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My interests lie primarily in the re-use of shipping containers as housing within a community setting. In pursuing the question of that use and its setting, it has become apparent that there is a need to document and explore the elements that make up the current day shipping container, and the elements that comprise home and community to better understand how shipping containers may be modified to fit into these settings. So in my study of shipping containers and the process involved in transforming the containers into a housing module, I have explored three community settings and the way in which both the interior and exterior can be adapted for the user and the surrounding context. Each of these investigations has informed the proceeding study and the final result is an amalgamation of the two, a result from my observations and reviews.

PLUGGING IN: REINTERPRETING THE TRADITIONAL HOUSING ARCHETYPE
WITHIN A COMMUNITY USING SHIPPING CONTAINERS

by

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CHAPTER I

INTRODUCTION

My interests lie primarily in the re-use of shipping containers as housing within a community setting. In pursuing the question of that use and its setting, it has become apparent that there is a need to document and explore the elements that make up the current day shipping container, and the elements that comprise home and community to better understand how shipping containers may be modified to fit into these settings. So in my study of shipping containers and the process involved in transforming the containers into a housing module, I have explored three community settings and the way in which both the interior and exterior can be adapted for the user and the surrounding context. Each of these investigations has informed the proceeding study and the final result is an amalgamation of the two, a result from my observations and reviews.

A standard shipping container is a five sided box with a double leaf door. Its original purpose was to transport goods around the world, and to streamline the shipping process. In recent years their function has expanded to include the use as a building resource. Because of their strength, availability, transportability, and cost, they have received attention as a viable alternative to traditional construction. These functions include apartment housing, offices, and event centers and are used within both the commercial and residential industry.

Shipping containers present several challenges when being prepared for residential use, many of these issues common to small housing, these issues are examined to include the meaning of home which goes beyond the definition of where one lives. Families play a key role in the function of home, and the needs of the family are integral to designing a home. Within the community setting, shipping containers are viewed as cell-like structures that are combined, and are defined by a group of people that often share common values, within a common geographical locale. Two authors have written on techniques in which the concepts of community and home are applied, and they will be used through the design investigation as guidelines for the design development.

Through three design investigations, each within a different context and with a different user group, the function of the container as a housing model within a community has been explored and analyzed. The contexts for each include student housing, disaster housing, and military housing. Each study informs the next investigation, with the design process pushing forward based on what was observed from the previous study.

The goal for this study is to show that shipping containers are a viable resource for housing in a variety of situations and that they can be modified and adapted to accommodate the user's needs and promote a sense of community within the context.

CHAPTER II

REVIEW OF LITERATURE

Shipping Containers

What is a Shipping Container

A standard shipping container has five closed sides and an opening at one end with a double leaf door (see Figure 1). It comes in a variety of sizes and is intended for transferring and storing goods of all kinds. Designed to be used by trucks, trains, and ships, its size and construction is dictated by transport conditions (Slawick, Bergman, Buchmeier, Tinney, 2010). A standard shipping container consists of a steel construction (typically COR-ten steel). The walls are constructed using a frame and filling design which allows for modification of size and load bearing reinforcement. Both the frames and fillings are designed to take dynamic and static loads into consideration. Dynamic loads occur during transportation and mounting while static loads result from the weight of the containers and the contents it holds. The corner posts of a container are used to distribute loads and are designed to withstand deformations in response to changes in load distribution. Containers fall into two categories depending on their use. When used solely for shipping, containers are generally referred to as an ISO container, a Cargo Container, or a Conex Box. When used for building construction or storage, containers are called an ISBU Module or ISBU (Intermodal Steel Building Unit), or a GreenCube.



Figure 1. Standard Shipping Container with Double Leaf Doors.
<http://www.dimensionsguide.com/wp-content/uploads/2010/01/Shipping-Container-Width.jpg>

History of Shipping Containers

Most anywhere in the world there is a shipping container waiting to transport the next load of cargo across sea or land. Shipping containers originated as a response to a need for a more efficient and standardized way to move products. Their purpose, originally, was to store and transport cargo worldwide. Today, shipping containers have evolved to not only to provide storage and transportation, but also to act as building modules to create a new type of architecture.

Creation-Origin of Shipping Containers, How and Why Were They Created

Shipping containers introduced the possibility of shipping pre-packaged boxes on ships, trucks, and trains anywhere in the world. The need for standardization of container equipment became important for handling equipment in the 1780's and by the 1830's the railroads were using "loose boxes" containers from trucks or ships for their coal loads. In

1926, Brown Industries began experimenting with lightweight aluminum trailer bodies and is now credited with building the first shipping containers for use on trains and ships. In the 1930's, Harry Werner and Joe Numero created the first refrigerated container. During WWII, Werner worked with the U.S. Army to create a standardized eight-foot steel container that could be pre-loaded before placement on ships for transport to Europe. Ocean Van Lines (OVL) purchased the first commercial containers in 1949, but widespread use of the containers failed to take off due to the lack of specialized docks, truck chassis, and cranes for their handling.

In 1955, Malcolm McLean, a trucking giant from North Carolina, formed the Sea-Land company and in 1956 revolutionized trans-ocean shipping by introducing the world's first container ship. In 1970, container design was standardized worldwide with the introduction of the International Standards Organization (ISO) shipping container (Sawyers, 2008).

In addition to their use for shipping and storage, containers today are now being used as temporary and increasingly as permanent housing and building structures.

Uses of Shipping Containers in the Housing Industry

History of Shipping Containers as Housing

Shipping containers were first put to new uses in their unconverted forms as tool sheds or storage spaces. In 1987, Phillip C. Clark filed a patent for a "method for converting one or more steel shipping containers into a habitable building at a building site and the product thereof." This patent provides step by step instructions on the

mounting of one or more shipping containers to a foundation, removing inner sidewalls, and installing a roof, ceiling, windows, and doors.

The military used containers for makeshift shelters and for transporting Iraqi prisoners of war during the Gulf War in 1991. Ventilation was provided for by cutting holes into the container. Nine years later, in 2001, the firm, Urban Space Management, completed a project called Container City located at Trinity Buoy Wharf in the London Borough of Tower Hamlets. It was installed in four days, and fitted out over a period of five months (See Figure 2). In 2002, this was expanded with a second phase (Container City II) and offices were constructed on the same site in the Riverside Building in 2005. The first official two-story container home in the United States was designed by Peter DeMaria in 2006, and containers continue to be used today to house a variety of activities, including military shelters which are often reinforced with sandbags stacked along the exterior to protect against weapons such as rocket-propelled grenades (RPGs) (See Figure 3.).



Figure 2. Container City by Urban Space Management
<http://upload.wikimedia.org/wikipedia/en/9/92/Containercity2009.JPG>



Figure 3. Combat Housing Using Shipping Containers.
<http://a1.l3-images.myspacecdn.com/images02/105/384f5b5b42844a54a62e9183fccc268e/l.jpg>

Types of Use

Shipping containers have a variety of applications within the housing industry. Because of their simplistic form, containers can be looked at as building blocks. By

placing containers side-by-side, an interior space comparable to many small building designs can be created. Due to their strength, containers can be stacked to create multi-story structures, and the simplicity of their construction speeds the building process (Sawyers, 2008). There is an abundance of containers, which results in a relatively low cost solution for construction, and because shipping containers are built to be transported quickly across great distances, they can be shipped to sites quickly and easily.

Applicable in both the commercial and residential practices, containers can be used as research facilities, event facilities, student accommodations, hospitals, temporary structures in times of emergency, combat housing, or private residences (see Figures 4, 5, and 6).



Figure 4. The eCORRE Complex, by APHIDoIDEA Architects.
<http://inhabitat.com/rolling-green-roofed-environmental-center-made-from-65-shipping-containers/>



Figure 5. An Example of Emergency Housing.
<http://inhabitat.com/2-million-haitians-live-in-tents-they-still-need-our-help-rebuilding/>



Photo Credit Peter Aaron / Esto

Figure 6. The 12 Container House by Adam Kalkin.
http://www.architectureandhygiene.com/12conHouse/12con_main.html

Strengths and Weaknesses of Shipping Containers

Shipping containers are universally applicable building modules in the construction sector. Like other construction methods, containers have both strengths and weaknesses when being used in the housing industry. The advantages of shipping

containers for use as housing include: strength and durability, modularity, transportability, availability, and cost. Container's weaknesses include: temperature, labor, and difficulties with construction sites (See Table 1).

Table 1.

Strengths and Weaknesses of Using a Shipping Container for Housing.

Feature	Strengths	Weaknesses	Adaption
Strength & Durability	Designed to carry heavy loads, and can thus support multiples of their own self-weight. They are also designed to resist harsh environments while being transported on ocean going vessels, trucks, and trains.	Strength is compromised when shell is modified, and containers are not built to carry loads such as large roofs. While they do resist the affects of harsh environments, they are vulnerable to degradation caused by natural elements.	Reinforcement modifications can be installed such as metal or wood framing to support the modifications to the container. Containers also can be treated and sealed to resist the deterioration of materials and occasional maintenance can be performed as well, such as de-rusting and painting.
Modularity	Container's cell-like structure is suitable for layout systems with small rooms, which can be joined together.		
Transportability	Containers conform to standard shipping sizes allowing them to be easily transported by ship, truck, or rail.	Transportability	Containers conform to standard shipping sizes allowing them to be easily transported by ship, truck, or rail.
Availability	Widely Available	Site, trade agreements, and the current need for containers can alter the availability of containers.	
Cost	Used containers are available at a cost that is low compared to a finished structure built by other labor-intensive means such as brick and mortar.	The cost of the container can increase depending on the prices of raw materials used such as steel.	

Table 1. Continued

Strengths and Weaknesses of Using a Shipping Container for Housing.

Feature	Strengths	Weaknesses	Adaption
Temperature		Shipping containers are made from steel which conducts heat very well. In areas of extreme temperature variations, the interior of the container can become uncomfortable for the use of human occupancy	By insulating the container, and installing HVAC systems, the interior environment can become comfortable for any environment.
Labor	Units are pre-formed so labor is directed at modification rather than creation or assemblage	Modifying containers requires welding and cutting skills, which are considered to be a specialized labor, which adds to the construction cost.	Shipping containers can be shipped with each module prefabricated so that a limited amount of skilled labor is required to assemble the parts.
Construction Site		Maneuvering containers around a construction site generally requires the assistance of a crane or forklift.	Containers can be easily oriented on the site as needed.

Shipping Containers as a Home

Shipping containers present several challenges when used as housing. These challenges reside in the conflicts found in small housing and include the individual's privacy, issues with crowding, human territoriality, and spatial behavior. Scholars have explored the effects these issues have on the human psyche for years including Hall (1976), Altman (1975), Stokol (1976), and Evans (1976). These issues serve to help us organize our behavior in a space, including our interactions with others, provision for personal space and boundaries, and control of stimuli.

Our interactions within the interior are compounded by the challenges of the aesthetic quality of the exterior of the container and how it brings up visual associations with shipping ports, trucks traveling the highway, and storage units near construction sites. The form of the container, an eight-sided box can be limiting in space but when viewed as a modular system, the container can offer a wide range of spatial solutions when combined. However, the interior of the container can be finished the same way a stick-built home would be, with the same amenities and can be modified to satisfy the user's desires (See Figure 7). Containers can also be attached to each other, entire sides removed to create a larger space.



Figure 7. An Example of the Interior of a Shipping Container Home.
<http://www.alldoing.com/shipping-container-house-residential-plans-with-new-models/>

The Meaning of Home

Home can be defined as the place where one lives, referring to the physical structure, but there is a lack of consensus when the definition of the meaning of home comes into play. The following is a sampling from the literature as to how writers on the subject define home. Tunner (2011) defines home as an extension of a shelter that

provides its inhabitants with a greater source of strength and well being. Bachelard (1964) states that “Our house is our corner of the world, and it is our resting place.... All really inhabited spaces bear the essence of the notion of home, and the imagination creates a home out of whatever shelter it finds itself in” (p. 6). Porteous (1976) described a home as a “Territorial Core,” a preferred space and a fixed point of reference. Dovey (1985) suggested that home represented “an ordering principle in space (p.55).” Despite many different definitions, there is one commonality among them - , “home” goes beyond the literal act of providing shelter - it is an emotional sanctuary and interweaves itself throughout our identity. According to Rapoport, our homes are most closely associated with our sense of who we are and what is more important than the spatial definition of home is the affective qualities and human relations within a home. Homes are a visual expression of the importance attached to different aspects of life, and the variety of perceptions of reality. They express the fact that societies share goals and life values (Rapoport, 1969). Homes are the creation of an ideal environment made visible.

Designing a Home: What do Families Need in a Home

The concepts of “home” and “family” both conjure up images of personal warmth, comfort, stability, and security. The home has many applications, a space for privacy, sociability, freedom, responsibility, leisure, and work. The relationships within the family are central to people's conceptions of home life. The idea of home and family are interconnected, Gilman (1976) proposed that a home is only a home “while the family is in it.” When the family is out, it is only a house.

According to Graham and Crow (1989) there are three key aspects of domestic social relations that contribute to the linking of home and family together. The first is the importance of the home as a private place with access restricted to family members and occasionally privileged others. The private sphere of the home is marked off from the public sphere of society in terms of who is encountered there, the activities undertaken there, and the styles of behavior thought appropriate. The second aspect is that the home is a place of security, control, and freedom. Among other things, being at home means that an individual can feel safe and in command, free from the intrusion and direction of others. The third is that the home is a place of creativity and expression in which activity, even activities such as housework and repair work, takes on special significance (Graham & Crow, 1989).

Shipping Container Housing Communities

Shipping containers are not limited to use as only individual residential units, they can and are used to create residential communities. These communities range from student housing communities to military housing in combat areas. The first residential community made from shipping containers was constructed at Trinity Buoy Wharf within London's Docklands (See Figure 8.). Built in 2001, this complex is made up of 20 shipping containers and is used as live/work spaces. In Amsterdam, Keetwonen is one of the largest shipping container communities in the world. Made up of 1,000 units, it is used as student housing (See Figure 9.).

Another example of a container community is in Chengdu, the capital of Sichuan province in Southwest China. This city is made up of eleven million, many of them

migrant workers in need of inexpensive housing (See Figure 10). The U.S. military also use shipping containers to house their soldiers overseas, and have been since the 1970's (See Figure 11.).



