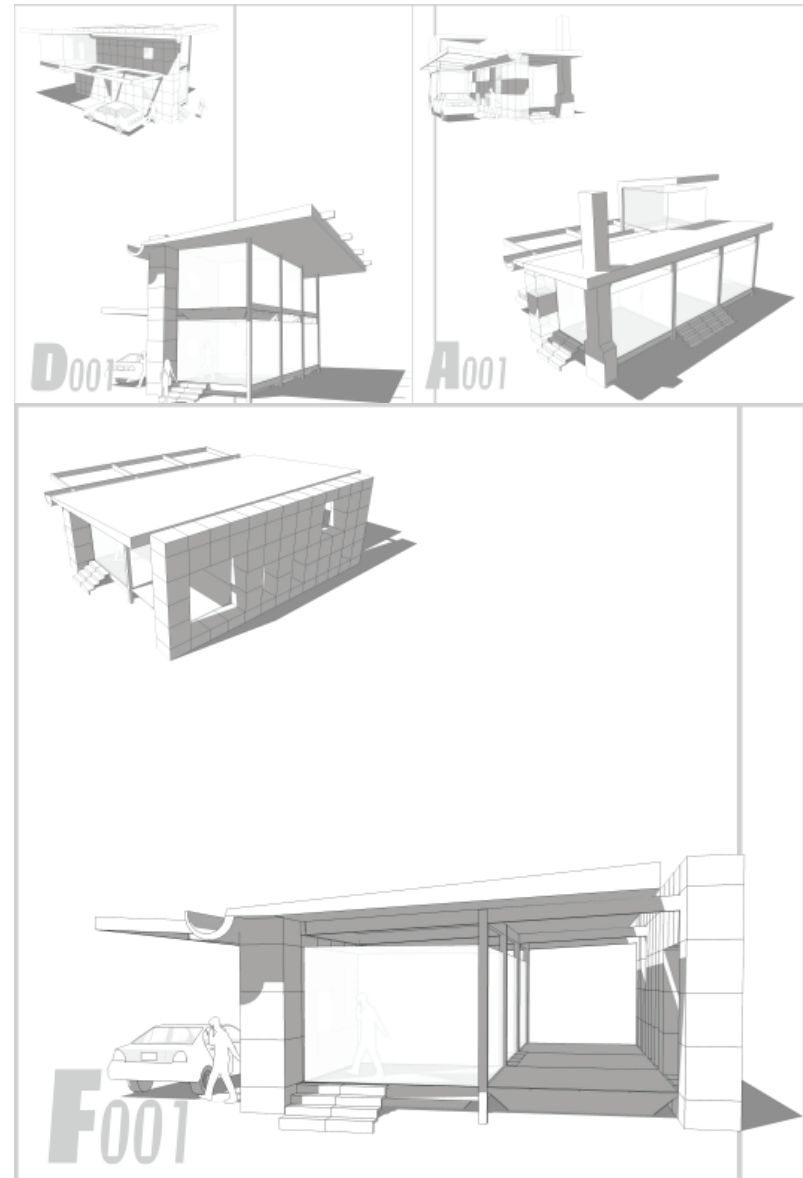


Figure 3.17. Design iteration collage.

