Condensed Living in Emergency Situations: Creating a Sense of Comfort and Safety Through Design

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CONDENSED LIVING IN EMERGENCY SITUATIONS
CREATING A SENSE OF COMFORT AND SAFETY THROUGH DESIGN

by

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Architecture

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This thesis derives from the idea that one should always strive to help others, and to use their skills and talents to positively influence the lives of others. Stemming from this belief, the goal of this thesis design project was to investigate the amalgamation of comfort and safety in transportable disaster relief shelters. Through focusing on human factors and sustainability, a transportable structure was designed to provide relief to those in need, specifically in an urban environment.
ABSTRACT

Condensed Living in Emergency Situations is a design based thesis that focuses on the amalgamation of comfort and safety through the design of a transportable disaster relief shelter. The “Unit” provides private and comfortable shelter to those displaced by a natural disaster, specifically in an urban setting. The concept for this thesis stems from the aftermath of Hurricane Sandy in 2012, and the recovery and rebuilding process that then took place. Recognizing the occurrence and the positivity of community comradery, this thesis design proposes a feasible solution to creating comfortable shelters for those displaced, while eliminating the need to relocate these families from their existing neighborhood.

A combination of interior design and architectural methodologies, along with personal experiences, influenced the design of the “Unit”. Human factors and sustainability practices were included throughout the design process, and they are evident in the final design concept. Though this design concept can be implemented globally, a specific site location was chosen for the purpose of this thesis. Based in New York City following a theoretical coastal storm, this thesis design project demonstrates how the “Unit” can positively influence the lives of others who are negatively affected by a natural disaster.
# TABLE OF CONTENTS

Title Page  
Copyright Page  
Signatures........................................................................................................................................................i  
Acknowledgments........................................................................................................................................ii  
Preface...........................................................................................................................................................iii  
Abstract.........................................................................................................................................................iv  
Table of Contents..........................................................................................................................................v  
Introduction...............................................................................................................................................1  
Precedent Studies........................................................................................................................................9  
Context......................................................................................................................................................18  
Program.....................................................................................................................................................23  
Schematic Design.......................................................................................................................................27  
Design Development................................................................................................................................32  
Structure..................................................................................................................................................60  
MEP..........................................................................................................................................................64  
Sustainability...........................................................................................................................................69  
Conclusion...............................................................................................................................................73  
Resources...............................................................................................................................................76
INTRODUCTION
BACKGROUND
This thesis project was created in response to the devastation caused by Hurricane Sandy in the New York - New Jersey Metropolitan Area in 2012. Though this project aims at the recovery and rebuilding phase following a natural disaster, research regarding the entire event is necessary to understand the situation as a whole. Data and information collected from Hurricane Sandy was used as a baseline for this thesis design project.

HURRICANE SANDY
OVERVIEW
Hurricane Sandy was the second-largest Atlantic storm on record, and was a catastrophic event for the New York - New Jersey Metropolitan Area in the fall of 2012. Sandy began on October 11 off the west coast of Africa as a tropical wave, and quickly progressed and strengthened up to a Category 3 hurricane on October 25. As the path of this storm moved north-northwest it dissipated into a post-tropical cyclone with hurricane-force winds, and made landfall near Atlantic City, New Jersey on October 29. Hurricane Sandy affected 24 states and damaged or destroyed hundreds of thousands of homes, created tens of billions of dollars in damages, and at least 162 people were killed in the United States.

INTRODUCTION

One of the most predominate affects from Sandy was the storm surge, which contributed to disastrous flooding. Storm surge is defined as the irregular rise of the water level above the predicted astronomical tide due to a storm. The height of the water above the normal tide level is how a storm surge is calculated. During Hurricane Sandy, the storm surge occurred around the time of the Atlantic Coast’s high tide. This contributed to the high levels of water that infiltrated the coast line. In Battery Park, on the lower tip of Manhattan, the storm surge was a record setting 9.41 feet\(^1\). Large sections of Lower Manhattan had flood waters which reached about 17 feet, according to a survey done by the Federal Emergency Management Agency (FEMA). Figure 2 (right) illustrates the estimated flood levels throughout the City from surveys and weather data collected by FEMA.

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INTRODUCTION

EVACUATION SYSTEM

New York City’s Coastal Storm Plan (CSP) contains a list of procedures for many different categories that the City follows when responding to a coastal storm. The categories include: storm tracking and notification, decision-making, evacuation, sheltering, logistics, public information, and recovery and restoration. For this thesis the procedures for evacuation, sheltering, and recovery and restoration have been examined. The evacuation section determines the procedures that will be implemented to evacuate the population that is at risk due to storm surge and other dangerous storm conditions. The sheltering section is a set of plans determining how the city will accommodate up to 600,000 evacuees at one time. The plans include implementing a combination of evacuation centers, hurricane shelters, and special needs shelters. The recovery and restoration section focuses on attending to survivors with medical needs, food, debris removal, restoring services, and repairing infrastructure.

During the time of Hurricane Sandy in 2012, the CSP dictated three evacuation zones: A, B, and C. These zones were developed through analyzing maps created by the U.S. Army Corps of Engineers focusing on potential flooding caused by storm surge, geography of the low-lying areas, and the proximity to bridges and roads. Zone A includes the areas that are most susceptible to coastal storms, including the coastline and low-lying areas. It is noted that Zone A is to be evacuated in the event of a Category 1 hurricane. Additional low-lying areas that are susceptible to stronger storms such as a Category 2 and higher hurricane are covered in Zones B and C.