Figure 8. Container City I, located at Trinity Buoy Wharf, London.
<http://en.wikipedia.org/wiki/File:Containercity2009.JPG>



Figure 9. Keetwonen, Student Housing in Amsterdam.
<http://thistinyhouse.com/2009/shipping-container-villages/>



Figure 10. Shipping Container Community Housing Migrant Workers.
<http://weburbanist.com/2011/05/22/living-in-a-box-chinas-shipping-container-apartments/>



Figure 11. Military Housing for Soldiers Stationed in Cambodia.
<http://www.timyoho.com/BVApage/16THFiles/Cambodia-D'Amato/030506-D'Amato-3Connex.jpg>

Housing and Community

Community can be defined as a group of interacting people that often share some common values, living within a shared geographical location, generally in social units larger than a household. An individual's sense of community extends beyond the physical membership.

Sarason (1974) defined the sense of community as the sense that one was part of a readily available mutually supportive network of relationships upon which one could depend, and as a result of which one did not experience sustained feelings of loneliness...it is a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together (p.830).

The idea of community also involves the notion of a community having borders or boundaries. Goldring (1996) explains that these boundaries serve to establish a dividing line for the domains and tasks of people, which a community stakes out for itself. Boundaries also act as mechanisms to secure a certain amount of independence from the surrounding environment. Within the boundaries of a community, there is often a unifying architecture and aesthetic that helps to distinguish the community from others. This aesthetic can extend to lawn care, vehicle maintenance, and trash disposal. These communities often house common areas of play within their borders to include playgrounds, parks, pools, and sometimes community centers with gyms, Wi-Fi, and makeshift cafes.

Communities can vary from one locale to the other, but their distinction is not limited to their geographical location. Communities within different neighborhoods,

suburbs, towns, and cities have their own individual identities. Communities can also share a common culture that sets them apart from others. These cultures can include a shared ethnicity, religious belief, or specific need, such as disabled persons or an older age group. The membership of a community can be dictated by a common identity other than location. An example of this would be a professional community, in which a group of people comes together with the same or related occupations.

Application of “Home” and “Community” Techniques

The range of people's experience of the home and community reflects the diversity of life that takes place there. Christopher Alexander, author of *A Pattern Language*, lays out a framework for applying these ideas of home and community to a design. Alexander calls this framework Pattern Language. The purpose of this language was to provide a non-technical vocabulary of design principles for the use of those who do not work within the industry. This Pattern Language is comprised of patterns listed under different categories such as interiors, exteriors, lighting, and orientation (See Table 2.). When combined these patterns become a language, one that is customizable for the needs and goals of the space. Alexander explains that choosing only the patterns that are applicable to the project's goals and combining them with the overall design is the ideal method of completing the process of creating a customized language.

Table 2.

Sample of Christopher Alexander's Pattern Language as it Applies to Community, Housing, and Family.

Category	Pattern	Description
	Household Mix	Encourage a mix of household types in every neighborhood, so that one-person households, couples, families with children, and group households are side by side
	Degrees of Publicness	Make a clear distinction between three kinds of homes-those on quiet backwaters, those on busy streets, and those that are in between.
Communities and Neighborhoods	Connected Play	Lay out common land, paths, gardens, and bridges so that groups of at least 64 households are connected by a swath of land that does not cross traffic. Establish this land as the connected play space for the children in these households
	Public Outdoor Room	In every neighborhood and community, make a piece of the common land into an outdoor room-place it beside an important path and within view of many homes and workshops

Table 2. *Continued**Sample of Christopher Alexander's Pattern Language as it Applies to Community, Housing, and Family.*

Category	Pattern	Description
Housing	South Facing Outdoors	Always place buildings to the North of the outdoor spaces that go with them, and keep the outdoor spaces to the South.
	Wings of Light	Make the building or wing long and as narrow as you can—never more than 25 feet wide
	Long Thin House	In small buildings, don't cluster all the rooms together around each other; instead string out the rooms one after another, so that distance between each room is as great as it can be.
Transformation of the Family	Main Entrance	Place the main entrance of the building at a point where it can be seen immediately from the main avenues of approach and give it a bold, visible shape which stands out in front of the building
	House for One Person	Conceive a house for one person as a place of the utmost simplicity: essentially a one-room cottage or studio, with large and small alcoves around it. When it is most intense, the entire house may be no more than 300 to 400 square feet
	House for a Couple	Conceive a house for a couple as being made up of two kinds of places—a shared couple's realm and individual private worlds. Imagine the shared realm as half-public and half-intimate; and the private worlds as entirely individual and private.
	House for a Small Family	Give the house three distinct parts: a realm for parents, a realm for the children, and a common area. Conceive these three realms as roughly similar in size, with the commons the largest

Table 2. *Continued*
Sample of Christopher Alexander's Pattern Language as it Applies to Community, Housing, and Family

The Most Important Areas and Room (In a House)	Indoor Space	With occasional exceptions, make each indoor space or each position of a space, a rough rectangle, with roughly straight walls, near right angles in the corners, and a roughly symmetrical vault over each room
	Common Areas at the Heart	Create a single common area for every social group. Locate it at the center of gravity of all the spaces the group occupies, and in such a way that the paths, which go in and out of the building, lay tangent to it.
	Indoor Sunlight	Place the most important rooms along the South edge of the building and spread the building out along the East-West axis.
	Intimacy Gradient	Lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domains

Nan Ellin wrote about community in her book *Integral Urbanism*. Ellin writes of five elements to apply to any community design. These elements include Hybridity, Connectivity, Porosity, Authenticity, and Vulnerability. “Whether applied to existing urban fabrics or new development, Integral Urbanism activates places by creating thresholds-places of intensity- where a range of people and activities may converge” (p.). These approaches emphasize the importance of permeable membranes, system diversity, and the ability to be self-adjusting and always evolving (Ellin, 2006). The five qualities are guidelines for how to create a successful community (See Table 3.).

Table 3.
Nan Ellin's Five Elements of a Successful Community.

Element	Description
Hybridity	The process of connecting people and activities at points of intensity and along thresholds
Connectivity	Similar to Hybridity, Connectivity is focused on linking people and activities at certain areas
Porosity	An element with the ultimate goal of enhancing one's experience within a community-allows some seepage, but not free flow.
Vulnerability	The allowance of things to happen, things that may be unforeseen.
Authenticity	Results from a community that is a combination of large-scale and small-scale interventions, both systematic and serendipitous.

Summation

Shipping containers serve a variety of functions. Still used as a mode of transporting goods from one port to another, their use has been expanded to create a new type of building vernacular. Because of their strength, durability, portability, and availability, they provide a ready resource for inexpensive construction that can be used in both the commercial and residential industry. Within a community and a home, shipping containers can be viewed as building blocks that are combined to create meaningful spaces and connections.

CHAPTER III

CREATIVE PROCESS

Throughout my time at the University of North Carolina, Greensboro, I have investigated the reinterpretation of different types of housing and their communities using shipping containers. The first exploration consisted of looking at student housing and the educational community. The second explored disaster housing and the community of those who has endured loss from a disaster. The third and final investigation explored military housing within the military community. As part of my design process, I plan to review each of these investigations. Descriptions of these investigations are presented below.

Fall 2009: Student Housing

The scope of this investigation was to reinterpret the existing manufactured home while investigating patterns, relationships, and the quality of life within a manufactured home community, in comparison to a larger and more urban habitat. The planned site was on the East side of the Tower Village dormitory located on the campus of UNC-Greensboro. The plan involved a structure that not only would include residential units, but also classrooms, a marketplace, a coffee shop, and administration offices. The goal was to create a mixed-use space that would allow for diversity often found in large cities, and with no tangible boundaries. My intention was to create a structure that would

permeate throughout the UNCG community as recommended by Nan Ellin, and would have a connection to the surrounding area

Precedent Studies

When I began my studies in the Fall of 2009, I knew that I was interested in the re-use of shipping containers as a source of housing, but was unsure of the context in which this would take place. I began the fall studio exploring how the manufactured home could be reinterpreted using shipping containers. I chose student housing as the context for this study. I began to look at precedents for inspiration, including the \$20,000 dollar home built by Auburn University School of Architecture's students and faculty (See Figure 12), and the projects submitted to Habitat for Humanity of Greater Charlottesville's competition, Urban Habitats (See Figure 13). Habitat for Humanity was searching for a new housing model with the Sunrise Trailer Court as the location for this study. Further inspiration was found in the student housing located in De Uithof, near Utrecht University (See Figure 14).



Figure 12. The \$20 K House I built by Auburn University Students.
<http://apps.cadc.auburn.edu/rural-studio/Default.aspx?path=Gallery%2fProjects%2f2005%2f20kversion1%2f>



Figure 13. “Trailer Park” Designed by Craig Konyk, Timo Koeppe, Jonathan Louie, and Ivan Sorensen.



Figure 14. Student Housing for Utrecht University.

Concept Generation

My idea generation came from looking at traditional vernacular and thinking about how this visual language could start to incorporate shipping containers to create a new type of vernacular. I looked at both contemporary and conservative structures (See Figure 15.). Further idea generation came from the exploration of existing structures made from shipping containers (See Figure 16.). My next step in the generative process was to experiment with the shipping container form by stacking and rearranging scale models to create a community structure (See Figure 17.). I decided to use the 8' x 8' x 20' shipping container as the basic unit through which I would conduct the investigation. After a variety of explorations, I chose an arrangement that I felt could fit into the context and would provide a platform on which the investigation could proceed (See Figure 18.).



Figure 15. Sketches of Existing Vernacular, Using both Traditional and Contemporary Techniques.

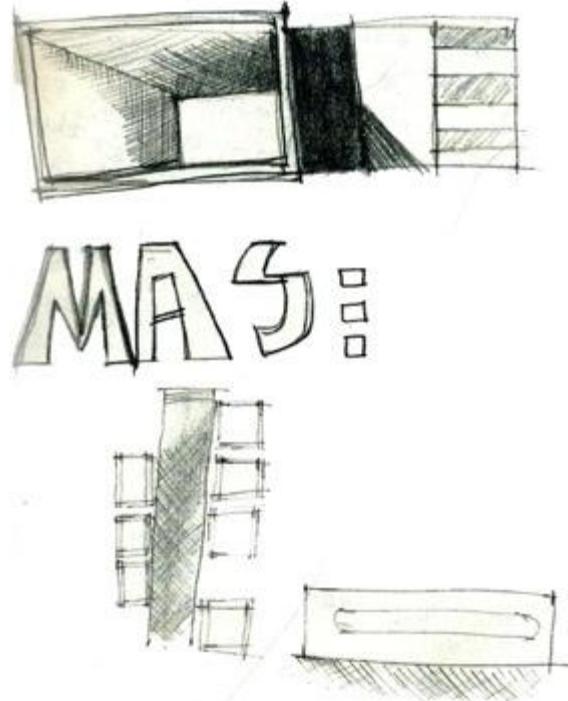


Figure 16. Sketches of Current Structures Using Shipping Containers.



Figure 17. Process Models for Student Housing Community.

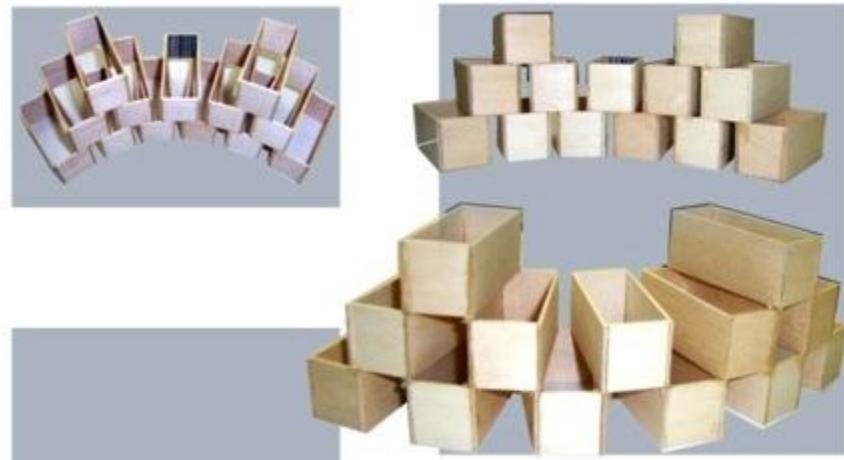


Figure 18. Final arrangement for Scale Model Arrangement Exploration.

Design Development

Once concept generation was completed, my next step was to start developing the structure where the shipping container units would be inserted. Using a 3D modeling program, I continued to explore the layout of the containers as well as how the structural elements would come together to house and support the containers (See Figures 19, 20, & 21.).

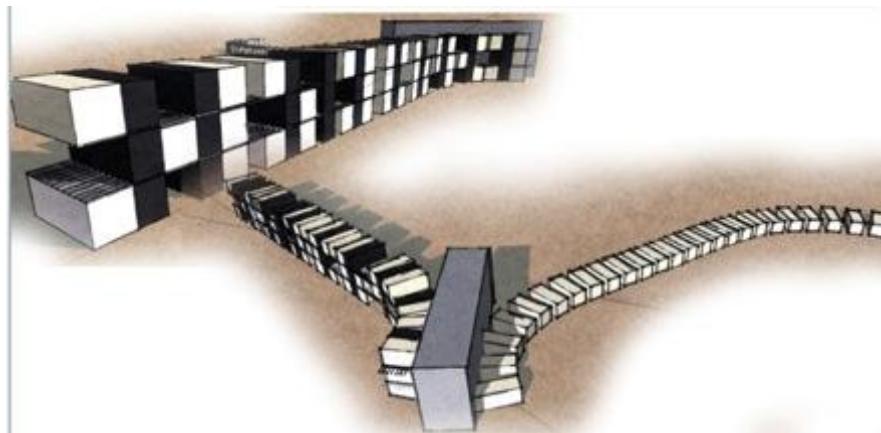


Figure 19. Preliminary 3D Model of Student Housing Structure.



Figure 20. Study of Student Housing Arrangement.



Figure 21. Exploration of Structural Elements and Circulation of the Design.

Further development of the structure continued with the development of the interior the units. This presented some challenges because the programming for the space required living spaces for two users as well as and ADA bathroom. I went through several ideas, which included a single and double bedroom unit with the bathroom extending from the center of the container (See Figure 22). After further refinement, I decided on locating the bathroom in a central core with a shipping container on either side (See Figure 23). One container would house the sleeping areas, and the other would

house the kitchen and living areas. This was not the final iteration because it did not create the same visual language that the individual containers did (See Figure 24).