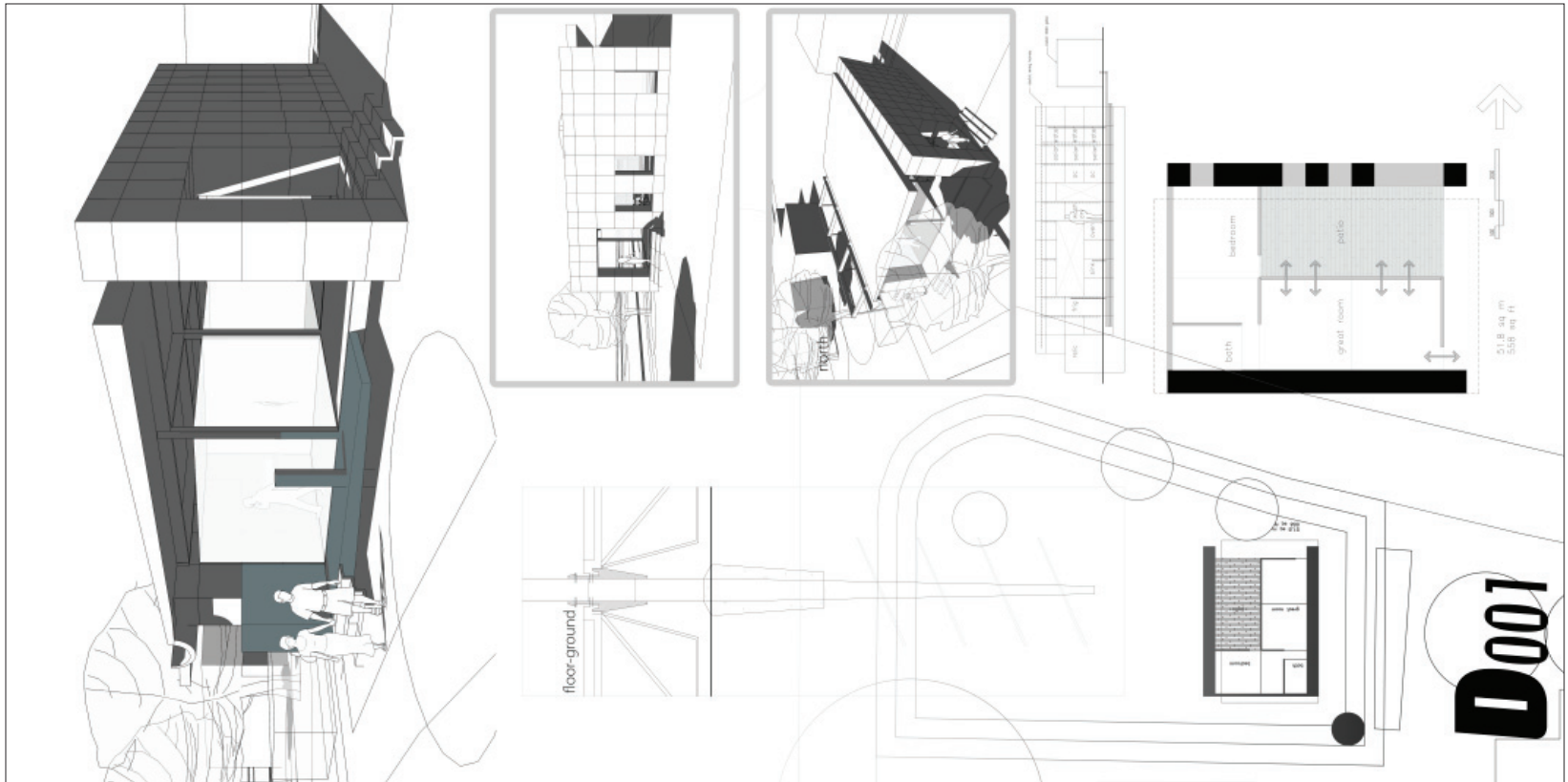


Figure 3.18. D001 Board

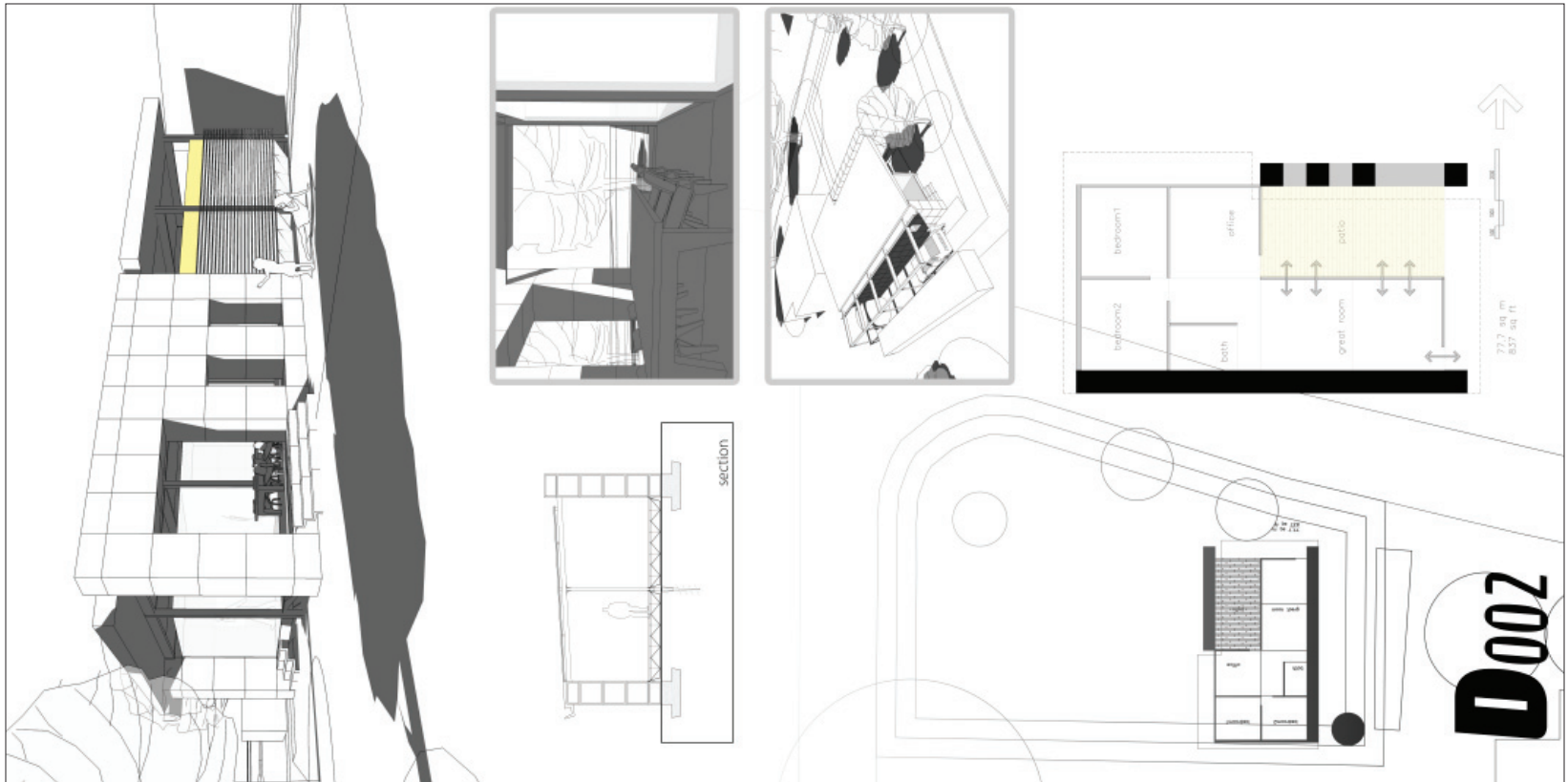


Figure 3.19. D002 Board



Figure 3.20. D003 Board



Figure 3.21. D001 Graphic

Open Source

The open source model of operation and decision making allows concurrent input of different agendas, approaches and priorities, and differs from the more closed, centralized models of development. The idea of open sourcing this building system came after reading about Google's opens source software models. Platforms like android empower many through a common language while simultaneously stimulating further development of the platform itself. This open source mentality is also used with Apples' iPhone application store. The application store gives development tools to users so that they can create and sell their application on Apple's iPhone platform.

There is a platform plug-in relationship occurring in many of these open source models. In the apple's case the iPhone acts as the evolving platform, and the plug-ins are created by anyone who can learn the development language.

This platform plug in relationship is similar to the way the FASH spine acts as the platform and the organs act as the plug-ins. Now, the language becomes the 900mm x 900mm grid and hardware connections to it. Any developer or craftsman can create plug-ins for the system and harness the FASH's common spine platform to distribute it to many users.

For the "Build a FASH" open source project, 14 similar

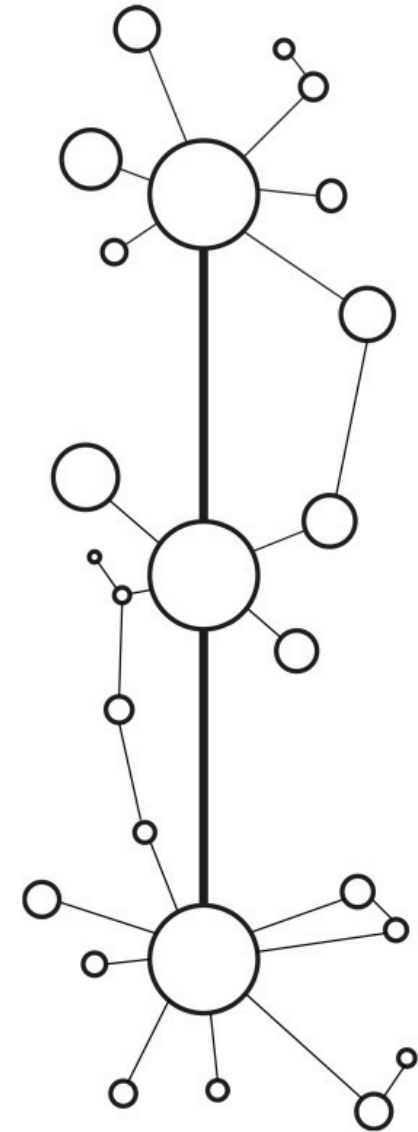


Figure 3.22. Open source diagram



Figure 3.23. Brown bag of parts given to open source team



Figure 3.24. Brown bag and chipboard sites given to open source team

kit of parts bags were made from the basic FASH language.

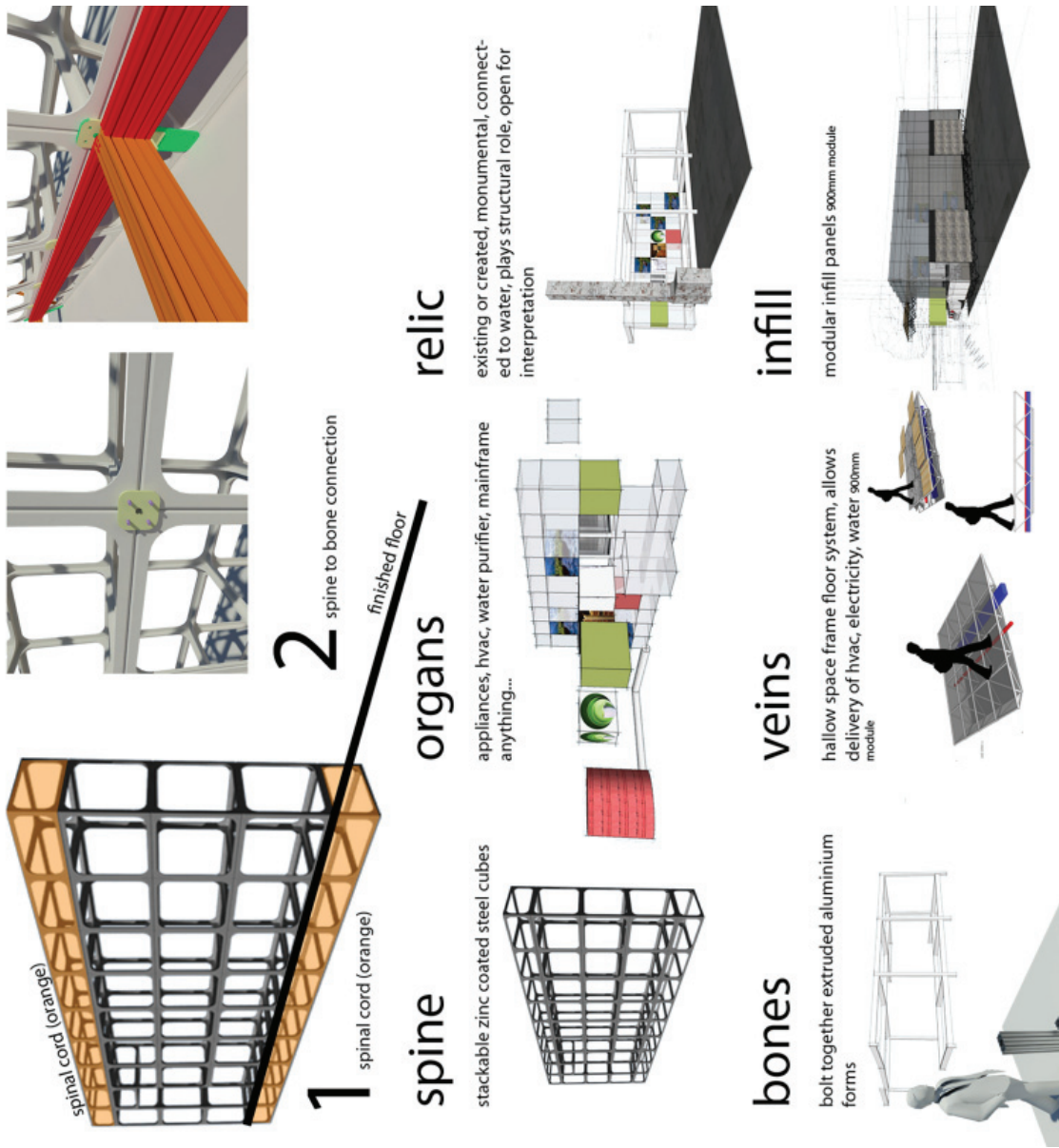
Each bag included 2 instructional pages, spine cubes, lengths of bone structure and vein squares. 7 of the kits were distributed to the Open Source Team at USF's School of Architecture and Community Design. The remaining 7 kits were retained and design by me, Chris Cox.

Open Source Team:

- Kuebler Perry [student]
- Logan Mahaffey [student]
- Mario Rodriguez [student]
- Joshua Sperduti [student]
- Tim Keepers [student]
- Dana Neilsen [student]
- Mark Weston [professor]



Figure 3.25. Open source handout 1



Site



- Blue - street edge
- Yellow - Property line
- Red - Set-back
- Theoretical site open to interpretation
- Note Solar orientation

Relic

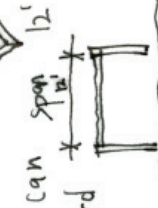
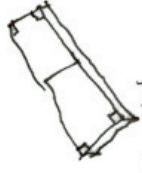


- Existing Condition.
- Build from chipboard.
- Connection to water
- Open to interpretation

Kit



- $3/8" \times 3/8"$ cubes represent origin & spine
- $12' \times 12'$ vein can be cut into $6' \times 12'$ vein or glued into $12' \times 24'$



- Bones can span 12' Standard

or

- Bones can be trussed for any theoretical length



- Micro lumber can be used as tension member
- can be Mullions
- open for any size

- Chip Board - SIP structural insulated panel
- used for infill walls
- used for exterior walls
- used for roof
- open for interpretation

questions?

emailchriscox@gmail.com

Figure 3.26. Open source handout 2

Statesman

After designing 7 sketch models with the open source project, 2 houses were selected for further development.