Figure 3 (top right) is the 2012 New York City Evacuation Zone map which identifies the location of each of the three zones as used during Hurricane Sandy. The City has since restructured the evacuation zone system and implemented the new system during the 2013 hurricane season. In the new system, Zones A, B, and C are replaced by Zones 1-6 which includes an additional 640,000 New Yorkers. This change is seen in Figure 4 (bottom right) which is a portion of the 2015 New York City Evacuation Zone Map.

In preparation for Hurricane Sandy, Mayor Bloomberg issued a mandatory evacuation of Zone A. This evacuation affected approximately 375,000 New Yorkers and urged them to leave their homes and communities to seek safety before the storm; however, thousands of people did not leave. After the storm, the City took a survey of Zone A residents to help understand the communication between City Officials and

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the general public regarding the evacuation process. The survey of residents who did not evacuate showed that the most significant factors for staying were they believed:

- the storm would not be strong enough to be a danger
- their home was elevated enough to prevent flooding
- their home was well built

Of those who were surveyed for not evacuating prior to the storm, 29% evacuated in the aftermath. The City also polled all who evacuated, either before or after the storm, finding that 67% evacuated for more than 48 hours, 78% stayed with friends, and 2% stayed at a city evacuation shelter.

SHELTER SYSTEM

New York City uses a tiered method to organize their shelter system. The tiers correspond to the evacuation zones, which together can accommodate up to 600,000 people. A majority of the City’s shelters are Department of Education buildings and City University of New York buildings, which total around 500 facilities. These facilities are selected as Hurricane Shelters and Evacuation Centers. The City’s evacuation shelter system is defined as a safe place outside of the evacuated zone, designed to meet the basic health and safety needs of evacuees. These shelters are not intended to provide food and accommodations for longer than 3 days, which is a significantly shorter duration of time than what is actually needed by those who could not return to their homes due to extreme damage by a storm.

During Hurricane Sandy, the City opened the first tier of shelters, about 76 facilities, which is enough to accommodate the approximate

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INTRODUCTION

number of people in Zone A, roughly 71,000 people. These shelters opened to the public on October 28, the day prior to Sandy’s impact\(^1\). The majority of people who sought shelter arrived on October 30, the day after Sandy made landfall. From October 28 to November 12, over 23,000 people utilized temporary shelters.

On November 2, the City began to consolidate the shelter facilities and transitioned the remaining occupants to other temporary housing options, which were hotel rooms. Personal interviews suggested that the stay in these hotel rooms were very stressful. Many families stated that they had to move from room to room due to previous bookings. This constant transient living did not provide the families with the necessary support to promote recovery.

After a few months, the City stopped funding the hotel rooms, and the remaining occupants, who were families that could not return to their homes, were on their own to find another place of refuge. Not only did these families have to continue to manage and rebuild their previous home, but they then had to figure out where to live during the rebuilding process.

INTRODUCTION

COMMUNITY CAMARADERIE

Following destruction like Hurricane Sandy, it is common to see a drastic increase in community camaraderie. Places, like New York City, which are notorious for “never knowing your neighbor” demonstrate that after a devastating event, people share, join forces, and work together. Figure 7 (right) is an image that gives a glimpse into the community camaraderie that occurred in Alphabet City following Hurricane Sandy. The storm left over 8.5 million customers without power, so the neighbors worked together and created a cell phone charging station that was powered through a stationary bike. Neighbors took turns spinning the bike so others could charge their phones and make the necessary phone calls for their recovery. The support provided by a community is an essential step to recovery, so why take the families who need this support and bonding away from their communities?

This is where the “Unit” comes in. The “Unit” removes the transferring of these families into hotel rooms, but rather into temporary housing units that can be located right outside of their flood damaged home. Families remain in their communities and on site during the rebuilding process, resulting in a more efficient recovery.

Figure 7 Alphabet City Community Charging Station
Jonathan Maus/BikePortland

Figure 8 The "Unit" on Site
PRECEDENT STUDIES
REACTION HOUSING SYSTEM

In 2005 Hurricane Katrina displaced thousands of people from their homes and into poorly-equipped, overcrowded shelters. The resulting chaos from this disaster inspired Reaction founder Michael McDaniel to create the Exo Housing System. Each unit is 620 pounds and is equipped with four wall mounted bunks, an outer shell made from aircraft-grade aluminum, and a floor plate made from steel tubing and birchwood. Twenty units of this modular housing system can fit stacked onto one tractor-trailer. Once delivered on site, the housing system only requires about ten minutes of construction time with four unskilled laborers.

Additional specialty units are available for bathrooms, showers, and other utilities.

The Reaction Housing System was examined to understand how the function of transportability can dictate the over-all design. This design solution focuses on immediate “reaction” housing while providing the basic need of shelter. This system however, does not provide the means for a family to utilize this shelter as a temporary home during the rebuilding process.
UBER SHELTER

The “T-Shel 2” is the result of collaboration between Ubersonal and World Shelters and their focus on providing a shelter which meets the needs of those who have been displaced from their homes due to disasters and conflicts. The modular product, T-Shel 2, pushes the boundary of the common relief shelter design by providing a second floor. The shelter collapses and can fit on a 4’ x 8’ x 2’ pallet, making it feasible to transport. When assembled, the shelter can be built into a 190 square foot, two-story structure.