Figure 22. Preliminary Views of the Interior Development.

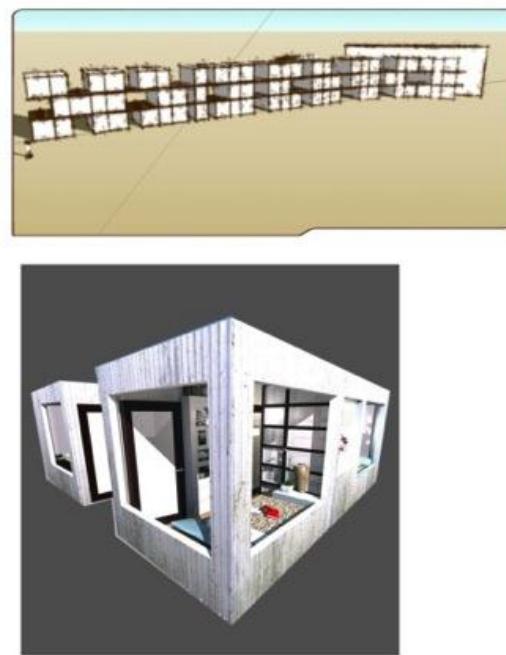


Figure 23. Preliminary Unit with Bathroom Located Between Two Containers.



Figure 24. Preliminary Elevations.

Final Iteration

The final iteration of the unit consisted of one container that housed two bedrooms, which were separated by built in closet units (See Figures 25 & 26). The bathrooms would be located in a central tower which would also house the circulation for each floor and would allow all plumbing and electrical elements to be installed within the tower and the container units would then be inserted into the structure (See Figure 27). The towers provide further connections by the installation of a hallway, which would connect the bedroom units to the bathroom and the living and kitchen space, which would consist of a second container on the other side of the tower (See Figures 28. and 29). My intended goal for the second container was that it could also house a second set of sleeping areas, depending on the need for housing and the amount of incoming students at the time. The type of spaces provided would be determined by the grade level of the student, which would provide another opportunity for mixed use, in that undergraduates, upperclassmen, and graduate students could be assigned to different units within the same structure.



Figure 25. Perspective of Final Student Housing Design.



Figure 26. Elevations of Final Iteration.

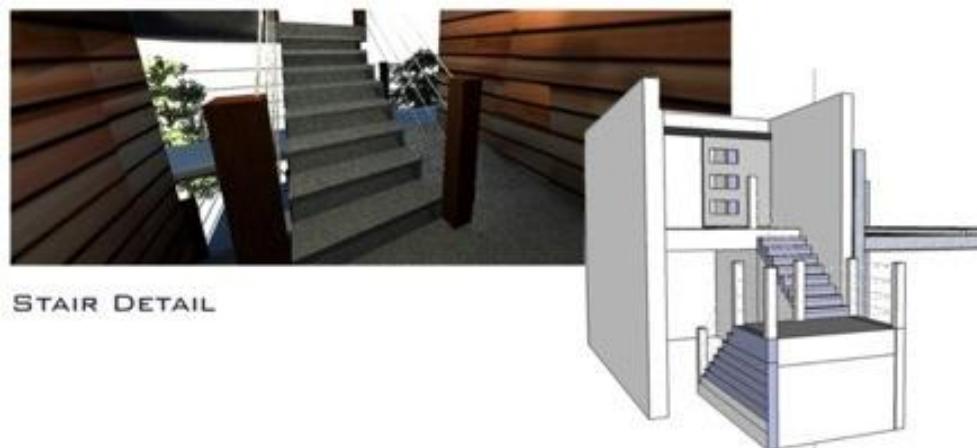


Figure 27. Detail of Tower and Stairs.

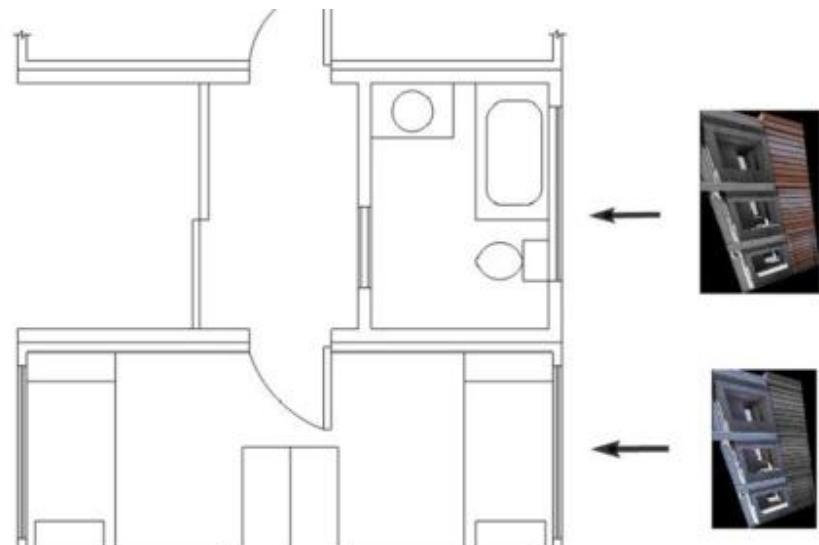


Figure 28. Plan of Sleeping Unit, Bathroom, Views of Tower, and Unit Connections.



Figure 29. Interior Views of Sleeping Unit.

Construction of Student Housing Design

For the construction of the student housing, I decided to use I-beams to form the frame on which the shipping containers would sit. I determined that W8 x 15 steel beams would be used for the beams and columns, and W14 x 20 steel beams would be used for the girders. A wood deck would then be installed on the steel frame and the containers would be secured on top. The containers would be secured by attaching steel plates,

which had an attached J-hook to the steel beams. The container would then be tied down to the J-hooks, thus connecting the containers directly to the steel frame. The tower would be constructed with wood framing and exterior finishes, and the I-beams would extend to the core of the tower (See Figure 30).



Figure 30. Detail of Steel Structure to House Shipping Containers.

My plan was to have the container manufactured partially within a factory and partially on-site. The shipping container would be shipped to the factory where it would be fitted according to specifications. Openings in the container wall would be cut to get ready for windows and doors, and then it would be coated with a thermal paint to provide extra insulation. Once on site, the containers would be lifted by crane and placed within the steel structure. After they were secured to the structure, the roof would be fabricated. Steel beams then would be welded onto the top of the container to provide reinforcement for the roof. Hurricane clips would be used to tie the metal roof to each beam for added security. Within the interior, a sub-floor and finished floor would be installed and metal

studs and drywall would be used to finish the interior walls and ceiling. Final touches would then include installation of doors, windows, and built-in furnishings.

Fall 2010: Disaster Housing

My second year started with the Fall 2010 studio. After working on the student housing my first semester, I chose to look at a different type of context for the next shipping container community. I focused my attention on disaster housing, and the communities that were dealing with rebuilding after natural disasters. New Orleans was still trying to recover from Hurricane Katrina, and Haiti has just endured a severe earthquake. I wanted to explore how shipping containers could be adapted to help these communities recover and adapt as quickly and as easily as possible. After some refinement of the scope of the project, I decided to create a housing model for disaster housing that took context, community, and adaptability into consideration. I also wanted to make sure that I developed the interior well for this project and considered the user's experience within the container. I chose New Orleans for the context of this investigation because of the devastation it had experienced, as well as the re-building process that was currently underway.

Precedent Studies

I began by gathering precedents for disaster housing. My first precedent was created from a shipping container, designed by a research group from Clemson University. The project was entitled SEED, and its purpose was to develop a new process for transforming shipping containers into housing for the use of those in the Caribbean region in the event of a Hurricane (See Figure 31.). The research group explained that

they chose shipping containers because they are strong enough to withstand hurricanes and seismic activity, and are a logical solution to the ongoing problem of what to do for those who have lost everything. The research group defined their project as a temporary solution, the containers would not be equipped with plumbing or electricity but their intention was to start thinking about the trend to re-use shipping containers in a new way.



Figure 31. Disaster Housing Project by SEED from Clemson University.

I began thinking about how shipping containers could be used as more than just temporary shelters, and how it could built in a way that could adapt to accommodate the users needs immediately after a disaster as well as months or years after a disaster. A precedent for this type of transitional architecture was found in the FLOAT House, designed by Morphosis Architects as a part of the Make It Right Foundation (See Figure 32.). The FLOAT House was designed to optimize the efficiency of mass-production while respecting the unique culture and context of New Orleans. Located within the

Ninth Ward, Morphosis described their design as a growth out of the indigenous typology of the shotgun house, which is predominant throughout New Orleans and the Lower Ninth Ward. What makes the FLOAT House unique is its function when there is a flood. The base of the FLOAT House integrates all the house's systems and securely floats in case of flooding.



Figure 32. FLOAT House: Designed by Morphosis Architects.

Further precedence came from my Fall2 2009 project (See Figure 25). During this studio project, I had paid attention to the community aspect and I wanted to incorporate that study into this study, but focusing more on the interiors this time. The final source of inspiration came from Michael Jantzen's "M-vironments," which consists of manipulable components that are able to be connected in a variety of ways to a matrix

of support frames (See Figure 33). These frames can be assembled and disassembled in different ways to accommodate a wide variety of needs.



Figure 33. Michael Jantzen’s “M-vironments.”

Photo Analysis

Because I intended to create a housing model that responded to the vibrant culture of New Orleans, I felt it was important to document the type of housing that currently existed, as well as the new construction that was taking place as a result of Hurricane Katrina (See Figure 34.). Within this analysis, I explored different architectural elements in both traditional architecture, as well as contemporary architecture. The architectural elements include roofs, windows, architectural details, exterior elements, exterior finishes, interiors, and shading devices.

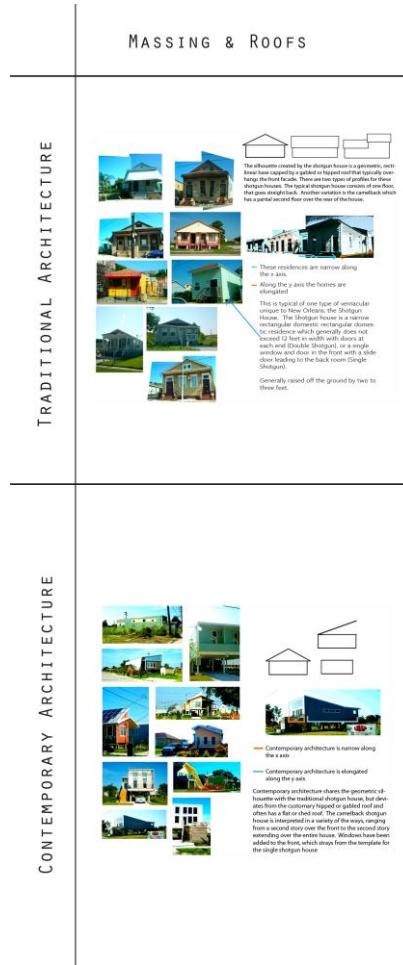


Figure 34. Excerpt From Photo Analysis Matrix created Fall 2010.

Some of the observations I made include the profile of traditional homes, which are typically made up of a geometric, rectilinear base, capped by a gabled or hipped roof that generally overhangs the front façade. This is compared to more contemporary architecture, which does not exclude the gabled roof but expands the variety of profiles to shed and flat roofs as well. New Orleans' traditional architecture makes use most often of full-length windows that extend from the floor to the ceiling. They often imitate the silhouette of the doors and are flanked on either side with shutters. Traditional

architecture is pretty consistent with the use of windows, but contemporary architecture varies more with the type of windows used. The full-length windows are not as common. One final example of the observations made during this photo analysis is the type of architectural details used in traditional and contemporary architecture.

In traditional architecture there are several architectural details that are common within New Orleans' vernacular. Ornate brackets, wooden and cast iron are used within the residential and commercial settings. Embellishments are used on door panels, and railings and columns are adorned with elaborate ironwork. Contemporary architecture dispenses with the decorative brackets and shutters, and relies on the structure of the building to act as part of the decorative elements. This includes exposed beams and pipes, as well as extended eaves. Geometric forms are introduced through materials and cutouts are used to identify particular elements of the building.

Concept Generation

For this project I intended to focus on an individual unit and its interior so I decided to use an 8' x 8' x 40' container for this project. I began by blocking out the zones of the container according to its intended function and whether it was a private, semi-private, or public space. At the same time I began to create a programming document that would specify the desired spaces to be provided, the user needs, and the goals for the project (See Table 4).

Table 4.

Programming Document for Disaster Housing Project.

Goals

The mission of this project is to design a disaster-housing model made out of shipping containers that can act as both temporary and permanent housing.

Objectives

Provide an environment for disaster victims that aids in the recovery process.

Create an architectural vernacular that represents the culture and architecture of New Orleans, LA.

Encourage a sense of community with the creation of the disaster housing.

The ability to have these units produced off site and then shipped to the site quickly

Location

New Orleans, LA

Users

Special User Groups

Single Families

Individuals: young adults, the elderly

Needs of Special User Groups

Physical Needs:

- An area for eating, food preparation, and storage
- An area for living: relaxing, entertaining, watch tv, and read
- An area for working: computer space, reading, studying
- An area for sleeping, dressing
- An area for bathing, showering
- An outdoor space for entertaining, relaxing, and creating connections

Psychological Needs:

- Sense of security
- Sense of community
- Sense of ownership
- Ease of recovery
- Ease of adaptation

Design Parameters

Size/Interior Dimensions

Single Unit: 8' x 8' x 40'

Interior must be multi functional

Maximize use of shipping container

Maintenance

Must be easy to maintain with little maintenance

Easy access to light fixtures, plumbing, and electrical

Use durable materials that are resistant to weather and vandalism

Design Development

With the premise that the interior would be modular and adaptable, I worked to develop an interior that provided the standard amenities such as an oven, sink, dishwasher, a bathtub, and refrigerator, as well as spaces that provided for entertaining,

relaxing, cooking, and sleeping (See Figure 35.). Since the site is located in New Orleans, I based the massing of this shipping container on a shotgun house, more specifically a camel back shotgun house. I did reverse it to provide a higher ceiling for the public space and a lower ceiling for the semi-private /private space (See Figure 36.).