The statesman, named after its grand north elevation was chosen for further development. This home integrates a covered car port, wrap around porch and 2 level exterior space. The south elevation is well covered while the north elevation opens to the site. Figure 3.28 shows the vein systems hollow floor panels as well as the plenum wall's chase space.

SEE APPENDIX B for model photos

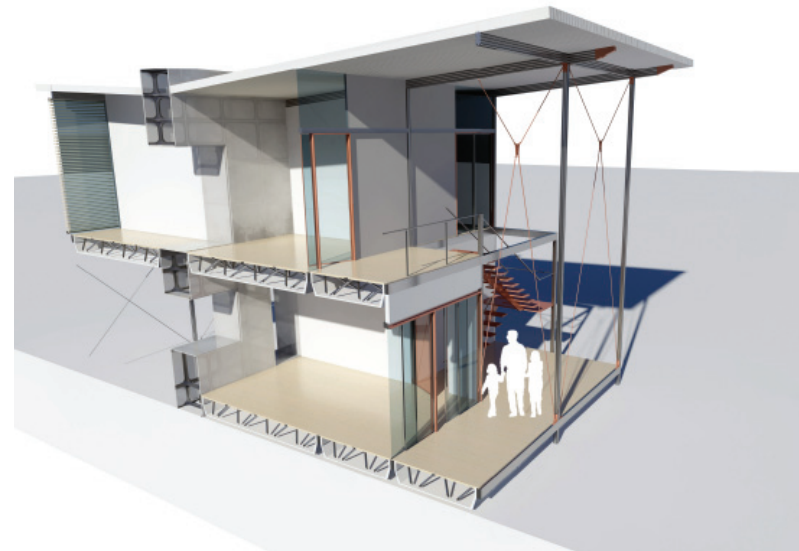


Figure 3.27. Statesman south elevation
Figure 3.28. Statesman section perspective

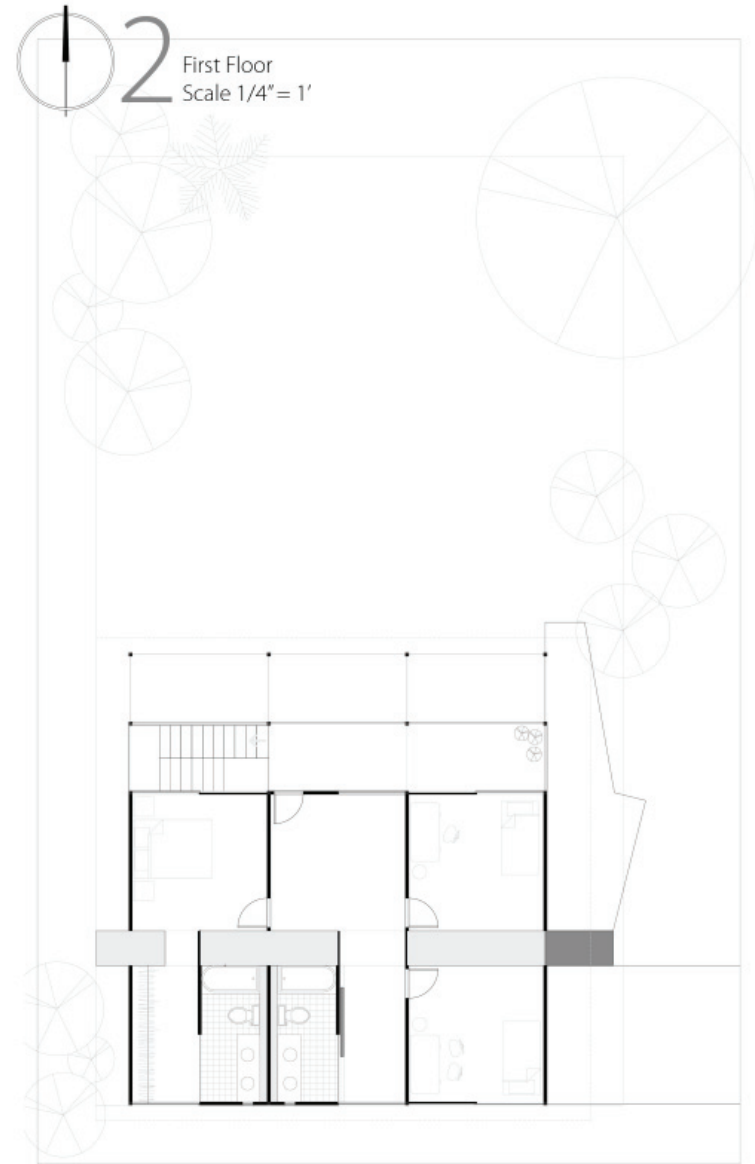
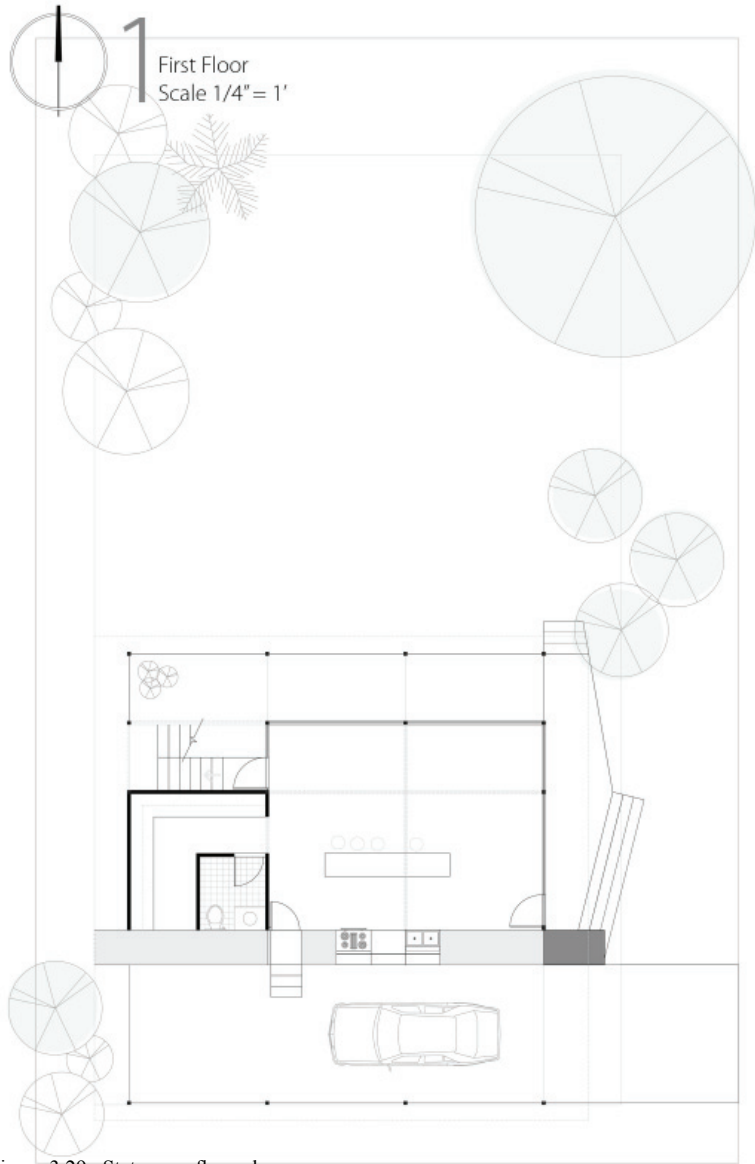


Figure 3.29. Statesman floor plans

Figure 3.30.
Statesman
perspective



The Fish

The Fish was selected for its absolute function driven design. It is the purest expression of the kit of parts efficiency. The design starts with 2 plenum walls anchored by a monumental relic - cistern. The west plenum wall serves as the kitchen, while the eastern wall serves as storage.

Figure 3.31 shows all the elements involved in the construction of a FASH.