Exploring the concept of verticality to increase the total square footage and functionality of a shelter is a great idea to explore. In condensed living where there is no room available to sprawl, building up is a viable solution.

An area for further exploration includes exploring and testing how multiple shelter units can interrelate with one another to share resources and create communities.
GREEN HORIZON’S PREFAB HOME

Green Horizon’s Prefab Home is an immediately deployable emergency shelter that can sustain a family of four with a week’s worth of food, water, and electricity. The structure is constructed from 100% recycled or reclaimed materials, and utilizes metal frame construction. The prefab home comes complete with electrical and plumbing systems, are sturdy enough to be stackable, and can be used together to create communities to share resources such as power and water. Electricity is created using photovoltaic panels and biofuel generators. The entire unit is capable of shrinking to a compact size in 1 minute 30 seconds. A set of wheels on the side automatically extend down and slides under the unit when it’s ready to move.

Incorporating utilities, such as electrical and plumbing systems, help create a comfortable living environment for occupants. The utilization of interior design programming and considerations for human factors to create a functional and comfortable space are areas for further exploration.
GLOBAL PORTABLE BUILDINGS INC.

Global Portable Buildings Inc manufactures portable buildings for emergency housing, temporary homes, work sites, and offices. These shelters use steel construction and measure 8’ x 20’ or 8’ x 40’. They do not require foundations nor on site structural assembly. The inspiration was cargo containers and these shelters have been designed to be transported within the standard cargo shipping industry. Several design configurations are available with varying amenities. The base model includes windows, doors, electrical wiring, telephone and internet connections, two inch insulation, vinyl flooring, and a utility room. Additional features include bathrooms, a kitchen, shower, bedroom, and solar powered electricity.

The Global Portable Buildings Inc. demonstrates how utilizing an already existing industry, such as cargo shipping for transportation, can create a feasible solution. However, the interior of these shelters are minimal in features and stark in design which prompts further design explorations and research.
BOAT DESIGN

The human body and its movement require a certain amount of space to perform a function efficiently. Understanding activity flows, which tasks relate to others, can help understand the interrelationship between functions and create a well-organized layout in limited space. This design strategy is demonstrated through interior design methods for boats. A successful boat layout encourages all design aspects to work as a whole to create a safe and efficient environment for the user.

Grand Banks Yachts is a leader in boat design when it comes to looking at meticulous craftsmanship, thorough and thoughtful spacial planning, and providing maximum comfort in such a confined space.

Yacht design featuring luxury accommodations and highly efficient storage systems provide insight into crafting comfortable, efficient living quarters within small, mobile spaces.
**PRECEDENT STUDIES**

**DIAGRAM KEY**

1. Flexible seating that can transition into additional beds
2. Compact storage
3. Vertical storage
4. Efficient and open kitchen design
5. Efficient and compact bathroom design

*Figure 17 Layouts, Grand Banks Yachts, Heritage Series www.grandbanks.com*
THE CYPRESS

The Cypress is one of four available designs by Tumbleweed Tiny House Company. Based in Sonoma, California, Tumbleweed Tiny House Company designs and builds small homes which range from 65 – 887 square feet. The company also provides detailed construction drawings and video tutorials so customers can use these guidelines to build their own tiny house. These houses use stick built construction methods and are permanently attached to trailers for easy mobility. The Cypress model is available in three different sizes: 18’ long and 130 sqft, 20’ long and 144 sqft, and 24’ long and 172 sqft. All models include a full bathroom, kitchen, lofted bedroom, and storage areas. The full bathroom contains a shower and toilet which can be connected to a sewer, an external holding tank, gray water system, or a composting toilet. The kitchen can include electric or propane cooktops or full stoves, refrigerator, and sink.
THE PURSUIT

Recreational vehicles, such as the Coachmen Pursuit Motorhome, offer the luxury of living in your own home without compromising mobility. There are various features and layouts available for a motorhome, and they can accommodate between two and eight people. The interior of a motorhome contains custom built furniture, most of which have multiple functions. A built-in booth can function as a table and bench, but then can convert into a twin bed for an additional sleeping accommodation. The Coachmen Pursuit Motorhome contains a porcelain toilet with foot flush, shower, 6 gallon gas water heater, demand water pump, and a generator.

The motorhome demonstrates through design, material specifications, and special systems that home-like luxury can be created in compact environments.
CONTEXT
CONDENSED LIVING IN EMERGENCY SITUATIONS
Alexandra Bush, CDT

CONTEXT

Figure 20 Map of the United States of America

Figure 21 Map of New York City
www.googlemaps.com
LOCATION
OVERVIEW
This thesis project focuses on New York City, on East 7th Street between avenues C and D. This area is located in Alphabet City, which is a neighborhood in the East Village of Manhattan. The site is relatively close to the East River, which contributed to the substantial amount of flood waters during Hurricane Sandy. As shown in Figure 22 (above) the site chosen is in Evacuation Zone 1, the most susceptible area to be effected by a coastal storm.