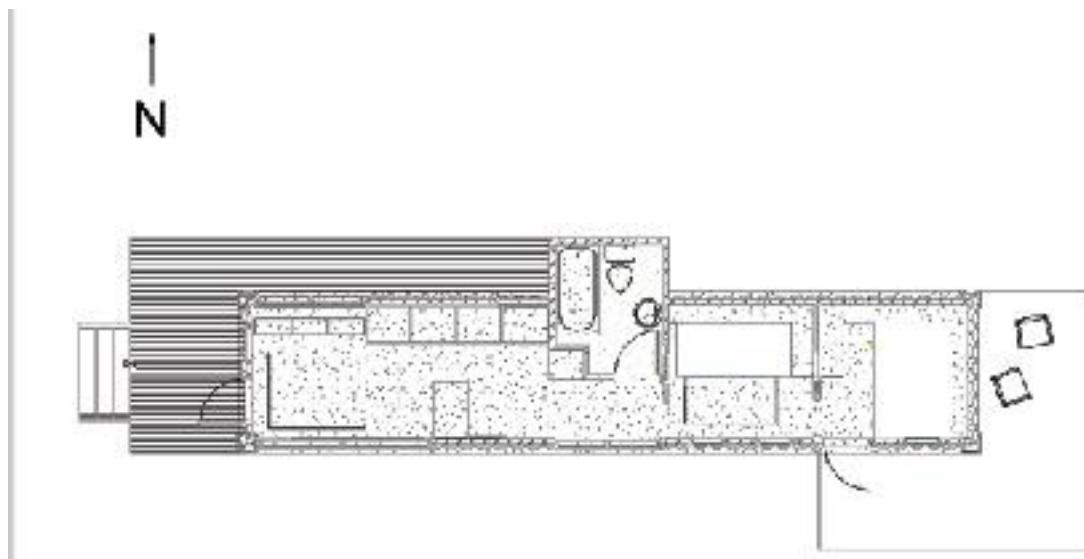


Figure 35. Floor Plan of Preliminary Container Housing Model Based on New Orleans' Vernacular.

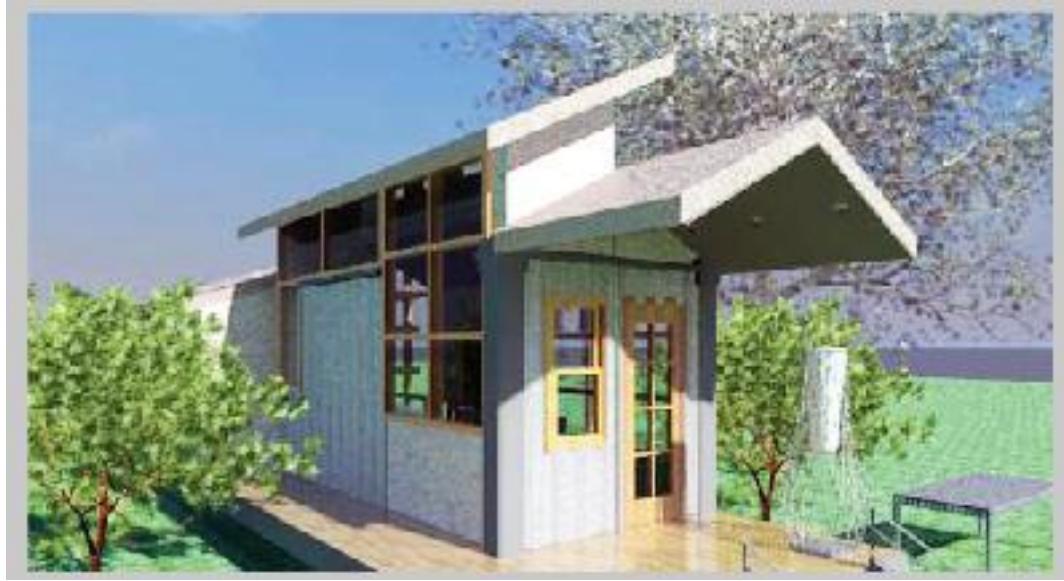


Figure 36. Perspective of Preliminary Container Housing Model Based on New Orleans' Vernacular.

Within the interior of the container, I first focused on the public space, creating curtain walls to provide more opportunities for light to enter the space, as well as to create an opportunity for two shipping containers to connect; these curtain walls would be that junction point (See Figure 37.). Because of the limited amount of space within the interior, I developed several detail elements to provide as much useable space as possible. For example, in the living area, I designed a modular storage unit to sit along the North wall that would provide various arrangements (See Figure 38). When all the units are stored together, it can act as a bookshelf or as a display space. When the units are pulled out it can act as a desk or extra seating. The tallest unit is stationary to allow for a TV or other electronics that are desired.



Figure 37. Perspectives of Interior of Container Housing Model with Curtain Walls.

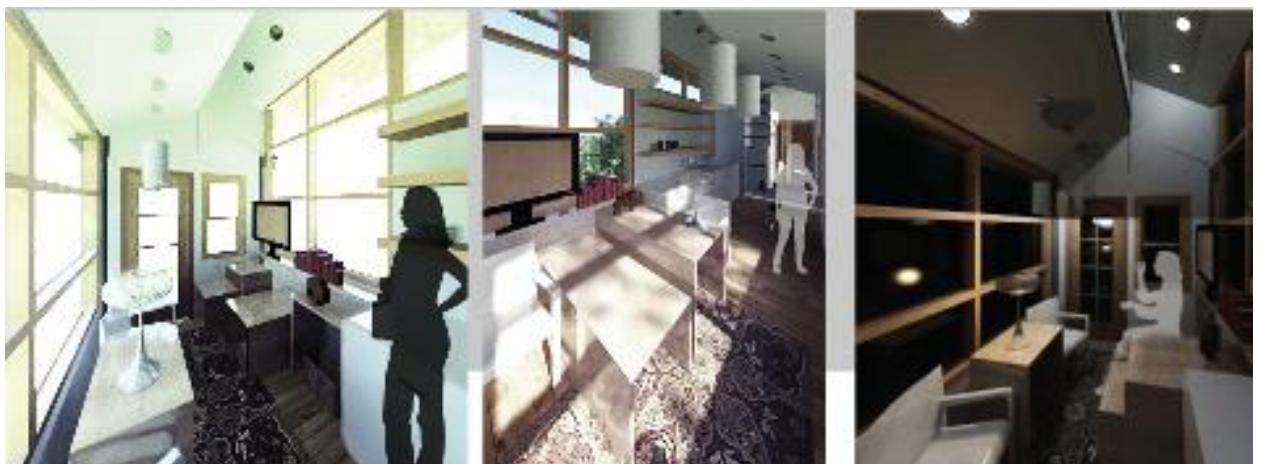


Figure 38. Perspectives of Modular Storage Unit in Different Arrangements.

The second detail within the interior that I developed is located in the kitchen. It is a table unit that hangs on the South wall of the kitchen area. The table is made up of three hinged panels; one panel adhered to the wall, the other panel attached by hinges. The hinged panel folds up and down; when folded down they create a table surface for eating and when it is folded up, it can be used as pinup space for the users (See Figure 39.).



Figure 39. Interior Perspectives of Table Unit Both Up and Down.

The final detail space is located in the bedroom, which is situated in the back half of the container. This is the private space, but to make the space have multiple functions, I decided to install Murphy beds that are surrounded by built in storage. When the bed is down, the space is a private space for the individual to sleep or relax. When the bed is up, the space can transform into a den or reading space. On the base of the bed, a panel would be attached with hinges and would fold down in order to create a desk and provide a workspace for the user as well (See Figure 40.).



Figure 40. Perspective of Bedroom with Bed Up and Bed Down.

Final Iteration

My first step was to rethink the roof, and decrease the amount of external materials that would be required. I then decided to switch from a 40-foot container to multiple 20-foot containers as I felt this would better satisfy the design's flexibility. One 20-foot container would provide the initial housing model and others could be attached as the user recovered and grew within the community. My intention with the 20-foot containers was that one would be used to house all the living functions until the user was able to expand (See Figures 41 and 42.). At that time a second 20-foot container could be added, and this container could provide space for the user to grow and develop the interior to accommodate their growing needs.



Figure 41. Perspective of Final Living Unit-Initial Unit that would House All Living Functions.



Figure 42. Floor Plan for Initial Unit.

The living space within the initial container would function, as a living and lounging space, and as a sleeping space at night with the aid of a sleeper sofa. With the addition of a second container this allowed the user to decide whether the living space would then accommodate the functions of a lounging space only or to keep its function as

both a living and sleeping space. I kept the modular table detail in the kitchen area and instead of inserting the bathroom on the side as I had previously, I decided to attach the bathroom to the back of the container using a portion of a second unit. This addition would be set on hinges so that the bathroom could rotate and create the junction point for expansion.

In addition to redefining the size of the container in use and the functions of the interior space, I also refined how the unit was modified to create the roof, windows, and the way in which the housing model responded to the chosen context (See Figure 43.). A shed roof was created on both the main structure and the bathroom, with transom windows, louvers, and curtain walls. The shed roof provided two functions; it was a more modern response to the gable roof seen on the shotgun house, but it also provided for a higher ceiling height, which further aided in the natural ventilation of the unit, which is another common characteristic detail of New Orleans architecture.



Figure 43. Elevations of Initial Unit with Shed Roof.

The second container would be attached when the user was ready to expand. This addition could accommodate any of the user's needs, but in my exploration I designed it to house two separate bedrooms (See Figure 44.). This too would be made using a 20-foot container, and like the bedrooms in the preliminary design would contain murphy beds that would be surrounded by built in storage. When the bed was down, the space would function as a private space used for sleeping, and when the bed was up, the space would transform into workspaces (See Figure 45.). Like the initial unit, the second unit would have a shed roof, transom windows, louvers, and curtain walls (See Figure 46).

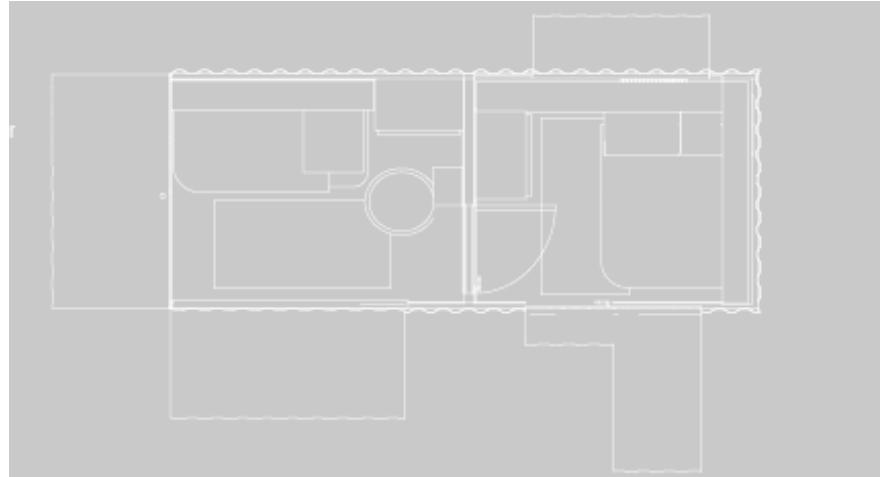


Figure 44. Floor Plan for Second Unit.

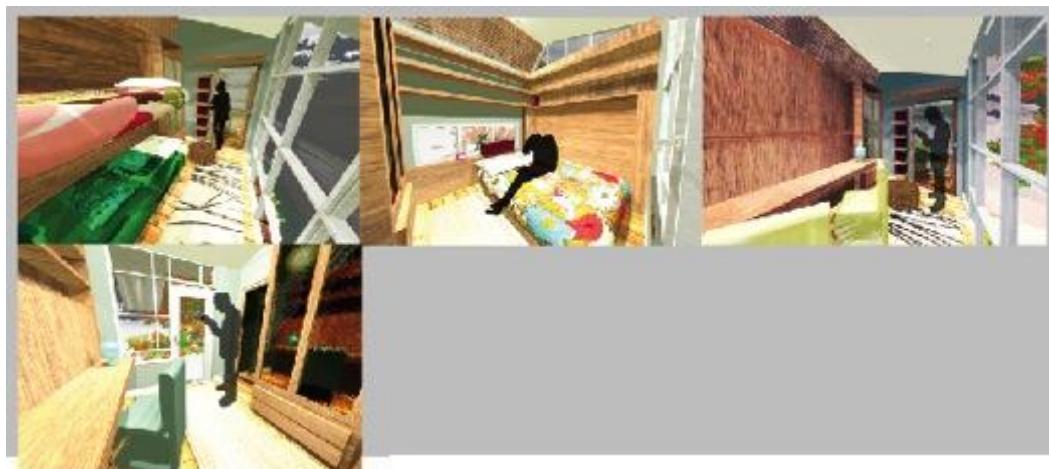


Figure 45. Interior Perspectives of Second Unit with Bed Up and Down

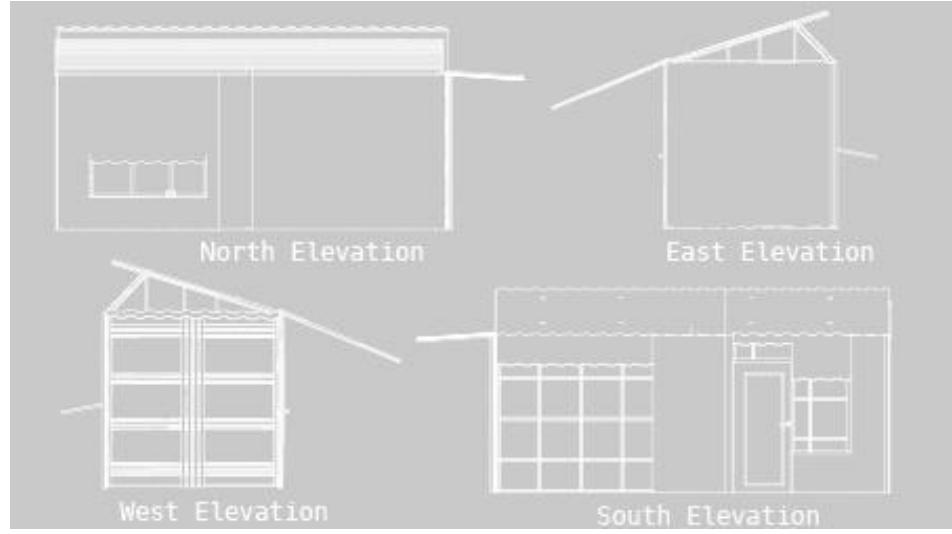


Figure 46. Elevations of Second Unit.