SEE APPENDIX B for model photos

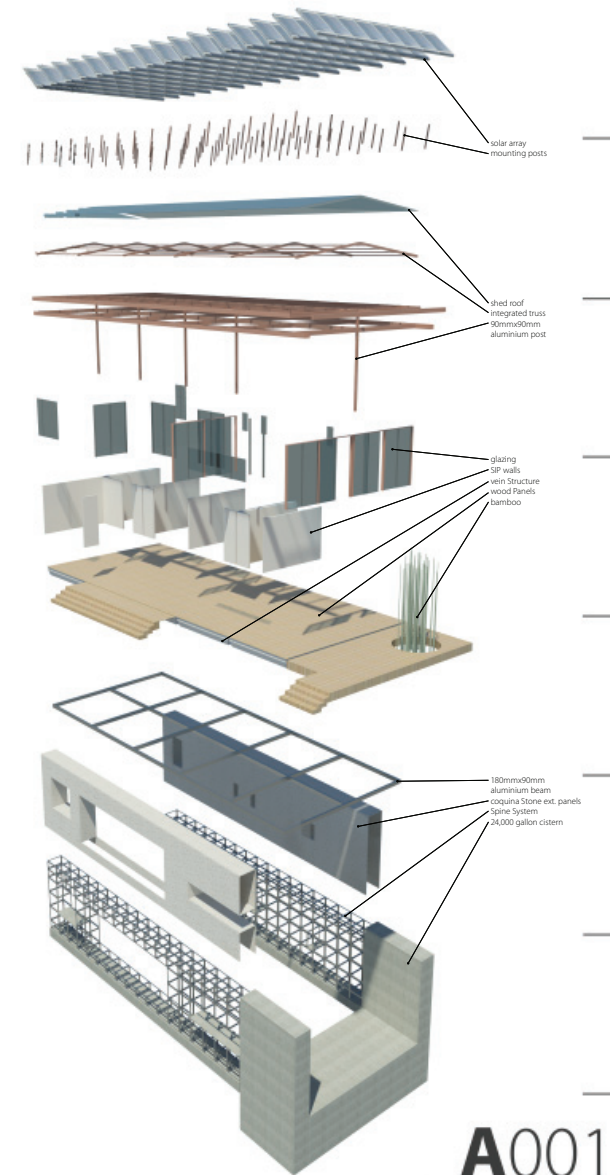


Figure 3.31. Fish exploded systems

A001

Figure 3.32. Bottom. Fish interior perspective
Figure 3.33. Right. Fish floor plan

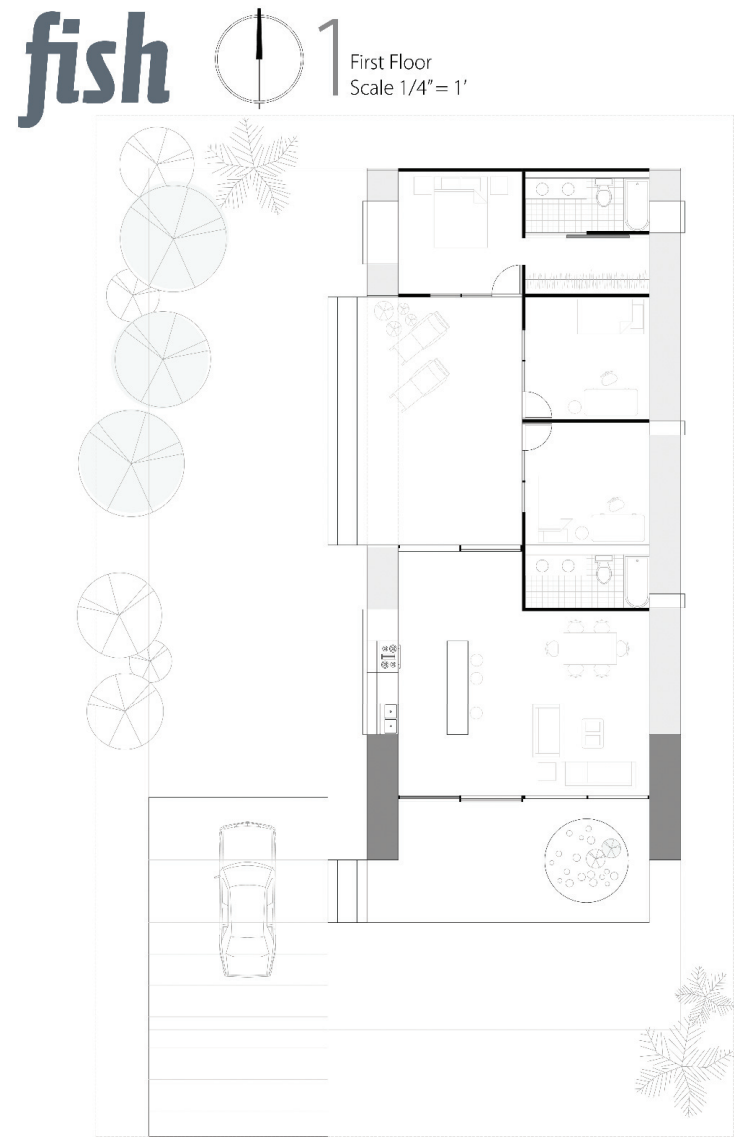


Figure 3.34. Top Left. Fish section perspective of floor system

Figure 3.35. Top Right. Fish spine and bone structure

Figure 3.36. Bottom. Fish section perspective interior space

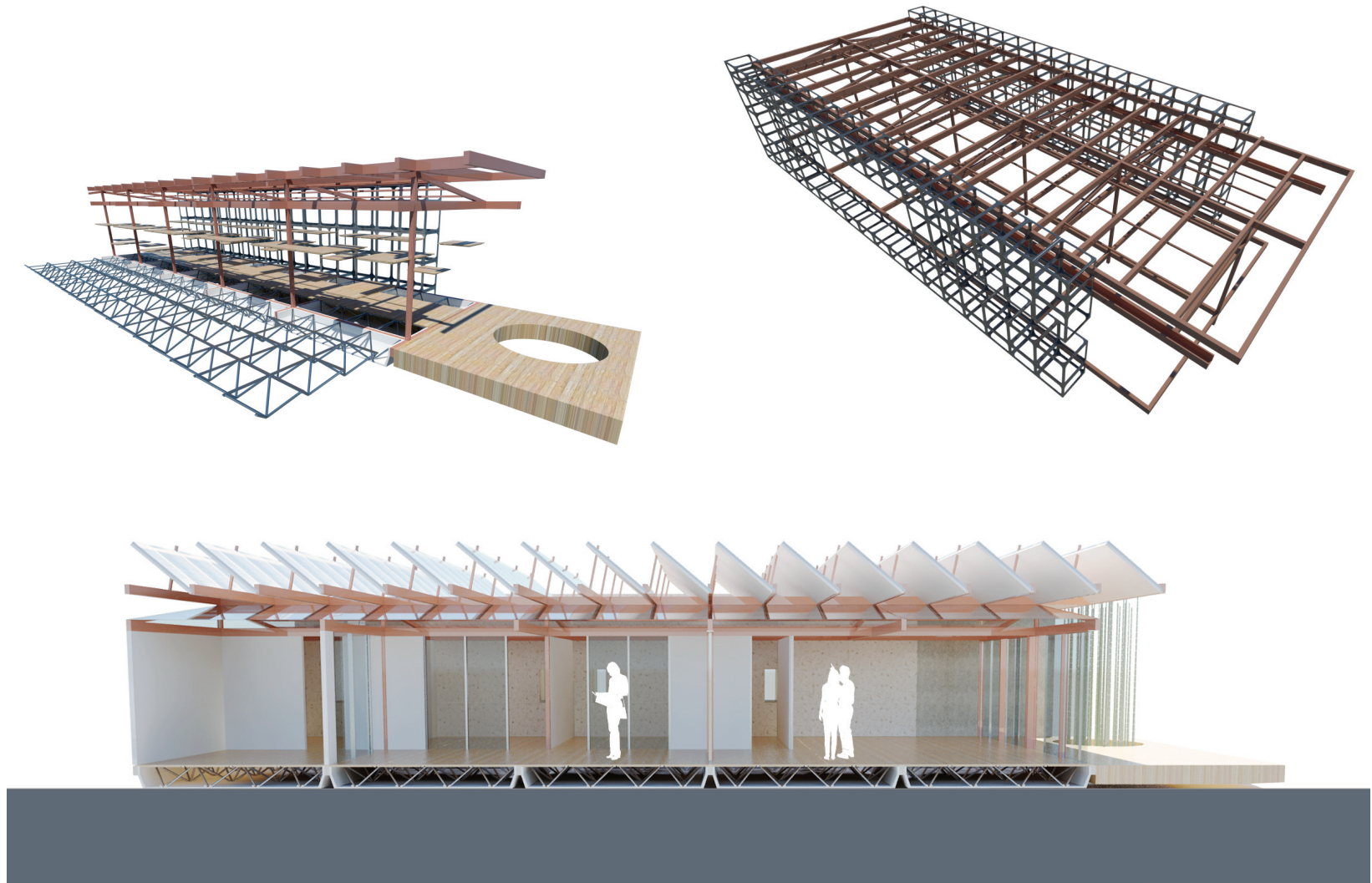


Figure 3.37. Fish east elevation.