This location is representative of a typical urban condition that would be impacted by a natural disaster, and demonstrates a potential scenero that can happen in any urban environment.
Figure 23. *Hurricane Sandy in Alphabet City*

Figure 23 (above) shows images of the flooding and damage that occurred on and around East 7th Street between Avenues C and D during and after Hurricane Sandy.
CONCEPT

SCENARIO

The scenario for this thesis takes place after a coastal storm which has flooded and severely damaged the basement apartments on East 7th Street, between Avenues C and D in New York City. Looking at the street as depicted in Figure 24 (above), there are a total of 35 basement apartment households that are affected through this thesis scenario. In response to this need to shelter 35 families, 35 Units will be deployed and installed on the site.

THEORETICAL ASSUMPTIONS MADE:

35 Total Apartments Affected

- (18) 1 Bedroom Apartments - Affecting 1-2 People
- (10) 2 Bedroom Apartments - Affecting 1-4 People
- (7) 3 Bedroom Apartments - Affecting 3-8 People

35 Total Units Needed

- 30 Single Units - Accommodating 1-5 People
- 5 Double Units - Accommodating 6-10 People

These assumptions are made through researching the demographics of the area.1

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1 “East Village (Alphabet City) Neighborhood in New York, New York (NY), 10002, 10003, 10009, 10012 Detailed Profile.”
INTRODUCTION
The recovery process of natural disasters requires a design solution that focuses on providing comfort to those displaced, while supporting community camaraderie. The design must create a comfortable place of refuge while evoking a sense of attachment, permanence, and ownership within a temporary time frame. The occupants are encouraged to unpack, settle into their dwelling, and interact with their community.

DESIGN REQUIREMENTS
The solution must be designed to accommodate the needs of up to a family of four and adjust to accommodate a family of 8, based on the research collected through the demographics of this area. The design solution must be able to utilize existing industries, such as material manufacturing and shipping transportation. This may dictate certain size restrictions as well as design limitations. Another major design requirement is to keep the families that are displaced in their neighborhood. This concept keeps the families in their community which benefits the rebuilding process of their previous home. Maintaining the connection between a family and their home provides hope and support, and it creates familiarity and a feeling of normalcy while coping with the destruction on hand.

DESIGN OBJECTIVES
COST
Create a practical design solution that can be implemented into existing infrastructures.

PORTABILITY
Design for travel efficiency. The solution will be transported to various locations in various conditions.

DURABILITY
The structure must be able to properly withstand its anticipated life-cycle, as illustrated on page 69.
MODULARITY
Utilize components and modular systems throughout the design.

CONNECTIVITY
Create a solution that highlights multifunctional spaces and adapts to the surrounding environment.

SPACIAL DESCRIPTIONS
The proposed solution must include the following programmatic functions to best emulate the design of a home:

- Entry
- Lounge
- Kitchenette
- Dinette
- Bathroom
- Sleeping
- Storage
- Utilities

Overlapping these functions will likely be necessary due to size restraints of the design solution.

ENTRY
The entrance must connect the interior environment to the exterior, while not intruding on the interior or exterior spaces. The entrance should begin the circulation flow through the interior spaces.

LOUNGE
An area for lounging is necessary to provide comfort to the occupants. The occupants must be able to rest, entertain, socialize, and work within this area.

KITCHENETTE
A kitchenette needs to provide the same amenities as an apartment. Included must be a proper method for an occupant to cook food. A refrigerator, sink and proper storage needs to be included as well. The kitchenette layout must be designed efficiently to minimize unnecessary movements. The kitchenette must be located in proximity to other areas of similar function so as to maximize use of space and utilities.
DINETTE
A dinette area must be included to provide an area for eating, working, and socializing. This area needs to be in relationship with the kitchenette and lounging area.

STORAGE
Storage must be incorporated throughout the design, encompassing both open and closed options, as well as small and large vertical options. An area dedicated for the storage of boxes and containers should be included as well.

BATHROOM
A bathroom which provides the same amenities as a bathroom in a residency must be included. The use of recognizable systems such as a toilet, shower, and vanity will provide accommodations that resemble a residential bathroom.

UTILITIES
An area dedicated to the electrical, plumbing, and mechanical utilities, which can easily be accessed, should be incorporated into the design. Ensuring that the design provides fresh water, gray and waste water collections, electricity connections, heating, and cooling, is essential to providing comfort to the occupant. Another feature that must be included to provide comfort and function is natural lighting and ventilation. The inclusion of natural lighting and ventilation must not compromise the privacy of the occupants.

SLEEPING
The design solution must be able to comfortably accommodate sleeping arrangements for up to 4 people. Utilizing twin beds, a sleeper sofa, or other innovative ideas will provide places to sleep.

STORAGE

UTILITIES
SCHEMATIC DESIGN
WORD MAP

The design process for the Unit began with word mapping. Illustrated below are a few of the significant words from a brainstorm session that were carried through the entire design process:

Figure 25  Word Mapping
Figure 26 (below) shows the different iterations of bubble diagrams that were developed to help see the possible connections and flow of functions that are required in the Unit.
BLOCK DIAGRAM
The block diagrams created while designing the Unit, as seen below in Figure 27 (below), graphically show the position and scale of a space or function.

