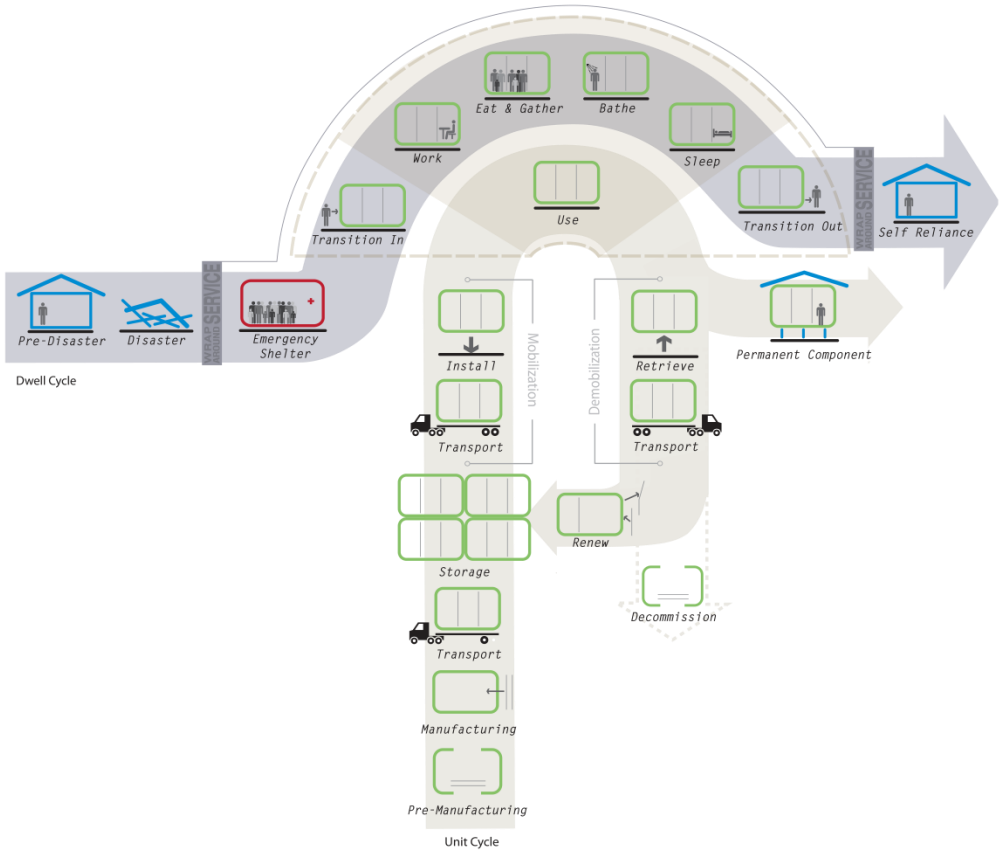
SERRI Report 80024-02



Temporary Disaster Housing Unit

SERRI Project: Prototype Design for Temporary Disaster Housing

Project Principal Investigator:
David Perkes, AIA

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Prototype Design for Temporary Disaster Housing

TEMPORARY DISASTER HOUSING UNIT

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ACRONYMS

ABA	*Architectural Barriers Act*
ADA	*Americans with Disabilities Act*
AHPP	*Alternative Housing Pilot Program*
BFE	*Base Flood Elevation*
CARRI	*Community and Regional Resilience Initiative*
DHS	*Department of Homeland Security*
EPA	*Environmental Protection Agency*
FEMA	*Federal Emergency Management Agency*
FEMA HQ	*Federal Emergency Management Agency Head Quarters*
FEMA TA	*Federal Emergency Management Agency Technical Assistance*
FFE	*Finish Floor Elevation*
GCCDS	*Gulf Coast Community Design Studio*
HUD	*Department of Housing and Urban Development*
IAQ	*Internal Air Quality*
IRC	*International Residential Building Code*
LEED	***Leadership in Energy and Environmental Design***
MAHPP	*Mississippi Alternative Housing Pilot Program*
MHCSS	*Manufactured Home Construction and Safety Standards*

MEMA	*Mississippi Emergency Management Agency*
ORNL	*Oak Ridge National Laboratory*
ORT	*Over Road Transit*
RV	*Recreational Vehicle*
PPM	*Parts Per Million*
SERRI	*Southeast Region Research Initiative*
SIP	*Structural Insulated Panel*
SF	*Square Feet*
TA	*Technical Assistance*
THU	*Temporary Housing Unit*
UFAS	*Uniform Federal Accessibility Standards*
USGBC	*United States Green Building Council*

SOUTHEAST REGION RESEARCH INITIATIVE

In 2006, the U.S. Department of Homeland Security commissioned UT-Battelle at the Oak Ridge National Laboratory (ORNL) to establish and manage a program to develop regional systems and solutions to address homeland security issues that can have national implications. The project, called the Southeast Region Research Initiative (SERRI), is intended to combine science and technology with validated operational approaches to address regionally unique requirements and suggest regional solutions with potential national implications. As a principal activity, SERRI will sponsor university research directed toward important homeland security problems of regional and national interest.