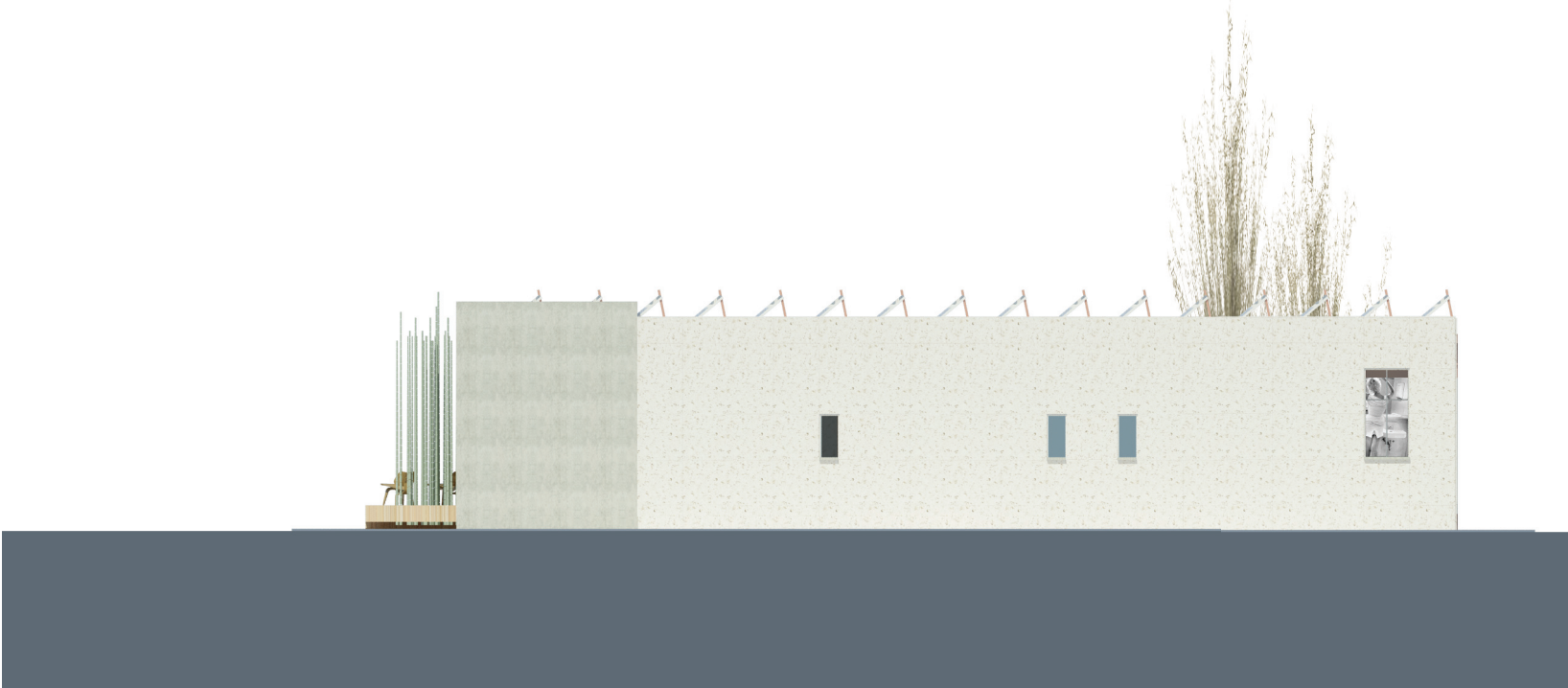


Figure 3.38. Fish main perspective.



WORKS CITED

“1966 VW Beetle.” <<http://www.1966vwbeetle.com/>>.

“2008 Dakar Rally Canceled.” <<http://howdywilcox.org/?m=200801&paged=2>>.

“Abandoned Mobile Home.” <<http://southfloridadaily.com/?p=223>>.

Ameri, Farhad, and Deba Dutta. “Product Lifecycle Management: Closing the Knowledge Loops.” *Journal of Computer Aided Design & Applications* 2.5 (2005): 577.

Benson, Tedd. “A Dismal Standard [Building].” *Fine homebuilding*, 2006 Spring-Summer, n.179 (2006).

Bosma, Koos, Dorine van Hoogstraten, and Martijn Vos. *Housing for the Millions : John Habraken and the SAR* (1960-2000). Rotterdam; New York, NY: NAI Publishers; DAP/Distributed Art Publishers distributor, 2000.

“Characteristics of New Housing.” *US Census Bureau*. 2008. <<http://www.census.gov/const/www/charindex.html#singlecomplete>>.

Deam, Shane. “*History of the Beetle*.” <http://www.volkswest.co.uk/beetle_history2.html>.

“Jack’s Crisp.” <<http://www.jackcrisp.com/store/productimages/tatami1900.jpg>>.

Kieran, Stephen, and James Timberlake. *Loblolly House : Elements of a New Architecture*. 1st ed. New York: Princeton Architectural Press, 2008.

Kunz, Martin Nicholas, and Michelle Galindo. *Best Designed Modular Houses*. Stuttgart: AVedition, 2005.

“Markham Suburbs.” <<http://upload.wikimedia.org/wikipedia/commons/thumb/1/14/Markham-suburbs.id.jpg.jpg/800px-Markham-suburbs.id.jpg.jpg>>.

McGinn, Daniel. “Home Sweet Gadget.” WIRED January 2008: 33.

“Old Jeep Photos and Advertising.” <<http://blogs.4wdandsportutility.com/6286200/miscellaneous/old-jeep-photos-and-advertising/index.html>>.

Oliver, Paul. *Built to Meet Needs : Cultural Issues in Vernacular Architecture*. 1st ed. Amsterdam ; Boston ; London: Architectural, 2006.

“Park Machinery.” <http://www.fer-mec.com/cart_eng/parco_macchinari_eng.htm>.

“Process Performance Solutions.” <http://ftq360.com/Solutions_Builder.htm>.

Roney, Maya. “Foreclosure’s building problem.” 2007. <<http://www.msnbc.msn.com/id/20393984/>>.

Sack, Florentine. *Das Offene Haus : Für Eine Neue Architektur*. Berlin: Jovis, 2006.

“Schwarze Industries.” <<http://www.schwarze.com/PressReleases/A7UNIMOG.html>>.

“Seven steps to complete PLM.” <<http://machinedesign.com/ContentItem/69211/SevenstepstocompletePLM.aspx>>.

Silver, Nathan. *The Making of Beaubourg : A Building Biography of the Centre Pompidou, Paris*. Cambridge, Mass.: MIT Press, 1994.

Smith, Elizabeth. “Cutting Costs with Modular Construction.” 2007.

Steele, James, Charles Eames, and Ray Eames. *Eames House : Charles and Ray Eames*. London: Phaidon, 1994.

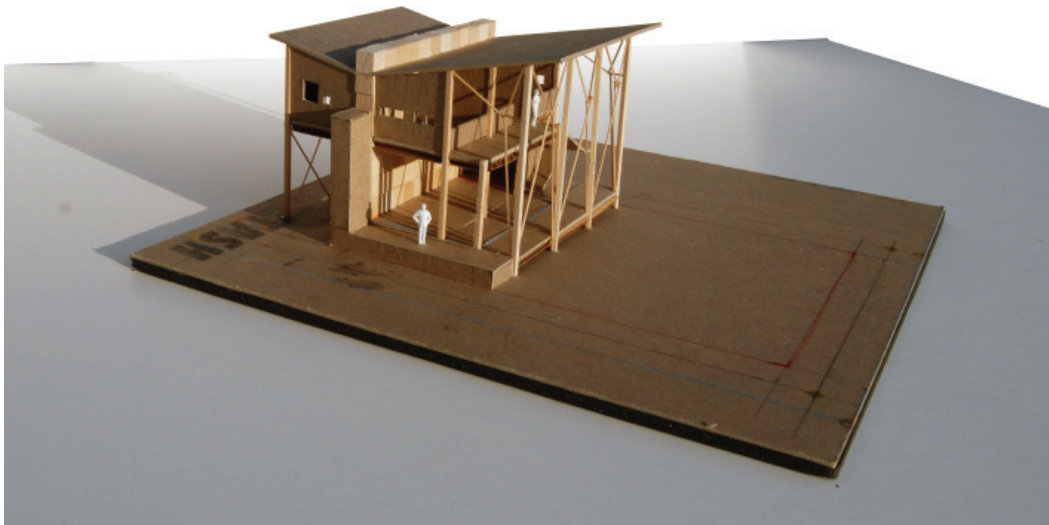
Tracy, Dan. “BUILDING HOMES: BUILDING PROBLEMS.” 2003. <<http://www.orlandosentinel.com/business/orl-asecuc-f31103103oct31,1,3487175.story>>.

Wand, George. “History of the Unimog.” 2006. <<http://www.off-road.com/offroad/Mercedes+-+Unimog/History-of-the-Unimog---Mercedes--Off-Roadcom/ArticleStandard/Article/detail/336076?contextCategoryId=38218>>.