FORM CONCEPT SKETCHES
Ideation began with inspirational concept sketches that were refined with practical iterations. There were many different design solutions created during this phase, and they were refined to the final concept of the Unit.
SKETCH MODEL
As the design process continued a more technical design approach took place. In order to understand and refine the pop-up roof concept a few sketch models were created.
DESIGN DEVELOPMENT
UNI

Housing units with U in mind

Figure 31 Logo

Figure 32 The “Unit” on Site
OVERVIEW

The “Unit”, overall, when closed is 20’ long by 8’ wide by 10’ high. These dimensions are the absolute maximum in order for the Unit to be shipped on a truck into New York City. These dimensions replicate those of a shipping container, making the “Unit” feasible to ship in an already existing industry. When working with the dimensions above and developing a comfortable design to accommodate a family of four, it was determined that more room was needed in the “Unit”. Rather than expanding the footprint of the “Unit” and imposing on the sidewalk and interrupting the function of the street, expanding up was determined as the best solution to obtaining more space, and fitting into an urban environment. A pop-up crank system raises the roof an additional three feet to allow room for lofted bunks. The three foot dimension was developed because to provide comfortable head room when in the loft area without creating a large span for the windows to fill.
INSTALLATION

1 Front steps slide out imitating a drawer slide system that locks into place. The steps have rabbet stops on the back to prevent them from entirely coming out from under the structure.

2 There is a manual crank system that raises the roof up three additional feet. The roof is structurally supported by structural steel tubing which rises from within a larger structural tube. Once at the correct height, the steel tubing is locked into place using a structural pin system, similar to pop-up tent systems.

3 Once the tubes are locked into place the awning windows on the 8 foot wide facades are pulled down and locked into place. When locked into place, a gasket seals to reduce unwanted air infiltration and exfiltration. Once the windows on the 8 foot sides are locked, the awning windows on the 20 foot wide facades are pulled down and locked.
4 The “Unit” is now in place and the utilities can be connected. A water truck provides fresh water to all “Units” on site. Each “Unit” has its own fresh water holding tank, but depending on the situation and the site arrangement of the “Units”, multiple “Units” can utilize a larger tank and share resources. A single generator services all of the “Units” on a given street. The generator provides electricity to each “Unit”.

Figure 39 “Unit”- Step 4

Figure 40 Street Rendering
The interior of the “Unit” is unique compared to existing transportable disaster relief shelters. The goal is to provide a comfortable and familiar environment in which families can recover. Stemming from traditional residential elements, the interior turns into a home by using familiar fixtures. The interior design of the “Unit” reflects the inspiration that came from interior layouts and design of boats.

The interior is composed of multiple fixture components which are built into the “Unit” to prevent theft and to make the transition to the reuse phase easier. The components correlate to each function: kitchenette, dinette, lounging, sleeping, and storage. Another benefit to breaking the interior of the “Unit” into modular components is that it accommodates combining two “Units”, which creates the “Double Unit”. The “Double Unit” is further explained on page 41.
43-44. The entrance to the “Unit” is a durable sliding door to avoid the necessary clearance of a door swing. Once through the entry, every inch of the “Unit” has been designed to maximize space and optimize function. The lounge area offers a sofa adjacent to multiple shelving units which can serve as an entertainment area or workstation. Next to the sofa is a side table which also provides a place for the instant hot water heater below. The counter to the kitchenette is flanked by two angles which help move the occupant through the space while also creating depth perception, which is important in a tight space. The kitchenette is fully equipped with a below the counter refrigerator, an electric two burner stove top, a circulation vent system above the stove top, a sink with a drying rack above, and various types of storage. The wall cabinets in the kitchenette have glass doors to create depth at eye level, while the base cabinets below have solid doors to provide privacy for storage. In between the kitchenette and bathroom is a vertical closet with a bifold door. This provides essential vertical storage for the occupants. Across from the kitchenette and closet is the dinette area. This is a booth set up that also turns into a twin bed. The table top drops down and rests on a lip below the seat cushions. The seat cushions slide down and meet in the middle over the table top to form the twin bed. Below the seats are two drawers for more storage. Above the dinette and sofa is the raised loft. Spanning the length of the loft, below the bunks, are storage cubbies that can be covered for privacy by the loft railing, which can drop down. The depth of the cubbies go half way to the exterior wall providing space for the recessed lights above the sofa and dinette table.
The ladder for the loft is between the sofa and dinette area and leads up between the two twin beds. At the end of the “Unit” is the bathroom. To make the small bathroom space feel more open, the vanity is mounted on the wall and floats over the floor. The negative space between the floor and the cabinet helps the room feel lighter and open. A tall medicine cabinet over the vanity provides private storage while the open shelves above the toilet provide more storage without imposing on the room. A small shower is also included but has been designed to also function as a tub. The ceiling of the bathroom is recessed to provide privacy and create loft space for the storage of boxes and containers. The “Unit” has been thoroughly designed to provide comfort to the occupant without compromising on function.
Figure 44 Interior Rendering, One

Figure 45 Interior Rendering, Two
FINISHES

1. PAINT - CLASSIC WHITE
2. PAINT - FIRST STAR
3. FABRIC - HAZE
4. GLASS TILE - WHISPER GREEN
5. CORIAN - SILVER BIRCH
6. PORCELAIN TILE - WOOD GRAIN

OVERVIEW
The interior finishes selected for the “Unit” have been chosen for durability, sustainability, and aesthetics. The variety of finishes chosen is minimal keeping manufacturing, maintenance, and aesthetics in mind.