The purpose of not specifying exactly how the two units came together was to allow that decision to be made by the user. But I did explore two options for how the connection could be accomplished. In my interpretation I envisioned the doors of the container would open to become the walls at the junction point. A flat roof would be installed, as well as a flooring system and would then be sealed and ready for residency. The first option would involve the second unit meeting the initial unit at a 90-degree angle (See Figure 47.) The second option would involve the second unit lining up with the initial unit along the same plane. Once again, the doors would open to create walls and would be welded to the initial unit. Both a floor and roof system would be installed creating an interior space where the two meet (See Figure 48.). In both instances, the bathroom would be rotated on its hinge at a 90-degree angle.



Figure 47. Exterior and Interior Perspectives of First Option.



Figure 48. Exterior and Interior Perspectives of Second Option.

Model and Material Exploration

During this exploration I also created a scale model to further aid in illustrating the modularity of my design (See Figure 49.). In my endeavor to achieve this I investigated several methods of construction and materials. This included wood, metal, and plastic as building materials, and different techniques such as laser cutters and vacuum forming. By using the laser cutter I was able to create molds in which I pressed thin sheets of aluminum into to replicate the corrugated metal found on shipping

containers. I found that I was not able to achieve the aesthetic I wanted with this technique because the aluminum was too rigid to fit into the small ridges in the mold. From there I looked at vacuum forming which achieved the corrugated metal aesthetic but also picked up every detail of the mold and the result did not reflect the craftsmanship I wanted to achieve. I decided to create the walls that would represent the corrugated metal out of wood and use the laser cutter to cut the windows out of hardi wood and acrylic. (See Figure 50.). This exploration reflects some of the methods that would possibly be used to create the units on a smaller scale. Technology would play a large role in the creation of these units, as they would be prepared off site and then would be sent to its destination and any final assembly would be done by hand.



Figure 49. Scale Model of Initial Unit.



Figure 50. Images of Material and Technique Exploration.

Installation of Housing Model

As part of my study, I designed the container home so that it would ship as a shipping container would; with a flat roof and no shading devices open. I intended for the container to be shipped in the closed position. The transoms, louvers, and shades would be folded down and the bathroom would sit flush with the container. At the site, the roof would fold up, as well as the transoms and louvers to create the shed roof. This would be the same for the bathroom. The shades would fold up and would be held up with simple supports. To provide opportunities for growth, the bathroom is set on industrial hinges so that it could fold out at 90-degrees and a second container could be attached. To fulfill the objective to maximize the use of the container, the shades are taken from the pieces of the container that were cut out for the creation of the curtain walls. The shade on the front is the second half of one of these pieces. The roof of this

container is the original roof and the shipping container doors would act as windows as well as the front door of the home. A diagram of this process can be seen below (See Figure 51.).

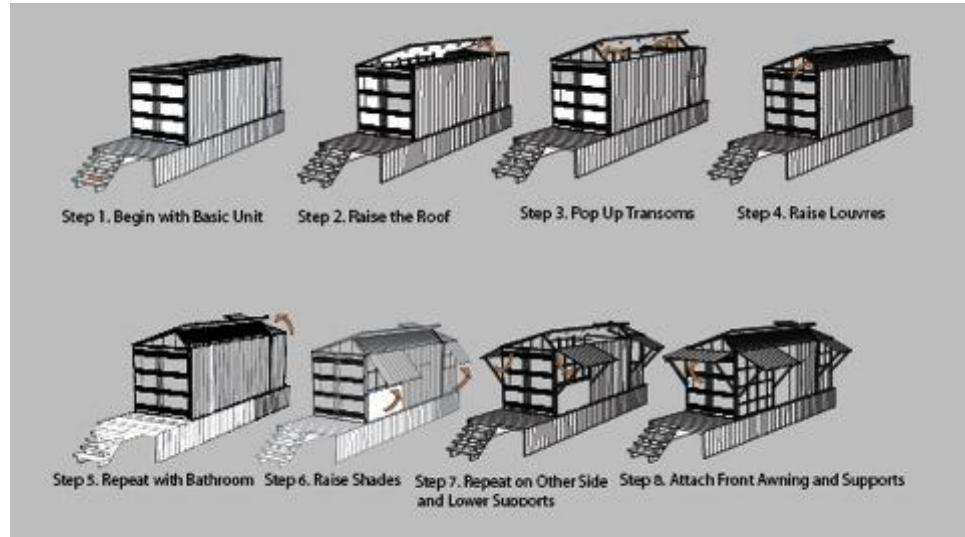


Figure 51. Diagram of Assembly Process.

Spring 2010: Support Study

As a part of my Advanced CAD class I took during the Spring of 2010 I chose to explore the interior environment of a modified shipping container and how it was affected by environmental elements using the environmental simulation program Ecotect. The intended purpose for this study was to demonstrate how shipping containers were impacted by extreme weather conditions through simulations. Elements of the study included solar exposure, daylighting and shading, thermal analyses, and prevailing winds.

Process for Preliminary Investigation

The application of this study began with modeling three models of an 8' x 8' x 40' shipping container in Revit. To better explore how alterations on the container can affect how the environment interacts with the interior, parameters were assigned to each of the containers. The parameters for these alterations included curtain walls, clerestory windows, and full-length windows; the arrangement varying within the individual design but the type remaining consistent with each one. The site for this study was New Orleans, LA. The second step for this study was to import the model into Ecotect. Within Ecotect I had to assign the functions for the model elements such as the doors, windows, and walls. For this preliminary study I kept the interior materials the same for each model, using wood for the floors and gypsum board for the walls and ceiling. Once the functions of the model elements were assigned, I began the analyses of the environmental factors. Once those were completed I compiled the results and reviewed each. I found that using one type of window throughout the design could not provide ideal results. The clerestory windows were able to reduce the thermal gain within the interior but did not provide enough natural lighting within the space and vice versa with the curtain walls. I concluded that a combination of the three types of windows would provide an ideal interior environment. My process and results can be seen below (See Figure 52.).

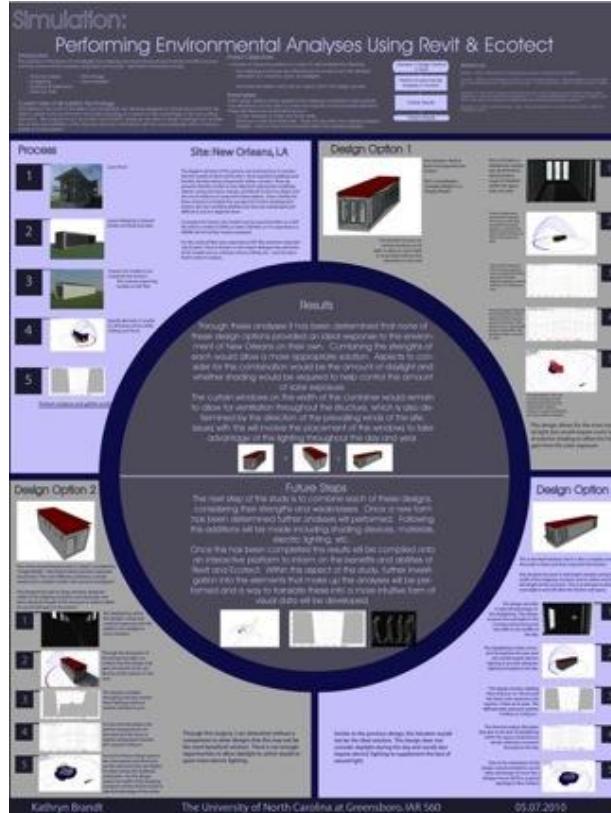


Figure 52. Final Poster of Environmental Study of Interior of Shipping Containers.

Extended Investigation

Based on my initial results with the preliminary investigation, I wanted to further investigate the interior environment of the shipping container by expanding the study. In collaboration with my professor, Tina Sarawgi, we worked to develop the parameters for this expanded investigation. We prepared a document that explored the theory behind digital simulation use and defined our process and the result we hoped to achieve. For the application of the investigation, I used the same container shell as the base model, a 8' x 8' x 40' container, but expanded upon it by applying an interior layout to the design. This interior layout informed on the placement of windows, but I kept the original parameters

for the study. I applied the use of only double-hung windows, clerestory windows, and curtain walls to three models, and then created a model that had a combination of the three types of windows so that I could compare the results of each and investigate whether my theory that a combination of the different windows would indeed provide an ideal interior environment.

Process for Extended Investigation

Like the preliminary investigation, I began by modeling the three units in Revit according to their individual parameters (See Figure 53). For the interior, I used the design I had developed during my fall 2010 investigation (See Figure 54.). Once each was built in Revit, I exported each in preparation for Ecotect. I then imported them into Ecotect, making sure all the model elements were assigned the correct function (i.e. doors, windows, and roofs) (See Figure 55).



Figure 53. Interior and Exterior Perspectives of Three Models with Different Window Types.



Figure 54. Floor Plan of Interior Layout, Originally Developed in Fall 2010 Studio.



Figure 55. Screenshots of Process of Moving Model From Revit to Ecotect.

As part of the study, some parameters for the investigation were set. These parameters are shown below (See Figure 56.), and include the types of analyses I wanted to perform, the iterations, and the times of year, all set within New Orleans, LA. Ecotect can display a variety of elements that come into play in the interior environment such as the movement of the sun around the structure throughout the year (See Figure 57), and the wind movement (direction and speed) at the site location (See Figure 58.).

Aperture	Material Options	Day of the Year	Daylighting	Solar exposure	Shading	Thermal Performance
Clerestory	Option 1	Hottest Day				
		Coldest Day				
		Equinox				
	Option 2	Hottest Day				
		Coldest Day				
		Equinox				
	Option 3	Hottest Day				
		Coldest Day				
Aperture	Material Options	Day of the Year	Daylighting	Solar exposure	Shading	Thermal Performance
Windows	Option 1	Hottest Day				
		Coldest Day				
		Equinox				
	Option 2	Hottest Day				
		Coldest Day				
		Equinox				
	Option 3	Hottest Day				
		Coldest Day				
Aperture	Material Options	Day of the Year	Daylighting	Solar exposure	Shading	Thermal Performance
Curtain Wall	Option 1	Hottest Day				
		Coldest Day				
		Equinox				
	Option 2	Hottest Day				
		Coldest Day				
		Equinox				
	Option 3	Hottest Day				
		Coldest Day				

Figure 56. Table Created for Simulation Study.

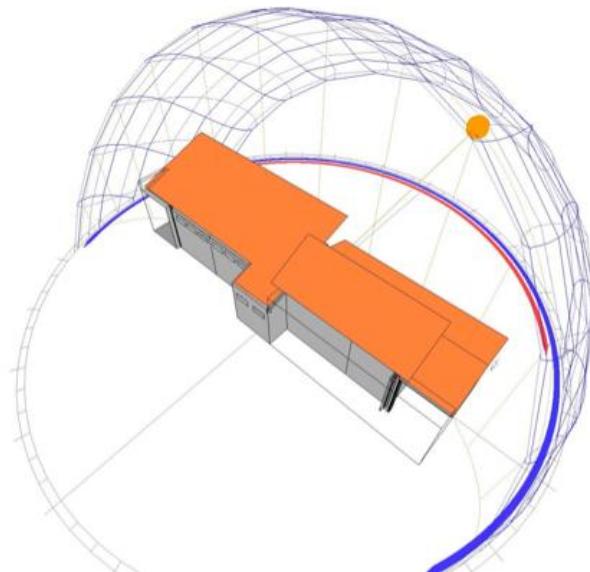


Figure 57. Sun Path in Relation to Shipping Container Model.

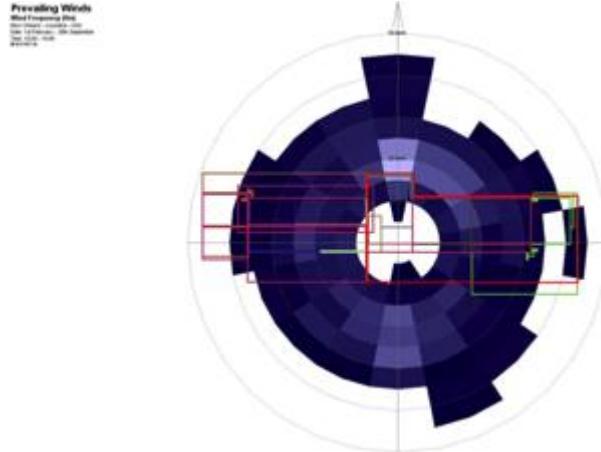


Figure 58. Prevailing Winds Diagram in Relation to Shipping Container Model.

Using Ecotect's Solar Rays Analysis, I could create illustrations of how the sun would hit the structure during different times of the day and year (See Figure 59). This was beneficial in that I could see how the sun would enter the windows at different times. The next analysis was a daylighting study, which provides the amount of daylighting within the space, displayed over an analysis grid (See Figure 60). During this investigation, I also explored the shadow ranges over the three days for all three options (See Figure 61). The shadow range analysis displays the shadows throughout a chosen time period, in this case from 12 a. m. to 11 p.m. Two final analyses I performed was the Solar Exposure Analysis (See Figure 62.) and the Thermal Analysis (See Figure 63.). The Solar Exposure Analysis measure how much solar exposure the structure receives and breaks it down into direct exposure and diffused exposure. The Thermal Analysis measures the interior temperature and exterior temperature at different times of the day.