APPENDICES

APPENDIX

Appendix A.
Open Source Project



South



North



East



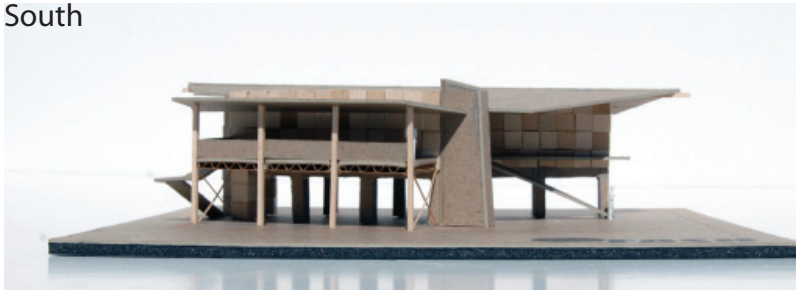
West





2

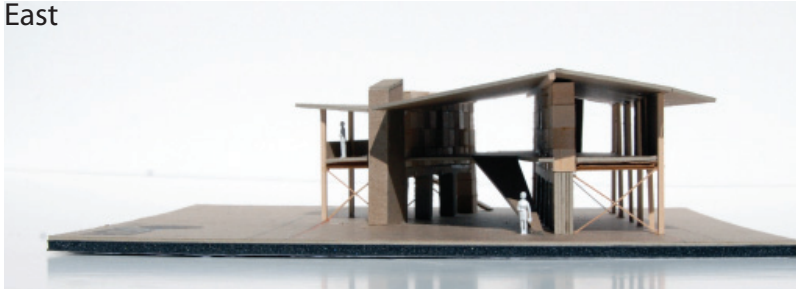
South



North

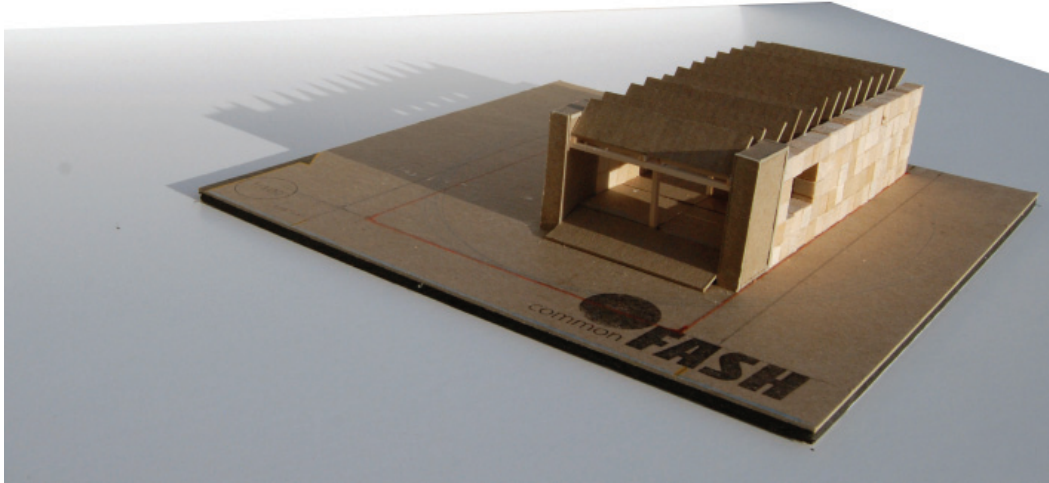


East



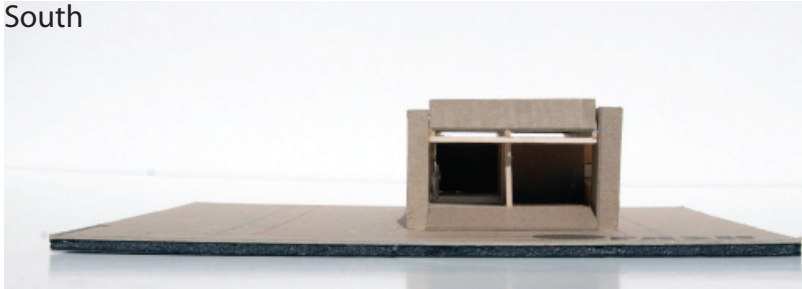
West





3

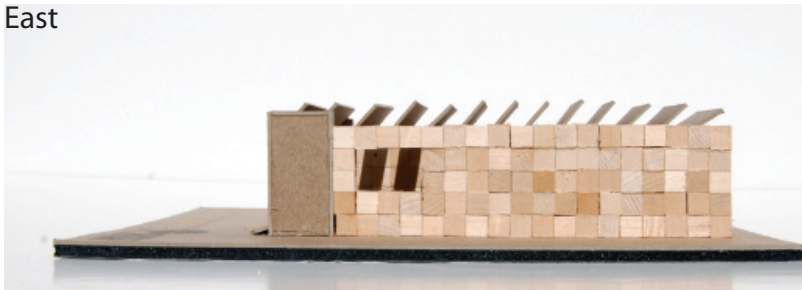
South



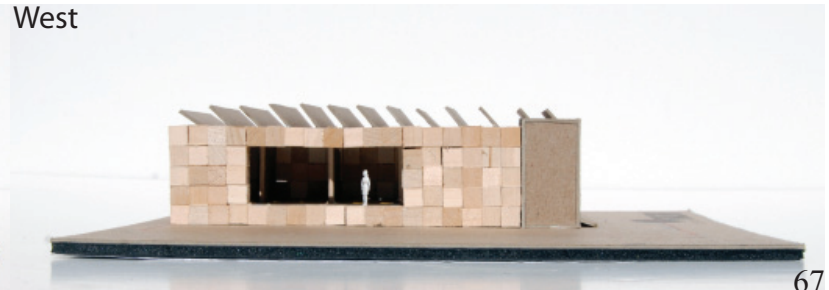
North



East



West



4



South



West



East



North





5

South



North



East



West





6

South



North

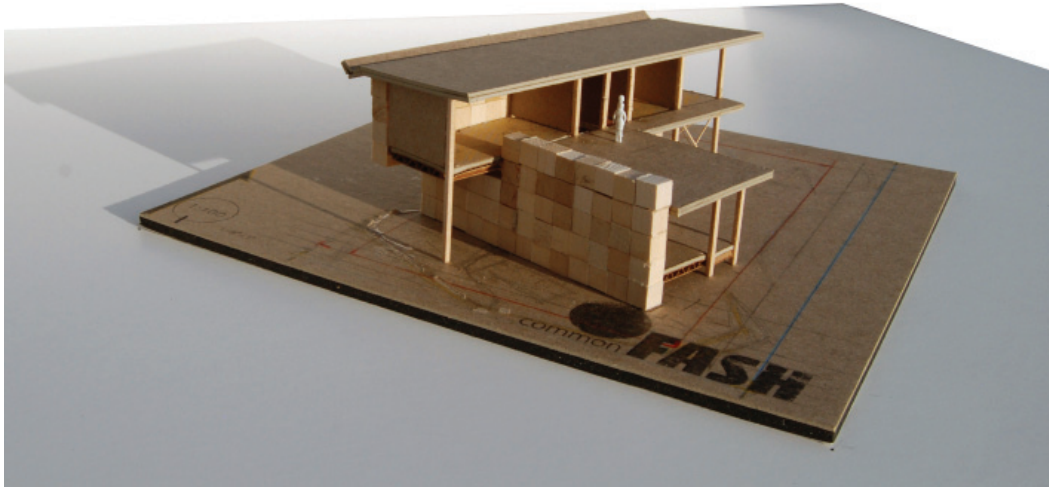


East



West





7

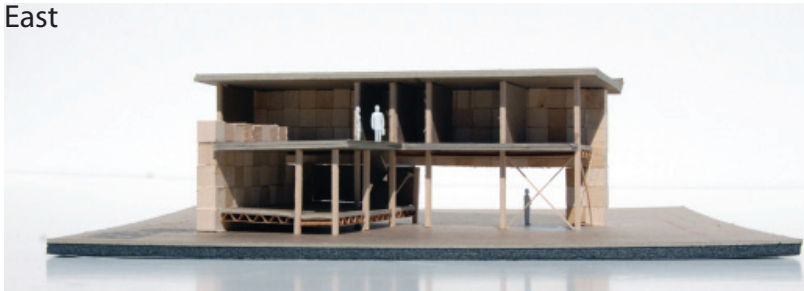
South



North

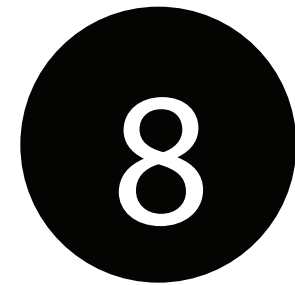
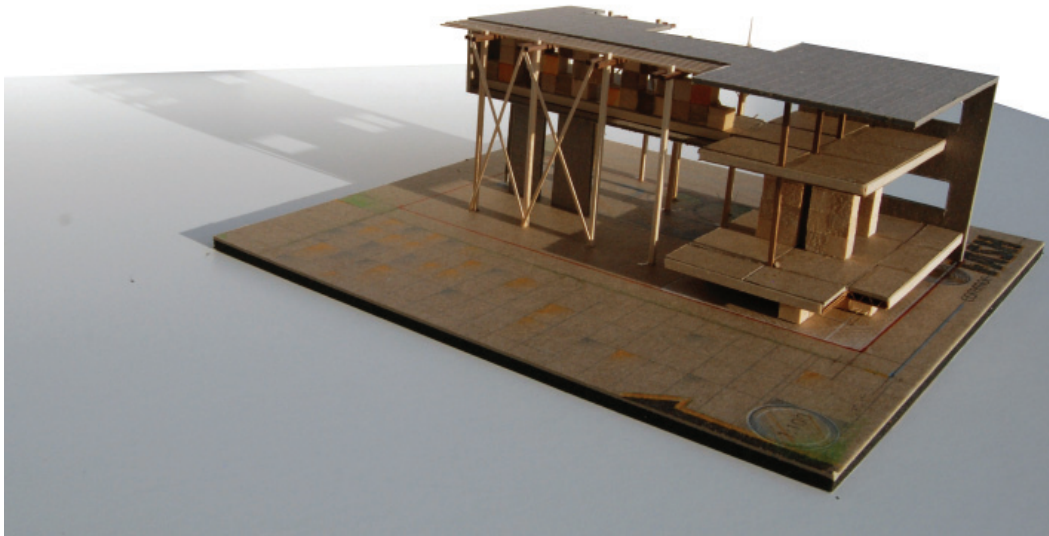