FABRIC
The fabric chosen for the dinette and sofa cushions is from Momentum Textiles in the color Haze in the Silica pattern. It is chosen for its durability and maintenance properties. The fabric has a 365,000 double rub count, and it can be washed with bleach. The fabric is also comfortable.
PAINT
The main paint color for the walls is First Star by Sherwin Williams, and all of the ceiling, trim, cabinetry, and doors are Classic White. First Star creates a warm atmosphere and prevents the interior of the “Unit” from being perceived as sterile. The incorporation of Classic White helps the “Unit” feel brighter and larger. The finish for these paints is ScrubTough from the Scuffmaster’s Health and Wellness Collection. The paints can withstand 8,000 scrubs, durable enough to withstand multiple iterations of tenants and cleanings.

CORIAN
Corian countertops are used on all of the horizontal work surfaces, and it is selected in the Silver Birch finish. The different particles within this Corian finish helps tie together the paint, fabric, and glass tile chosen.

GLASS TILE
Glass tile in Whisper Green from DalTile was chosen for the walls in the kitchen and shower areas. Glass tile was selected because it provides a touch of color without being bold, it also creates depth which is an essential illusion in a small space.

PORCELAIN TILE
The floor finish which spans the entire perimeter is a porcelain tile with wood grain from DalTile. This adds warmth to the overall scheme, and resembles typical residential wood flooring. The porcelain tile is more durable and easier to maintain than hardwood flooring.
Figure 47  *Finishes in "Unit"*

See Figure 46 on page 40 for material key.
DOUBLE UNIT

The “Double Unit” accommodates a larger family size, up to 10 people, without creating an entirely new system. The structural modularity of the “Unit” allows two “Units” to inter-lock structurally. The resulting arrangement of interior components creates very efficient circulation. The kitchenette components are arranged back-to-back providing a large and centrally located work space. As a result of the modular design, the two dinette components and the two sofa components can be located adjacent to each other, unifying those functions.

Figure 48 “Double Unit,” One
DESIGN DEVELOPMENT

Figure 49 "Double Unit," Two

Figure 50 "Double Unit," Three
SITE

An areal view of the "Units" deployed on site at East 7th Street between Avenues C and D. There are 30 single "Units" and 5 "Double Units" installed on this street.
GROUND FLOOR PLAN

The ground floor of the Unit is the main level for activities.

Figure 55  Ground Floor Plan
LOFT FLOOR PLAN

The loft of the Unit contains two twin beds and a large area for storage.

Figure 56  Loft Floor Plan
SECTION ONE

This section cuts through the Unit looking at the Kitchenette.
SECTION TWO

This section cuts through the Unit looking at the Dinette and Lounge areas.
 SECTIONAL PERSPECTIVE ONE

This elevation shows the dinette, sofa, and lofted bunks.
SECTIONAL PERSPECTIVE TWO

This elevation shows the kitchenette and vertical storage options.
Figure 62. Interior Rendering, Two
OVERVIEW
The “Unit’s” ceiling and base are framed with HSS 7x4x1/2 structural steel tubing. The walls are framed with HSS 6x4x1/4 structural steel tubes with 6” steel studs between the frames. The walls and roof are then completed with standard construction methods. On the exterior side of the framing, 1/2” Zip System sheathing is used which combines a moisture barrier and plywood. The exterior aluminum cladding is a 1-1/4” deep Flat Lock Tile System which provides the “Unit” with the necessary durability for transportation. The cladding immitates that of a shipping container contributing to the ways the “Unit” will work within that industry. A closed cell spray foam insulation is used between the studs as the primary insulation for the “Unit”, achieving an R value of 6 per inch. On the interior side of the walls and ceiling is a 1/2” layer of gypsum board. Utilizing a familiar residential material on the interior of the structure will help the occupants feel like they are in a residential space. Both the ceiling and floor of the “Unit” use 6” steel joists at 16 inches on center. The ceiling and floor also contain closed cell spray foam insulation between the joists. Under the base of the “Unit” an adjustable leveling mount and foot are used to ensure the “Unit” is level on uneven terrain.
STRUCTURE

DIAGRAM KEY

1. HSS 7 x 4 x 1/4
2. HSS 4 x 4 x 1/4
3. HSS 3-1/2 x 3-1/2 x 1/4
4. 1-1/4” Aluminum Flat Lock Tile System
5. 1/2” Zip System Sheathing
6. 4” Closed Cell Spray Foam Insulation within Wall Cavity
7. 4” Metal Studs @ 16” O.C.
8. 1/2” Gypsum Board
9. 3/4” Plywood Subfloor
10. 6” Metal Stud Joists @ 16” O.C.
11. Adjustable Leveling Mount and Foot
**CONSTRUCTIVE LIVING IN EMERGENCY SITUATIONS**

Alexandra Bush, CDT

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**STRUCTURE**

**DIAGRAM KEY**

1. HSS 7 x 4 x 1/4
2. HSS 4 x 4 x 1/4
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5. 1/2” Zip System Sheathing
6. 4” Closed Cell Spray Foam Insulation within Wall Cavity
7. 4” Metal Studs @ 16” O.C.
8. 1/2” Gypsum Board
9. 3/4” Plywood Subfloor
10. 6” Metal Stud Joists @ 16” O.C.
11. Adjustable Leveling Mount and Foot Figure 74
12. Telescoping Tube Detail Figure 73
13. Typ. Standing Seam Metal Roof Eave Detail Figure 72

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**Figure 72**  Typ. Standing Seam Eave Detail
www.copper.org

**Figure 73**  Telescoping Tube Detail
Square-Fit Telescoping Square Tubing

**Figure 74**  Adjustable Leveling Mount and Foot
www.industrialcomponentsgroup.com
MECHANICAL | ELECTRICAL | PLUMBING (M.E.P.)
OVERVIEW
The utilities of the “Unit” are installed differently than those in a permanent residency, but they provide the same level of function and amenity. All of the systems and fixtures used in the “Unit” have previously been developed and implemented in the R.V. and Marine industries.