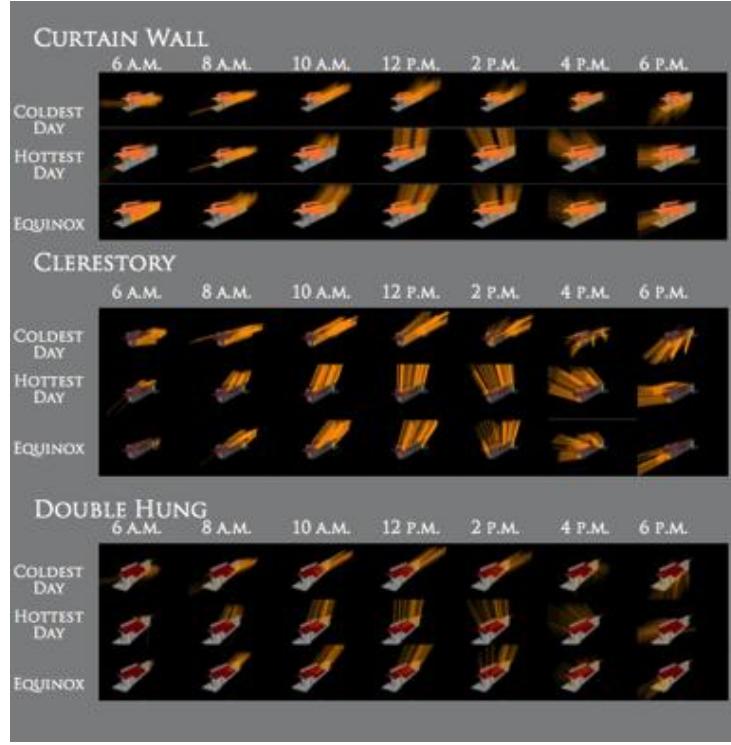


Figure 59. Matrix of Solar Rays during Chosen Days at Two-Hour Increments.



Figure 60. Matrix of Daylighting Study for Each Option on the Hottest Day, Coldest Day, and the Equinox.

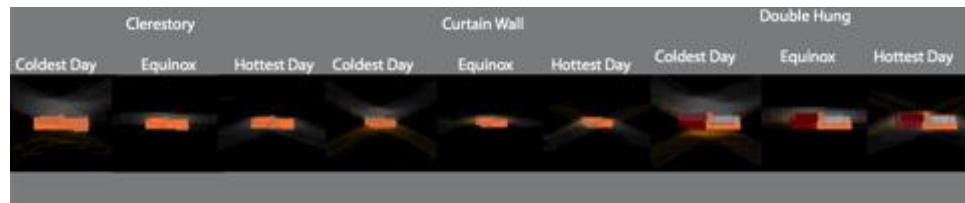


Figure 61. Shadow Ranges for Each Option on the Hottest Day, Coldest Day, and Equinox.

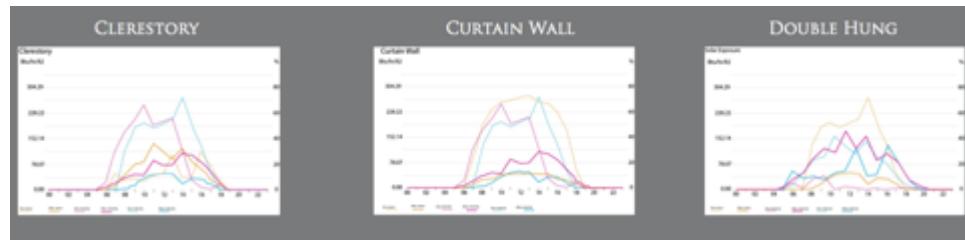


Figure 62. Solar Exposure Analysis for Each Option.

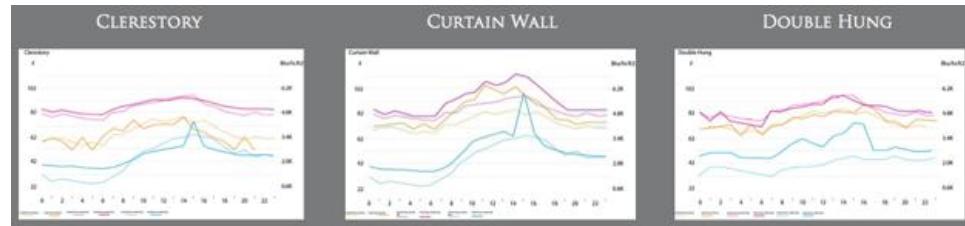


Figure 63. Thermal Analysis for Each Option.

After performing these analyses it was time to review the data so that I could create a hybrid that responded to the results of the initial investigation (See Table 5).

Table 5.
Observations of Each Option's Performance in Analyses.

	Lighting Analysis	Solar Exposure	Thermal Analysis	Thermal Comfort
Clerestory Windows	This option receives the least amount of light throughout the space	The maximum amount of solar exposure received is 220 BTUs at 12:00 pm	The increased shading of the interior results in the interior temperature reaching a high of 82° F. at 12:00 pm	This option provides the most interior comfort throughout the day
Double-Hung Windows	This option receives more light than the clerestory option, but less than the curtain wall option throughout the day	The peak solar exposure reaches 206 BTUs at 10:00 am and decreases to only 54 BTUs at 12:00pm	The interior temperature remains relatively consistent throughout the day at 82° F.	This option provides more interior comfort than the curtain wall option but less than the clerestory option throughout the day
Curtain Walls	This option receives the most light throughout the space	Due to the increased amount of daylighting, the exposure reaches 238.22 BTUs at 12:00pm	The interior temperature reaches a high of 86° F. at 12:00pm	This option provides the least amount of interior comfort throughout the day

Using these observations, I looked back at the container and its interior and applied a combination of curtain walls, clerestory, and double-hung windows throughout the space (See Figure 64). The hybrid option was then put through the same analyses the three original options underwent. The shadow range and daylighting study showed an even distribution throughout the space on each day (See Figures 65. and 66.). The strongest results came from the Thermal Analysis. In the Thermal Analysis we saw that the interior temperature remained relatively consistent throughout the day on all three days (See Figure 67.), in comparison to the three initial options whose interiors varied greatly depending on the type of window applied. With the Solar Exposure Analysis (See Figure 68.) we were able to achieve the same results within the space that we did using

just clerestory windows, despite the fact that we had curtain walls as well as clerestory windows and we were able to decrease the amount of exposure during the equinox.



Figure 64. Interior and Exterior Perspectives of Hybrid Option.



Figure 65. Shadow Range of Hybrid Option.

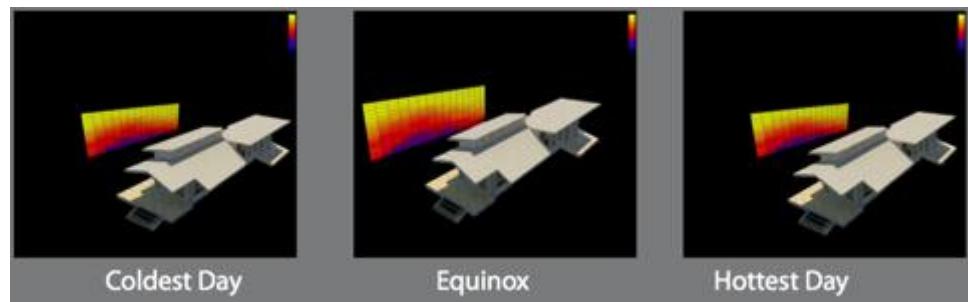


Figure 66. Daylighting Analysis of Hybrid Option.

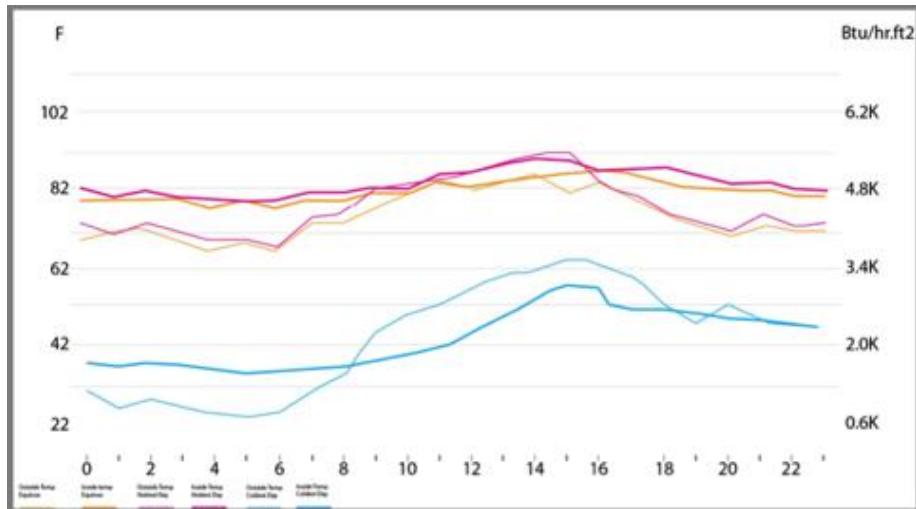


Figure 67. Thermal Analysis for Hybrid Option.

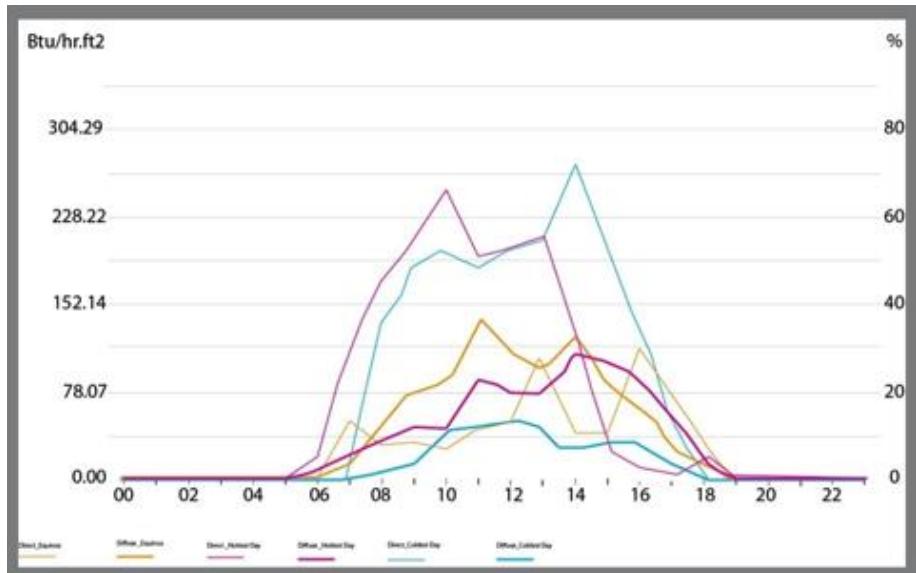


Figure 68. Solar Exposure Analysis for Hybrid Option.

The largest benefit of doing this study is the ability to provide visual evidence that shipping containers can be modified to create a comfortable space for its users.

Fall 2011: Military Housing

My intention for my final studio investigation was that it would be a combination of my previous two investigations set within a new type of community. I chose the military setting to be the final community in which I investigated the shipping container-housing model. The goal was to design a housing community constructed from shipping containers for the use of service members and their families located directly outside a military base within the United States. This community will be made up of studios made from a single shipping container and one, two, and three bedroom units made from multiple shipping containers. As I envisioned it, the users of this community could be members of a squad and their families. I wanted this community to act as a sort of support group for the families dealing with the absence of their loved ones who are deployed, and an aid in the transitioning of those returning from deployments through visual associations and a connection to their peers through community interaction.

Precedent Studies

Like the previous investigations I began this study by gathering inspiration. As I stated previously, I wanted to combine my studies from fall 2009 and fall 2010 as part of my design process, so my first precedent comes from the Student Housing design I developed in fall 2009 (See Figure 69.), and my second precedent was drawn from the Disaster Housing design I developed in fall 2010 (See Figure 70). These became the foundation for my final investigation. Further inspiration came from the Infiniski Manifesto House built by James and Mau Architects (See Figure 71). This was made from reclaimed shipping containers wrapped in sustainably harvested wooden panels on

one side and recycled mobile pallets on the other. Another inspiration of existing container architecture came from a prominent designer, known for his re-use of shipping containers, Adam Kalkin. His “Old Lady House” is built from shipping containers and was made for an elderly owner; its purpose was to prolong her independence into old age through its energy efficiency and easy maintenance (See Figure 72). My final source of inspiration came from Michael Jantzen, who I also used as an inspiration source in my study of disaster housing. His “M-velopes” were manipulable components that can be connected in a variety of ways to a matrix of support frames (See Figure 73).



Figure 69. Student Housing Developed in Fall of 2009.



Figure 70. Disaster Housing Developed in Fall 2010.



Figure 71. Infiniski Manifesto House by James and Mau Architects.



Figure 72. Old Lady House by Adam Kalkin.

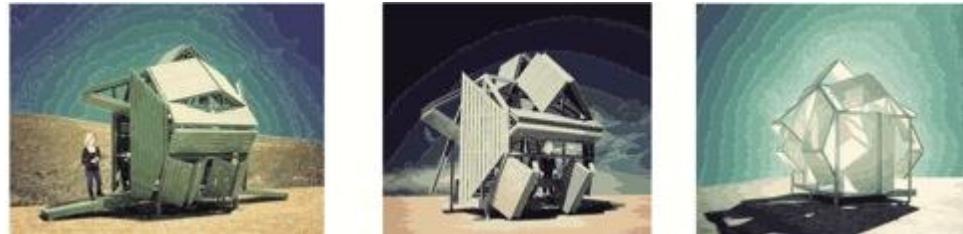


Figure 73. M-velopes by Michael Jantzen.

Design Development

As a part of my concept generation I gathered a few sources to aid in establishing some parameters for the design. Pulling from Christopher Alexander's *Pattern Language*, I built my own "Container Language" to help define the interior (See Appendix A). I re-examined my final design from the Disaster Housing investigation I did in the fall of 2010. Using the interior as the baseline, I refined it to create the single unit within a 8' x 8' x 40' container, a housing model that was intended for single and lower ranking soldiers (See Figure 74). From this point, I expanded the unit by attaching a second container to provide more space, which would be intended for the use of mid-ranking soldiers and their spouses (See Figure 75.). The third unit is made up of three 40-foot containers for the use of high-ranking soldiers, their spouse's, and children (See Figure 76). When the containers were expanded, the original structural framing of the containers would remain to act as structural framing for the unit, and columns would be installed to provide extra support.