East



West



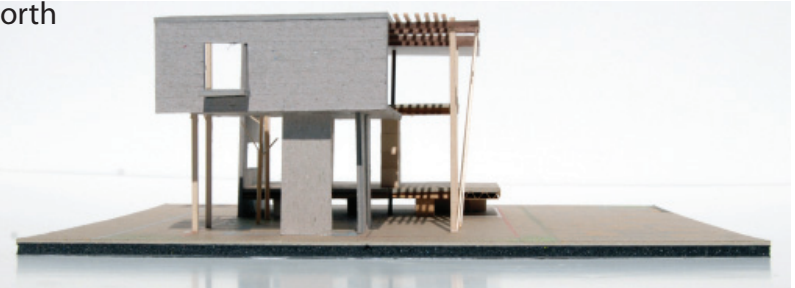


Tim Keepers

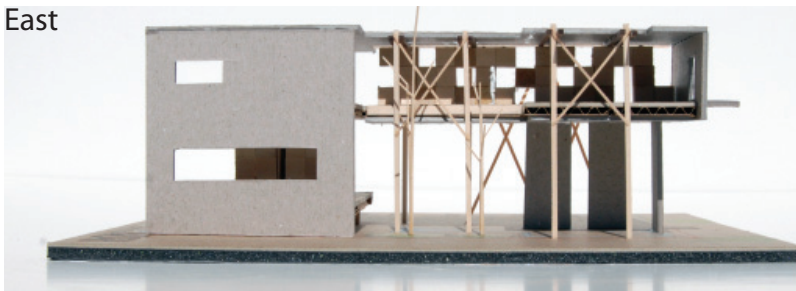
South



North

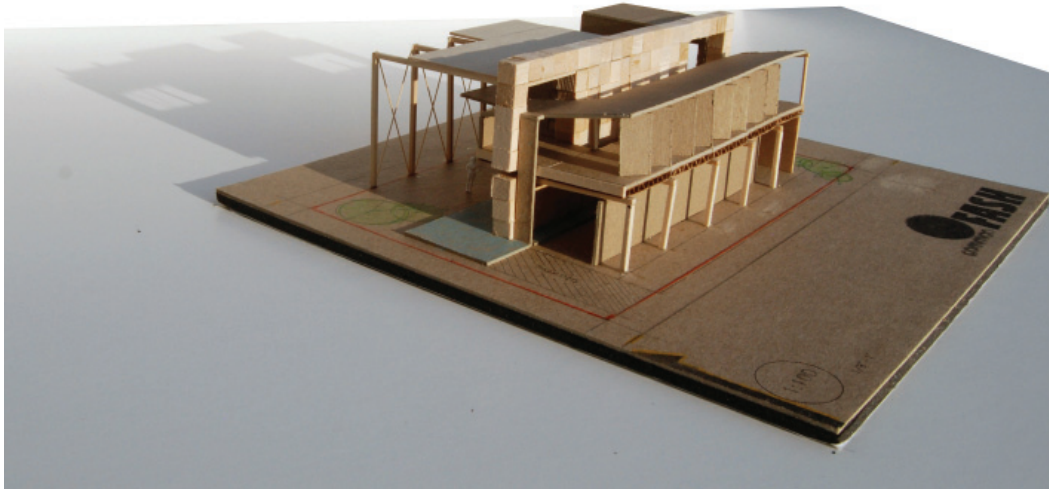


East



West



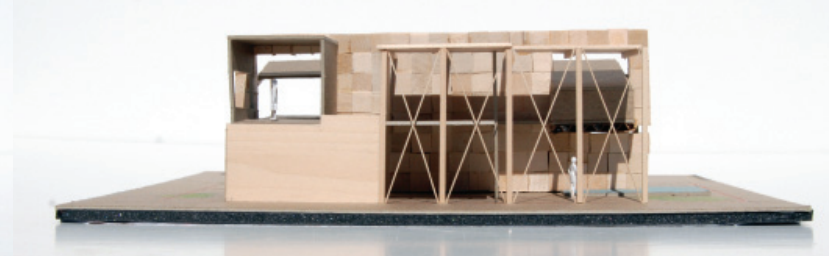


Joshua Sperduti

South



North



East



West

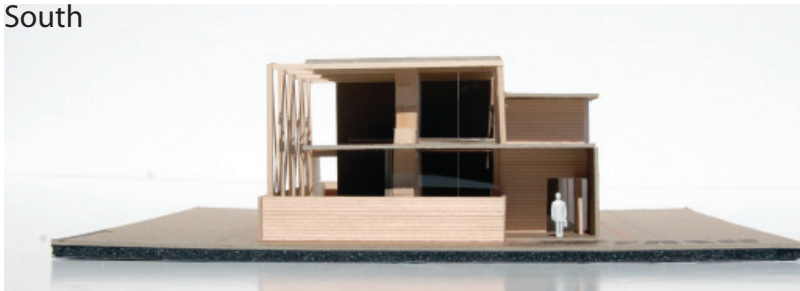




10

Mario Rodriguez

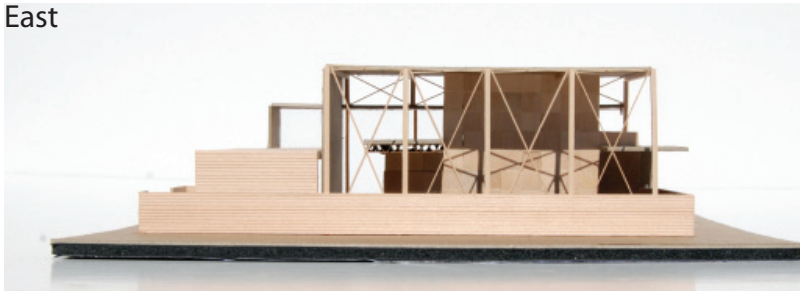
South



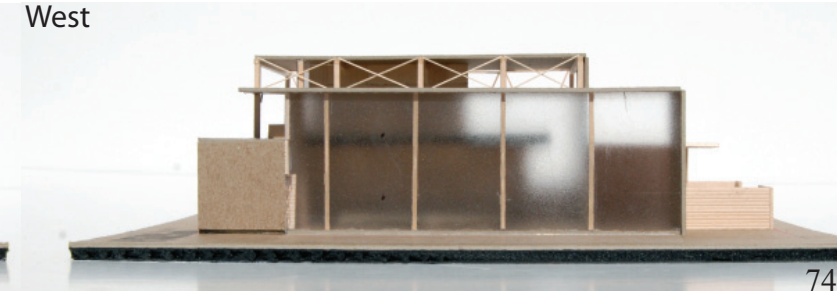
North

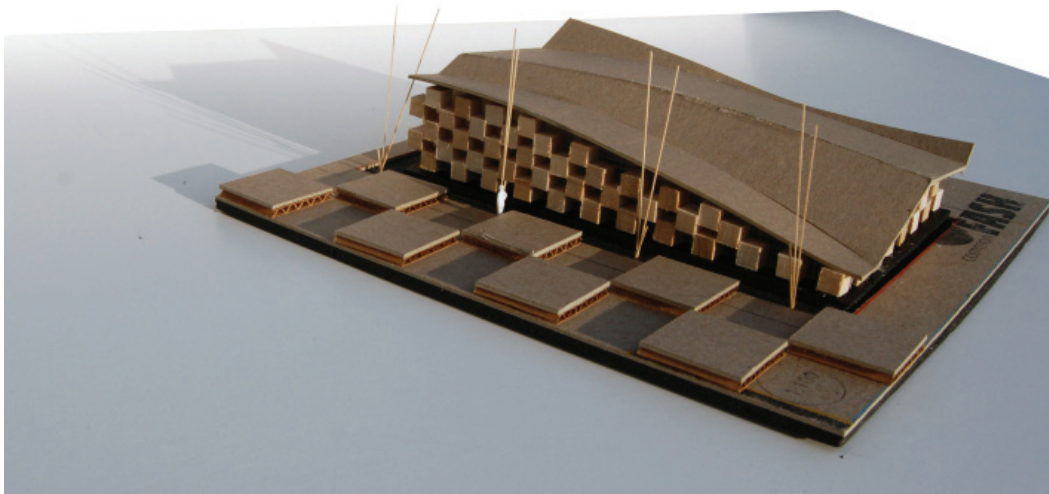


East



West

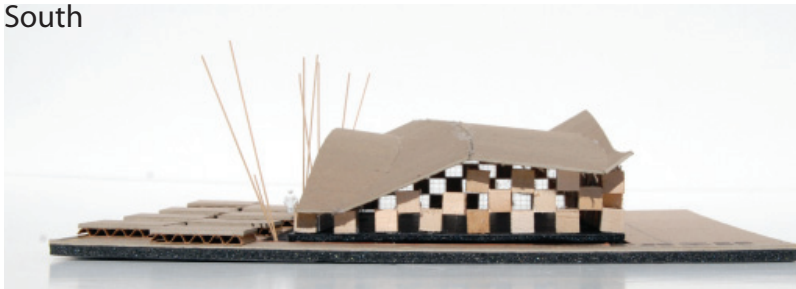




11

Mark Weston

South