Access to the systems and fixtures have been included in the design to promote accurate maintenance to the “Unit” prolonging it’s life-cycle. The panels allow access to the holding tanks to empty or fill, as well as the connection for the external generator which is provided on site to run multiple “Units” on a street.
HEATING AND COOLING
NATURAL VENTILATION

Thermal comfort is an essential factor when designing with human comfort in mind. The windows surrounding the perimeter of the “Unit” are all operable to provide natural ventilation. This also allows occupants to manually adjust as desired.

HEAT PUMP

In addition to natural ventilation, a heat pump is included in the “Unit”. The heat pump uses outside air to either provide warm air when the exterior air is cold, or cold air when the exterior air is warm. The heat pump only needs electricity to operate.

EXHAUST

An exhaust fan is located in the bathroom of the “Unit”. The air goes up through the dropped ceiling, and exits the “Unit” through the side wall. Including an exhaust fan helps maintain the “Unit”, and contributes to prolonging the “Unit’s” life span. The exhaust fan should be used in conjunction with the shower, as well as when the Unit is in storage and not in use.

DIAGRAM KEY

1. Heat Pump
2. Heated Air
3. Cooled Air
4. Exhaust Fan
POWER
Once installed on site, the “Unit” is connected to an on-site generator which provides power to all of the “Units” on the street. This plan consolidates resources and limits the amount of generators needed during a time when the availability is scarce.

The generator is used to power the interior lights, heat pump, water pump, refrigerator, stove top, hood, and exhaust fan.

LIGHTING
Recessed lighting is the primary lighting fixture for the “Unit”. There are three recessed lights in the extended ceiling to provide ambient lighting, as well as above the sofa, counter top, and the Dinette area. The bathroom light is incorporated into the exhaust fan fixture.

Natural lighting filters through the perimeter windows of the “Unit”. The height of the windows provides privacy and security for the occupants while still allowing natural light into the space. The top of the white cabinets which rests at the bottom of the windows, acts as a light shelf reflecting the light onto the ceiling which will help disperse the light into the center of the “Unit”.

Figure 77 Light Shelf Sketch

Figure 78 Interior Lighting Schematic
FIXTURES
The “Unit” contains fixtures which can be found in both the RV and Marine industries. There is a fresh water holding tank which provides fresh water, a gray water holding tank for collecting water used by the shower and sinks, and a black water holding tank for waste is connected only to the toilet. Both the gray and black water holding tanks vent up through the dropped ceiling in the bathroom and exit at the side of the “Unit”. On the back of the “Unit” there are exterior access panels which allows access to the holding tanks so as to be able to empty, fill, or connect to surrounding “Units” to share resources.

DIAGRAM KEY
1 Exterior Access Panels
2 Vents
3 Fresh Water Holding Tank
4 Gray Water Holding Tank
5 Black Water Holding Tank
6 Water Pump
7 Instant Hot Water Heater
Figure 80 "Unit’s" Life Cycle Assessment - Schematic
OVERVIEW
This thesis is designed in response to the impacts of global climate change, and the corresponding increase in natural disasters. Throughout the design process specific sustainability strategies were implemented to create the “Unit”. Continuously reflecting on the “Unit’s” life cycle was a key component to keeping the design on track. Figure 80 is a schematic of the “Unit’s” life cycle. Designing with production, distribution, installation, use, and end of life stages in mind creating a cohesive solution to this thesis problem.

PRODUCTION
The production stage of the “Unit” encompasses raw material extraction, materials, and manufacturing process. During the design process, this stage of the life cycle encouraged material reduction, knowledgeable material selection, and utilizing existing manufacturing processes. The proportions of the “Unit” are compatible with standard increments of materials, resulting in limited material waste. The “Unit” was also designed with existing manufacturing methods in mind. All materials, parts, and assembly processes are in place. Using these existing resources minimizes the impact of the “Unit” on the production stage. The selection process for the materials used in the “Unit” were chosen for their durability, maintenance, and sustainability factors, as well as aesthetics.

DISTRIBUTION
A main strategy that was incorporated throughout the design was to utilize existing industries and infrastructure. Working within the shipping container industry for shipment creates a practical design solution that is less intrusive to the manufacturing and distribution stages. When the “Unit” is not in use, it can be stored. Individual “Units” can be stacked and stored like shipping containers until they are needed on site.
INSTALLATION
The installation stage of the “Unit’s” life cycle contains unknown variables such as the exact location of installation and the conditions of the location. These unknown factors led to flexibility in the design so the “Unit” will function in a multitude of situations. When the “Units” are called into action they are delivered on site and require a minimal amount of installation work before they can be inhabited. The “Unit” is designed to have a minimal impact on the environment in which they are placed.