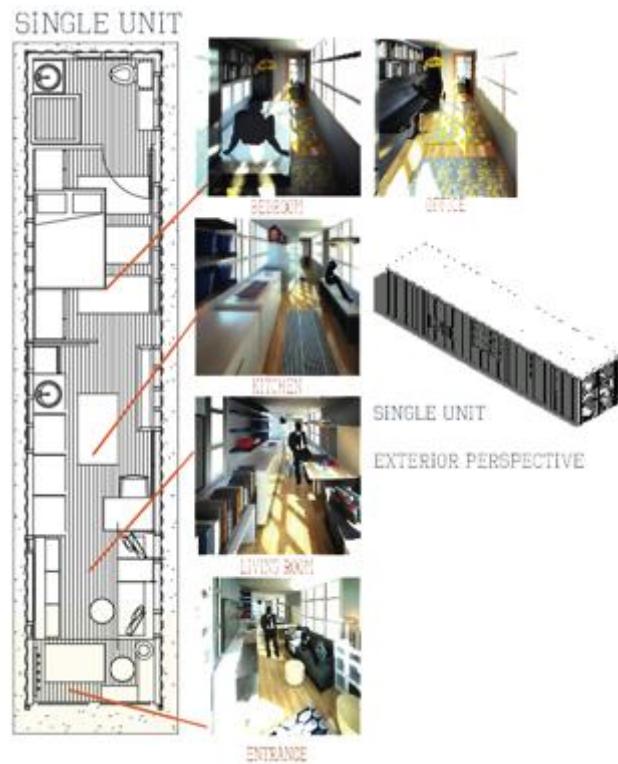


Figure 74. Floor Plan and Interior Perspectives of Single Unit.

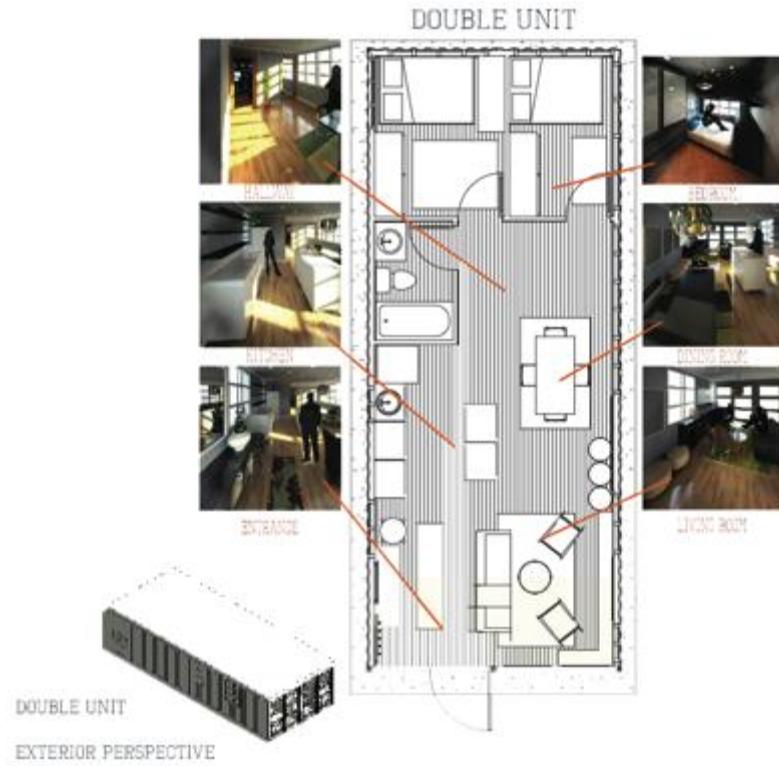
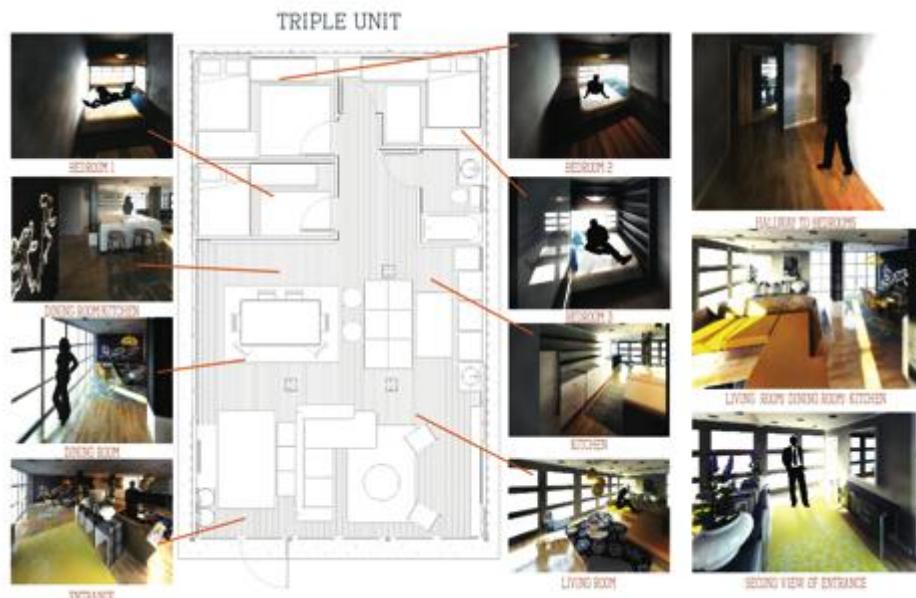


Figure 75. Floor Plan and Interior Perspectives of Double Unit.



Figures 76. Floor Plan and Interior Perspectives of Triple Unit.

The single unit is designed to act as a studio apartment, with each space optimized to accommodate a variety of functions. The double unit is set up much the same, but two private bedrooms are added as well as a dining room and kitchen island. As opposed to the single unit, the entrance is separated from the living space. With the triple unit, an additional bedroom is provided to total three bedrooms and the living, dining, and cooking space are expanded with the addition of more space. Each space was designed to accommodate activities the soldiers and their families would participate in such as gaming, relaxing, and entertaining. Once each unit had been developed, I began to think about how the units would be combined to form the community. I began by stacking the containers on top of each other, perpendicular in their arrangement (See Figure 77.).



Figure 77. Conceptual Images of Possible Community.

This initial investigation informed me of the way in which the containers could overlap. In this arrangement they formed smaller, more intimate community spaces. This way, the containers formed a style of architecture unique to them, and the individual units became the structural elements of the community as well as the residences for the users. My next step was to develop the entire community and the structural elements that would house the containers using the initial community investigation. I stacked the containers on top of each other, turning them at 45-degrees and setting the units next to each other. The final arrangement formed an upside down horseshoe, with each unit creating the shape of an X (See Figure 78).

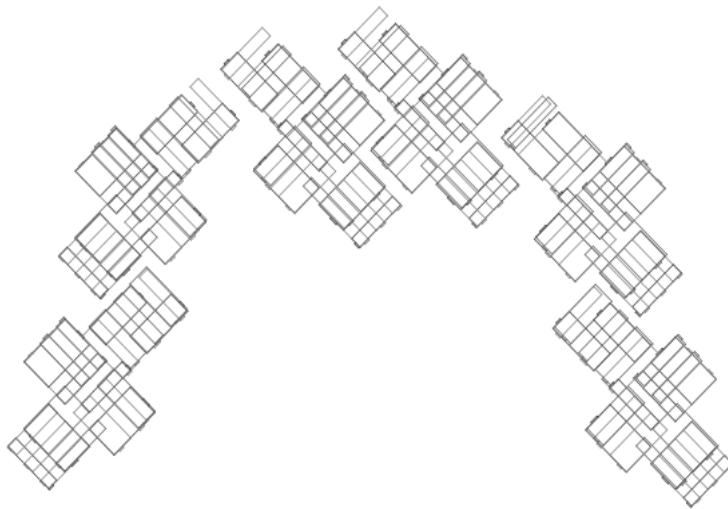


Figure 78. Final Community Arrangement.

Once I had settled on an arrangement, I started to explore the structural elements that would be used to form each floor and allow for circulation through each floor. I looked back to my study of Student Housing from the fall of 2009 (See Figure 79.). I decided to use the application of exposed framing from that study. As I had done previously, I used steel I-beams to create the columns and beams of the structure. However, I chose to use an industrial mesh made from recycled plastic for the floor because I wanted the users to be able to see the overlapping of the containers as well as to promote the interaction between each floor. Two stairs were installed, one on the exterior of the community and one on the interior of the community. The exterior stairs accesses the three floors, and the interior accesses the three floors and the roof. The roof is an area that I intended to be used as a community space for events and functions, small gatherings, and individual use. I also installed a canopy to provide shade for the roof (See Figure 80.).



Figure 79. Fall 2009 Student Housing Study.



Figure 80. Military Housing Unit.

After I developed the layout of the community, my final step was to create the community center. I wanted this space to contain specific spaces for certain activities such as laundry services, a gym, a wi-fi area, and an area for gaming. I began with a 8' x 8' x 40' container and rotated the container at 45-degrees and then attached the containers with curtain walls. The framing for the containers were kept intact and were exposed on the interior to retain the concept that this structure was made from shipping containers. The first floor of the community center housed the laundry services, the gym, and the wi-fi area, each area radiating from the entrance/reception area (See Figure 81). There are

stairs in the center of the wi-fi area that access the second floor, which houses the gaming center (See Figure 82.). The second floor also has areas for seating and holds a small library for the residents' use. From the second floor the terrace can be accessed and I also installed a canopy over the community center to define an out door area for markets, swap meets, and other community functions (See Figure 83). The canopy also acts to define the entrance of the community center for visitors.

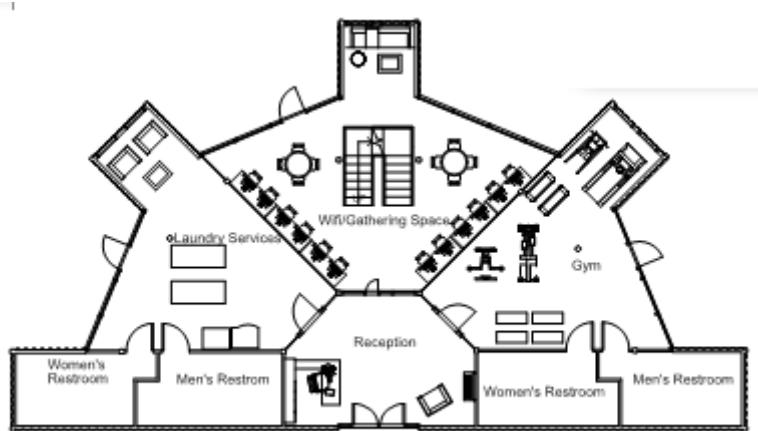


Figure 81. First Floor Plan for Community Center.

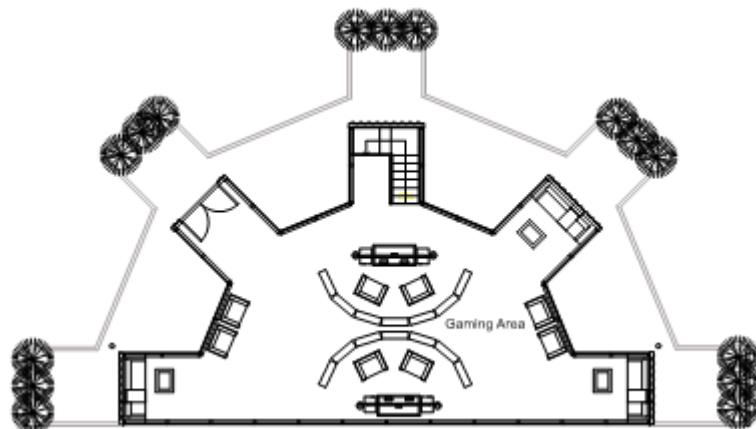


Figure 82. Second Floor Plan for Community Center.



Figure 83. Perspective of Community Center with Canopy.

Containers are an appropriate resource to use as military housing for many reasons. The military constantly uses shipping containers to transport supplies both overseas and within the states as well as to house soldiers stationed in combat areas. This provides a ready resource for the military to take advantage of and reduces the need to purchase additional material. The soldiers are familiar with the shipping containers, having worked inside them, loading and unloading supplies and are accustomed to living in them when they are performing their duty to the military. The use of shipping containers as housing in the states makes a connection for the soldiers to the work they do overseas and promotes the feeling of home for soldiers coming back after a tour of duty. The mix of the different units also enables the soldiers, no matter their rank to make connections to each other that they would not make if they lived in a traditional housing complex. The fact that each unit can act as an independent entity also enables the military to assemble them differently for different situations.

CHAPTER IV

CONCLUSION

By examining three different types of communities I have come to several conclusions. First, container housing has potential for real housing issues in places and at times when a comfortable and safe place to live is essential to well-being and community connection. Container housing also provides the potential for those for whom a permanent home is not a practicality-but it still is a place the occupant can call home.

A sense of home and shelter is a universal need, a place where we can make connections to others and a place of our own. Shipping containers are a viable resource that can satisfy this need without having to compromise on the quality of the experience within the interior. Their ease of transport makes them available in an almost unlimited amount of locations and their availability provides access to individuals with a variety of different incomes and budgets. The shipping container can be modified with a limited amount of labor and outfitted with all the amenities found in more traditional architecture. Because the cost of converting a shipping container is less than building a traditional home, a container home can achieve a larger amount of interior space and a higher quality of interior furnishings for the same cost. Through my design investigations I was able to explore a few of the possibilities in which a container can be modified to accommodate the occupant and to respond to its surrounding environment.

Whether the individual is a student living in a dorm and struggling to adapt to their surroundings, a single parent recovering from the loss of their home after a natural disaster, or a Seargent living off base with his family, getting ready for a deployment, container homes can adapt to accommodate the needs of the users. Because in times of crisis humans need the connection and support of others, shipping containers can facilitate this through their ability to be stacked and arranged in a variety of ways. Each of these communities experience struggles unique to their situation and the use of shipping containers can provide a unique characteristic to them and provides a customizable canvas on which they can create their home.

Although shipping containers can be modified to create complex and luxurious homes, they can also act as transitional or temporary homes for those of whom a permanent home is not practical. The extent to which the container is adapted to create a home can be determined based on the situation. As immediate housing after a disaster a single container can be used to create a small home until the occupant or resident can recover and then be modified to create a permanent home. Shipping containers can also be modified to create a housing community for the use of students who are experiencing an extreme transitional period from their life at home being supported by their parents to becoming independent adults responsible for themselves. Finally, shipping containers can aid in a constant transitioning for soldiers when they are deployed and when they return and for their families who need the support of members of the community while their loved ones are away.

In the end, qualities such as strength, availability, and transportability of container housing provide a range of flexibility that enables them to be adapted to different situations and needs. The ability to modify containers in a variety of ways enables the occupant to make it their own, whether as a temporary setting or a home they plan to occupy for years to come. The containers make it possible to enjoy a quality of living that approaches comparability to traditional housing at a far lower cost. Finally, the customization of the containers and their ability to easily plug in to different settings creates the environment where connections within a community can be made and an environment in which the community can establish their own identity.