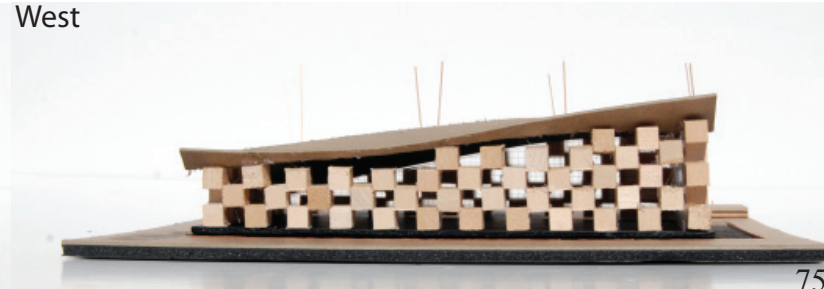
North

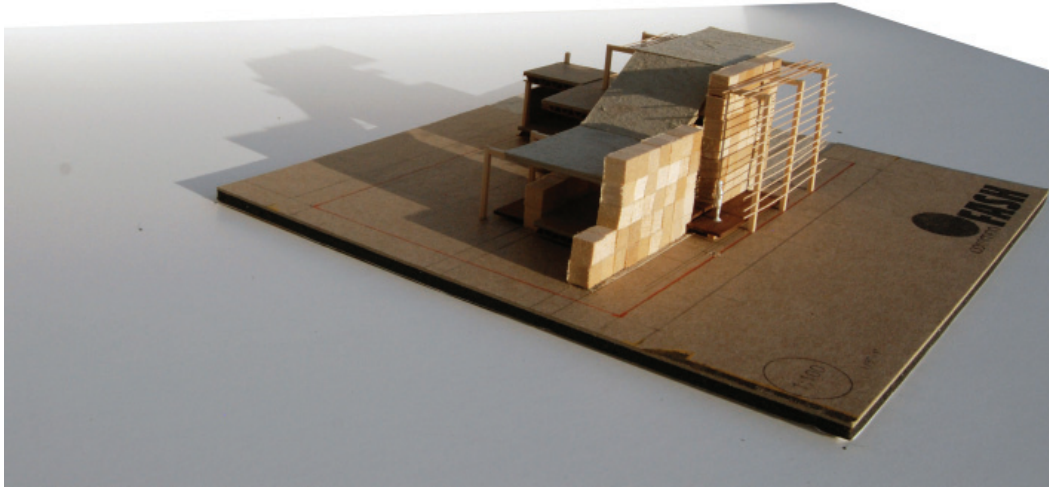


East



West





12

Logan Mahaffey

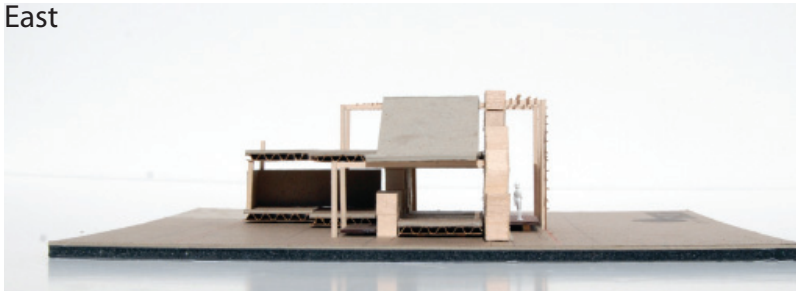
South



North

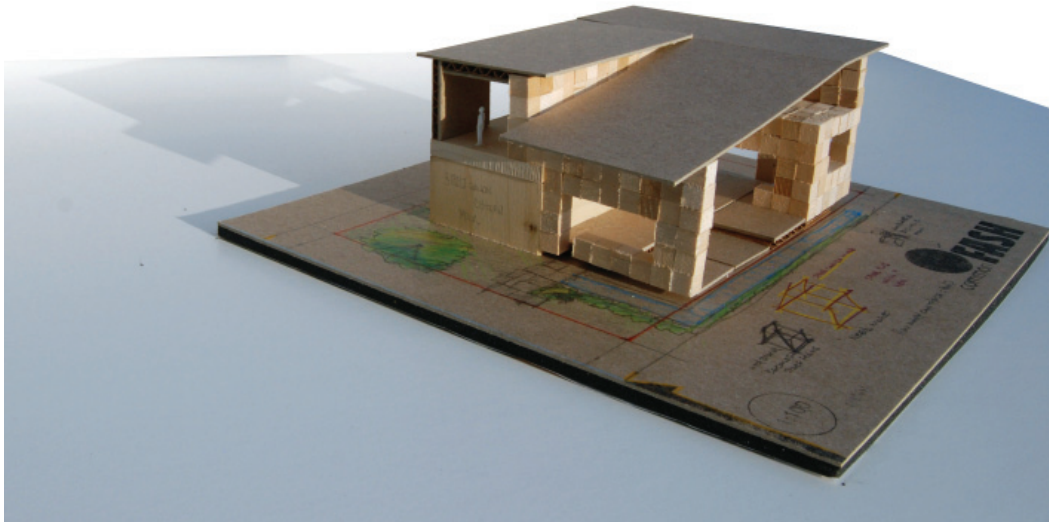


East



West

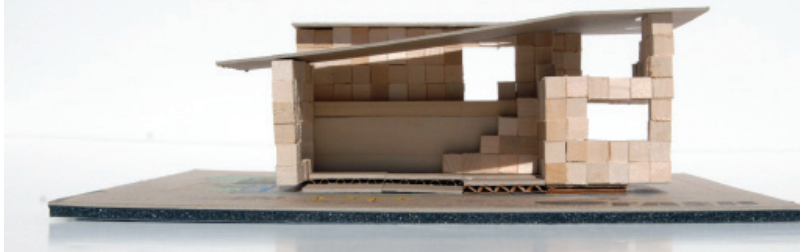




13

Dana Neilsen

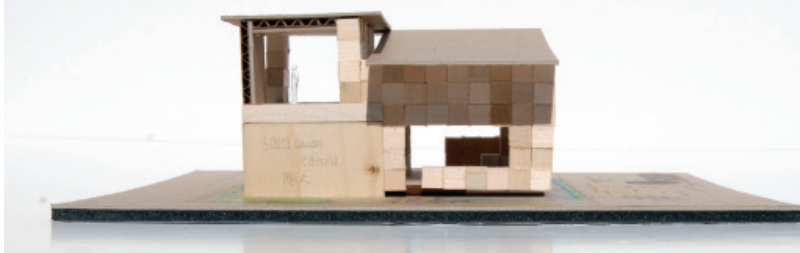
South



North

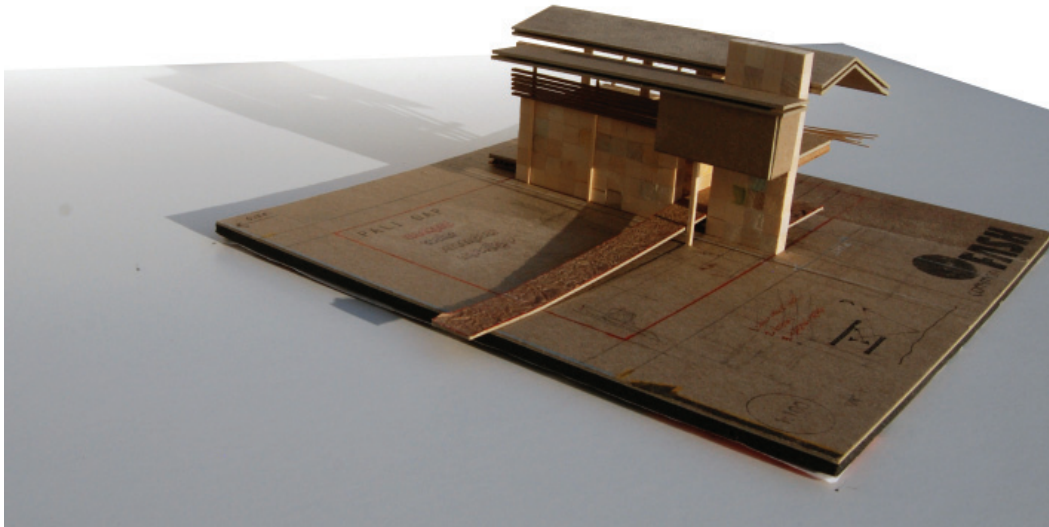


East



West

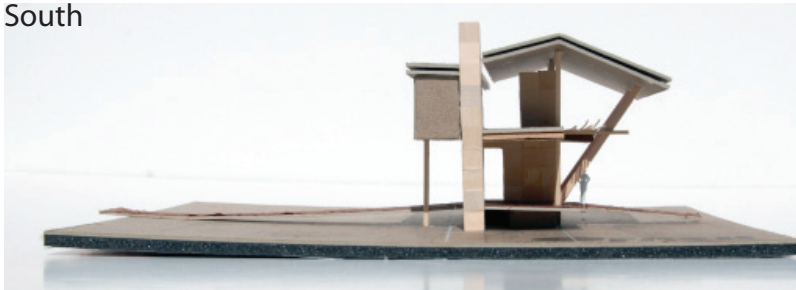




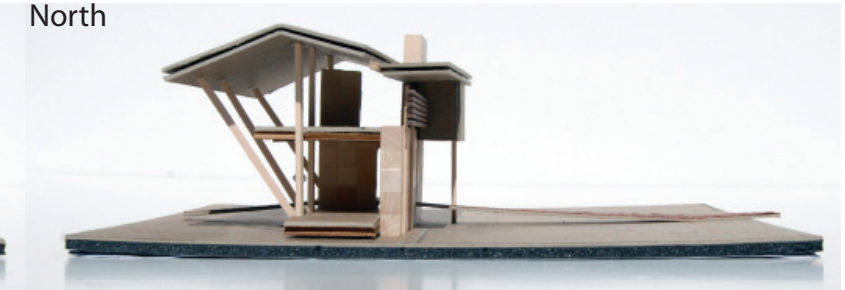
14

Kuebler Perry

South



North



East



West



APPENDIX

Appendix B.
Models