RECYCLING
Once a “Unit” has reached its end of life, the materials can be stripped out, separated properly, and feed into the existing construction recycling stream. Some materials, components, or utilities may be reused in the construction of other “Units”.

USE AND REUSE
The modular design solution of the “Unit” was created when thinking of the use and reuse life cycle stage. Working with modular components makes cleaning, maintaining, and recycling easier than if each feature of the “Unit” was a single entity. The durability of the “Unit” is another result of considering the use and reuse life cycle stage. Once the “Unit” is no longer needed by the occupant, the structure is collected and prepared for another use. The materials used in the “Unit” were chosen with this life cycle stage in mind.
CONCLUSION
OVERVIEW
This conceptual design based thesis, Condensed Living in Emergency Situations, developed a solution to the problem identified during the recovery efforts of Hurricane Sandy in the New York City area in 2012. The design solution, the “Unit”, provides a comfortable and safe temporary home for a family, and keeps them within their own community. The “Unit” focuses on human factors and is designed for the comfort of the occupants. This is successful through the materials, functional flow, and utilities provided by the “Unit”. The “Unit” supports community camaraderie by allowing the occupants to remain on their street to continue to provide support, encouragement, and help to their neighbors. By maintaining the families on the street near their previously existing home, the rebuilding process becomes more manageable. The “Unit” creates a positive impact on people and their communities during a devastating time.

CONCLUSION

DESIGN OBJECTIVES
COST
The “Unit” is a practical design solution which utilizes existing industries and infrastructure for material selection, manufacturing techniques, and transporation. This helps reduce overall cost for the “Unit”.

PORTABILITY
Working within the shipping container industry for shipment, and using RV and Marine utilities, the “Unit” can be transported to various locations in various conditions efficiently.

DURABILITY
The design and materials chosen for the “Unit” have been carefully considered with the anticipated life cycle in mind.
MODULARITY
The “Unit” is a modular design solution that can adapt through the use of the designed components. The modularity of the design helps optimize the use of materials so waste is reduced to a minimum.

CONNECTIVITY
The “Unit” highlights multifunctional spaces through the interior layout and designed components. The “Unit” also adapts to the surrounding environment through modular design, and encourages community camaraderie.

NEXT STEPS
A logical next step to developing the “Unit” is to further analyze the “Unit’s” life cycle. Future explorations exploring details from the extraction of the materials, manufacturing process, shipment to and from the sites, use, as well as the “Unit’s” end of life, will help refine the design and ensure this solution is as efficient and sustainable as possible. Other next steps include refinement of the structural and MEP details.
RESOURCES
LIST OF FIGURES

1 Hurricane Sandy Satellite Image www.weather.gov/okx/HurricaneSandy
2 Flood Areas and Levels from FEMA www.nytimes.com
4 2015 New York City Evacuation Zone Map www.maps.nyc.gov/hurricane
6 Long Road Home www.nydailynews.com
7 Alphabet City Community Charging Station by Jonathan Maus/ Bike Portland
8 The “Unit” On Site
9 Stacked Exo Housing Shells www.reactionhousing.com
10 Inside the Exo Housing System www.reactionhousing.com
11 Steps to Set up the Uber Shelter www.designboom.com
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20 Map of the United States of America
21 Map of New York City www.googlemaps.com
22 2015 New York City Evacuation Zone Map www.maps.nyc/hurricane
23 Hurricane Sandy in Alphabet City www.google.com
24 Thesis Site Scenario
25 Word Mapping
26 Bubble Diagrams
27 Block Diagrams
28 Preliminary Sketches
29 Form Concept Sketches
30 Sketch Model
31 Logo
32 The “Unit” on Site
33 “Unit” on Truck
34 “Unit” Closed
35 “Unit” Popped Open
36 “Unit” - Step 1
37 “Unit” - Step 2
38 “Unit” - Step 3
39 “Unit” - Step 4
40 Street Rendering
RESOURCES

41 Preliminary Floor Plan Sketch
42 Interior View, Kitchenette
43 Interior View
44 Interior Rendering, One
45 Interior Rendering, Two
46 Finishes
47 Finishes in “Unit”
48 “Double Unit,” One
49 “Double Unit,” Two
50 “Double Unit,” Three
51 Site View
52 Site Rendering, One
53 Site Rendering, Two
54 Site Rendering, Three
55 Ground Floor Plan
56 Loft Floor Plan
57 Section One
58 Section Two
59 Elevation One
60 Elevation Two
61 Interior Rendering, One
62 Interior Rendering, Two
63 Bathroom, One
64 Bathroom, Two
65 Bathroom, Three
66 Bathroom, Four
67 Bathroom, Five
68 Birds-Eye View, One
69 Birds-Eye View, Two
70 Framing Elevation
71 Structural Diagram
72 Typ. Standing Seam Eave Detail www.copper.org
73 Telescoping Tube Detail, Square-Fit Telescoping Square Tubing
74 Adjustable Leveling Mount and Foot www.industrailcomponentsgroup.com
75 Heating
76 Cooling
77 Light Shelf Sketch
78 Interior Lighting Schematic
79 Plumbing
80 “Units” Life Cycle Assessment - Schematic
REFERENCES


RESOURCES