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APPENDIX A

CONTAINER LANGUAGE

- Types of Housing
- Applicable to Interior
- Integral to Shipping Container Shell
- Applicable to Exterior/Shading

HOUSE FOR A SMALL FAMILY-*In a house for a small family, it is the relationship between children and adults which most critical-to achieve a balance between adults and children, a house for a small family needs three distinct areas: a couple's realm, a children's realm, and between the two.*

COUPLE'S REALM-a territory which sustains them as two adults, a couple, not a father and mother

CHILDREN'S REALM-a territory where the needs of the children hold sway
BETWEEN THE TWO- contains those functions that the children and the adults share: eating together, sitting together, games and bathing.

HOUSE FOR A COUPLE-*In a small household shared by two, the most important problem that arises is the possibility that each may have too little opportunity for solitude or privacy.*

1. The couple needs a shared realm where they can function together.
2. Each partner is also trying to maintain an individuality and not be submerged in the identity of the other

Conceive a house for a couple as being made up of two kinds of places- shared couple's realm and individual private worlds. Imagine the shared realm as half-public and half-intimate; and the private worlds as entirely individual and private.

HOUSE FOR ONE PERSON-*Once a household for one person is part of some larger group, the most critical problem which arises is the need for simplicity-* Most often men and women who choose to live alone, live in larger houses and apartments, originally built for two people or families. And yet for one person these larger places are most often uncompact, unwieldy, hard to live in, hard to look after. Most important of all, they do not allow a person to develop a sense of self-sufficiency, simplicity, compactness, and economy in his or her own life.

Conceive a house for one person as a place of the utmost simplicity; essentially a one-room cottage or studio, with large and small alcoves around it. When it is most intense the entire house may be no more than 300 to 400 square feet.

WINGS OF LIGHT – If we treat the presence of natural light as an *essential-not optional*-feature of indoor space, then no building could ever be more than 20-25 feet deep.

LONG THIN HOUSE – *The shape of a building has a great effect on the relative degrees of privacy and overcrowding in it, and this in turn has a critical effect on people's comfort and well-being.* The feeling of overcrowding is largely created by the mean point-to-point distances inside a building. To reduce this effect the building should have a shape for which the mean point-to-point distance is high.

In small buildings, don't cluster all the rooms together around each other; instead string out the rooms one after another, so that distance between each room is as great as it can be. You can do this horizontally-so that the plan becomes a thin, long rectangle

MAIN ENTRANCE-*The entrance must be placed in such a way that people who approach the building see the entrance or some hint of where the entrance is, as soon as they see the building itself.* Place the main entrance of the building at a point where it can be seen immediately from the main avenues of approach and give it a bold, visible shape which stands out in front of the building.

HIERARCHY OF OPEN SPACE-Essentially, spaces where people feel comfortable have

1. a back
2. a view into a larger space

Whatever space you are shaping, make sure of two things; First, make at least one smaller space, which looks into it and forms a natural back for it. Second, place it and its openings, so that it looks into at least one larger space.

SHELTERING ROOF- the roof plays a primal role in our lives. If the roof is hidden, if its presence cannot be felt around the building, or if it cannot be used, then people will lack a fundamental sense of shelter.

INTIMACY GRADIENT- *Unless the spaces in a building are arranged in a sequence which corresponds to their degrees of privateness, the visits made by strangers, friends, guests, clients, family, will always be a little awkward.* Every person entering a home has a very accurate sense of his degree of intimacy with the family and knows exactly how far into the house he may penetrate, according to this established level of intimacy.

Lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domain.

INDOOR SUNLIGHT-*If the right rooms are facing south, a home is bright and sunny and cheerful; if the wrong rooms are facing south, the house is dark and gloomy.* To get the sun right in your design, first decide upon your requirements for sun. If we approach the problem of indoor sunlight from the point of view of thermal considerations, we come to a similar conclusion. A long East-West axis sets up a building to keep the heat in during the winter, and to keep the heat out during the summer. **This makes buildings more pleasant and cheaper to run.**

Place the most important rooms along the South edge of the building, and spread the building out along the East-West axis. Fine tune the arrangement so that the proper rooms are exposed to the South-East and the South-West sun. Example: give the common area a full southern exposure, bedrooms South-East, porch South-West.

COMMON AREAS AT THE HEART-*No social group-whether a family, a work group, or a school group-can survive without constant informal contact among its members.* Any building which houses a social group supports this kind of contact by providing common areas. The form and location of the common area is critical. The common room functions as the heart of the space and the only balanced situation is the one where a common path, which people use every day, runs tangent to the common areas and is open to them in passing.

Create a single common area for every social group. Locate it at the center of gravity of all the spaces the group occupies, and in such a way that the paths which go in and out of the building lie tangent to it.

ENTRANCE ROOM-Arriving in a building, or leaving it, you need a room to pass through, both inside the building and outside it. This is the Entrance room. Some factors that influence the entrance room are:

1. The relationship of windows to the entrance.

A person answering the door often tries to see who is at the door before they open it.

People do not want to go out of their way to peer at people on the doorstep.

If the people meeting are old friends, they seek a chance to shout out and wave in anticipation.

2. The need for shelter outside the door.

People try to get shelter from the rain, wind, and cold while they are waiting.

People stand near the door while they are waiting for it to open.

3. The subtleties of saying goodbye.

Once they have finally decided to go, people try to leave without hesitation

People try to make their goodbye as non-abrupt as possible and seek a comfortable break.

3. Shelf near the entrance.

When a person is going into the house with a package:

He tries to hold onto the package; he tries to keep it upright, and off the ground

At the same time he tries to get both hands free to hunt through pockets or handbag for a key.

And leaving the house with a package:

At the moment of leaving people tend to be preoccupied with other things and this makes them forget the package which they meant to take.

5. Interior of the entrance room

Politeness demands that when someone comes to the door, the door is opened wide.

People seek privacy for the inside of their homes.

The family, sitting, talking, or at table, do not want to feel disturbed or intruded upon when someone comes to the door.

6. Coats, shoes, children's bikes...

Muddy boots have got to come off.

People need a five foot diameter of clear space to take off their coats.

People take prams, bicycles, and so on indoors to protect them from theft and weather, and children tend to leave all kinds of clutter around the door they use most often.

At the main entrance to a building, make a light-filled room which marks the entrance and straddles the boundary between indoors and outdoors, covering some space outdoors and some space indoors. The outside part may be like an old-fashioned porch; the inside like a hall or sitting room.

THE FLOW THROUGH ROOMS-*The movement between rooms is as important as the rooms themselves; and its arrangement has as much effect on social interaction in the rooms, as the interiors of the rooms.* The building with generous circulation allows each person's instincts and intuitions full play. The building with ungenerous circulation inhibits them. It not only separates rooms from one another to such an extent that it is an ordeal to move from room to room but kills the joy of time spent between rooms and may discourage movement altogether.

As far as possible, avoid the use of corridors and passages. Instead, use public rooms and common rooms as rooms for movement and for gathering. To do this, place the common rooms to form a chain, or loops, so that it becomes possible to walk from room to room-and so that private rooms open directly off these public rooms. In every case, give this indoor circulation from room to room a feeling of great generosity, passing in a wide and ample loop around the house, with views of fires and great windows.

SHORT PASSAGES-*Long, sterile corridors set the scene for everything bad about modern architecture.* Issues with corridors included:

1. Natural light
2. The relation of the passage to the rooms which open off it
3. The presence of furnishings.

Keep passages short. Make them as much like rooms as possible, with carpets or wood on the floor, furniture, bookshelves, beautiful windows. Make them generous in shape, and always give them plenty of light; the best corridors and passages of all are those which have windows along an entire wall.

TAPESTRY OF LIGHT AND DARK-*In a building with uniform light level, there are few "places" which function as effective settings for human events. This happens because to a large extent the places which make effective settings are defined by light.* People are by nature phototropic-they move toward light, and when stationary, they orient themselves toward the light. As a result, the places where most things happen are defined by non-uniformities in light, and all of them allowing the people who are in them to orient themselves toward the light.

Create alternating areas of light and dark throughout the buildings in such a way that people naturally walk toward the light, whenever they are going to important places: seats, entrances, stairs, passages, places of special beauty, and make other areas darker to increase the contrast.

SLEEPING TO THE EAST-The human body runs on cycles and rhythms. These cycles correspond with the cycle of the sun, which governs our physiology. According to a study by Dr. London from the San Francisco Medical School, our whole day depends critically on the conditions under which we waken. It is ideal to wake up immediately after a period of REM sleep, and the only way to make sure that you wake up at the right time is to wake up naturally. This is done by waking up with the sun. The sun warms you, increases the light, gently nudges you to wake up, in a way that is so gentle, that you will still actually wake up at the moment which serves you best.

Give those parts of the house where people sleep, an Eastern orientation, so that they wake up with the sun, and light. This means, typically, that the sleeping area needs to be on the Eastern side of the house; but it can also be on the Western side provided there is a courtyard or a terrace to the East of it.

FARMHOUSE KITCHEN-*The isolated kitchen, separate from the family and considered as an efficient but unpleasant factory for food is a hangover from the days of servants; and from the more recent days when women willingly took over the servants' role.* This arrangement implies that cooking is a chore and eating is a pleasure, while women, for all intents and purposes has agreed, by working in an isolated kitchen, to become a servant. The solution lies in the farmhouse kitchen where kitchen work and family activity were completely integrated in one big room.

Make the kitchen bigger than usual, big enough to include the “family room” space and place it near the center of the commons, not so far back in the house as an ordinary kitchen. Make it large enough to hold a good big table and chairs, some soft and some hard, with counters and stove and sink around the edge of the rooms; and make it a bright and comfortable room.

SEQUENCE OF SITTING SPACES-*Every corner of a building is a potential sitting space. But each sitting space has different needs for comfort and enclosure according to its position in the intimacy gradient.*

Put in a sequence of graded sitting spaces throughout the building, varying according to their degree of enclosure. Enclose the most formal ones entirely, in rooms by themselves; put the least formal ones in corners of other rooms,, without any kind of screen around them; and place the intermediate one with a partial enclosure round them to keep them connected to some larger space, but also partly separate.

BED CLUSTER-*Every child in the family needs a private place, generally centered around the bed. But in many cultures, perhaps all cultures, young children feel isolated if they sleep alone, if their sleeping area is too private. An ideal arrangement would be of individual spaces which the child “owns”, clustered around a common playspace so that they are all in sight and sound of one another, never too alone.*

Place the children's beds in alcoves or small alcove-like rooms, around a common playspace. Make each alcove large enough to contain a table, or chair, or shelves-at least some floor area, where each child has his own things. Give the alcoves curtains looking into the common space, but not walls or doors, which will tend once more to isolate the beds too greatly.

BATHING ROOM-Concentrate the bathing room, toilets, showers, and basins of the house in a single tiled area. Locate this bathing room beside the couple's realm- with private access- in position half-way between the private secluded parts of the house and the common areas; if possible, give it access to the outdoors; perhaps a tiny balcony or walled garden. Put in a large bath-large enough for at least two people to get completely immersed in water; an efficiency shower and basins for the actual business of cleaning; and two or three racks for huge towels-one by the door, one by the shower, one by the sink.

LIGHT ON TWO SIDES OF EVERY ROOM-When they have a choice, people will always gravitate to those rooms which have light on two sides, and leave the rooms which are lit only from one side unused and empty. Locate each room so that it has outdoor space outside it on at least two sides, and then place windows in these outdoor walls so that natural light falls into every room from more than one direction.

GALLERY SURROUND-*If people cannot walk out from the building onto balconies and terraces which look toward the outdoor space around the building, then neither they themselves nor the people outside have any medium which helps them feel the building and the larger public world are intertwined. Whenever possible, and at every story, build porches, galleries, arcades, balconies, niches, outdoor seats, awnings, trellised rooms, and the like at the edges of buildings-especially where they open off public spaces and streets, and connect them by doors, directly to the rooms inside.*

EATING ATMOSPHERE-*When people eat together, they may actually be together in spirit-or they may be far apart. Some rooms invite people to eat leisurely and comfortably and feel together, while others force people to eat as quickly as possible so they can go somewhere else to relax- Put a light over the table to create a pool of light over the group, and enclose the space with walls or with contrasting darkness.*

WORKSPACE ENCLOSURE-*People cannot work effectively if their workspace is too enclose or too exposed. A good workspace strikes the balance.*

THE SHAPE OF INDOOR SPACE-*With occasional exceptions, make each indoor space or each position of a space, a rough rectangle, with roughly straight walls, near right angles in the corners, and a roughly symmetrical vault over each room.*

WINDOWS OVERLOOKING LIFE-*In each room, place the windows in such a way that their total area conforms roughly to the appropriate figures for your region (25 percent or more of floor area) and place them in positions which give the best possible views out over life.*

HALF-OPEN WALL-*Rooms which are too closed prevent the natural flow of social occasions, and the natural process of transition from one social moment to another. And rooms which are too open will not support the differentiation of events which social life requires. Adjust the walls, openings, and windows in each indoor space until you reach the right balance between open, flowing space and closed cell-like space.*

INTERIOR WINDOWS-*Windows are most often used to create connections between the indoor and the outdoors. But there are many cases when an indoor space needs a connecting window to another indoor space.*

CLOSETS BETWEEN ROOMS-*Mark all the rooms where you want closets. Then place the closets themselves on those interior walls which lie between two rooms and between rooms and passages where you need acoustic insulation. Place them so as to create transition spaces for the doors into the rooms. On no account put closets on exterior walls. It wastes the opportunity for good acoustic insulation and cuts off precious light.*

SUNNY COUNTER-*Dark gloomy kitchens are depressing. The kitchen needs the sun more than the other rooms, not less. Place the main part of the kitchen counter on the South and South-East side of the kitchen, with big windows around it, so that sun can flood in and fill the kitchen with yellow light both morning and afternoon.*

GOOD MATERIALS-*Use only biodegradable, low energy consuming materials which are easy to cut and modify on site.*

LOW SILL-*When determining exact location of windows also decide which windows should have low sills. On the first floor make the sills of windows which you plan to sit by between 12 and 14 inches high. On the upper stories, make them higher, around 20 inches.*

FILTERED LIGHT-*Where the edge of a window or the overhanging eave of a roof is silhouetted against the sky, make a rich, detailed tapestry of light and dark, to break up the light and soften it.*