SERRI's regional approach capitalizes on the inherent power resident in the southeastern United States. The project partners, ORNL, the Y-12 National Security Complex, the Savannah River National Laboratory, and a host of regional research universities and industrial partners, are all tightly linked to the full spectrum of regional and national research universities and organizations, thus providing a gateway to cutting-edge science and technology unmatched by any other homeland security organization.

Because of its diverse and representative infrastructure, the state of Mississippi was chosen as a primary location for initial implementation of SERRI programs. Through the Mississippi Research Initiative, SERRI plans to address weaknesses in dissemination and interpretation of data before, during, and after natural disasters and other mass-casualty events with the long-term goal of integrating approaches across the Southeast region.

As part of its mission, SERRI supports technology transfer and implementation of innovations based upon SERRI-sponsored research to ensure research results are transitioned to useful products and services available to homeland security responders and practitioners. Concomitantly, SERRI has a strong interest in supporting the commercialization of university research results that may have a sound impact on homeland security and encourages university principal investigators to submit unsolicited proposals to support the continuation of projects previously funded by SERRI.

For more information on SERRI, go to the SERRI Web site: www.serri.org.

EXECUTIVE SUMMARY

Past FEMA Temporary Disaster Housing programs show the limitations of utilizing available travel trailers and manufactured housing products as an effective response to a housing need. These programs have revealed the apparent waste produced in a single use Temporary Housing Unit (THU), as well as a lack of attention to occupant needs during the recovery process, including health, space requirements, and safety. Other aspects of THUs require further investigation to inform new design specifications, including repeated interstate transport and the chain of responsibility throughout the life of the unit. While THUs must address a variety of long term needs, it is critical that they be deployed in a quick and organized fashion so that the unit may assist survivors of a disaster as soon as possible. Every stage in the life of a THU must be considered, from manufacturing through use to decommissioning. The primary recommendation of this research is for FEMA to follow a purpose-driven design approach to THU designs.

The principal purpose of a THU is to provide temporary housing for a recovering family or individual after a disaster. Temporary disaster housing is very different from vacation housing in a recreational vehicle (RV) or long-term housing in a full-size manufactured home; a THU should be informed by its unique requirements. Adherence to the HUD Code has addressed some of the problems with function and health issues, but reliance upon the HUD Code and the way it is administered within the manufactured housing industry will likely inhibit much needed design innovation. Commercially available RV and housing units do not meet the demands of a cost efficient and sustainable THU program because they are not easily maintained, durable enough for reuse, and most importantly, not designed to meet the needs of temporary housing following a disaster.

Based on these observations, the Gulf Coast Community Design Studio developed preliminary performance criteria through research and analysis of recent THU program standards. These performance criteria consider each stage of the THU life cycle and help to organize important requirements in each of those stages. From this point, performance criteria can be developed into detailed performance specifications that are produced in coordination with contracting procedure. A well developed set of performance specifications would enable FEMA to procure Temporary Housing Units that would be more cost efficient, less wasteful, and would better demonstrate FEMA's commitment to community recovery following a disaster.

1. INTRODUCTION

Providing disaster housing has been a continual challenge because traditional temporary housing units consist of either modified recreational vehicles or manufactured homes, neither of which is designed specifically for the unique challenges of disaster response and recovery. The Federal government has never had the in-house architectural and engineering services or capabilities to design the ideal disaster housing solution, relying instead on open market research that has yet to yield the perfect answer.

1.1 Original Capability Gap with FEMA Region IV

Recent costly and time-consuming problems with temporary disaster housing unit performance have highlighted the Federal government's need to:

i) Respond efficiently and effectively to future design and performance problems by ensuring the proposed housing design specifications meet the unique requirements of disaster housing. Housing design and performance problems may be due, in part, to the fact that the Federal government's current approach to disaster housing operations relies on using FEMA provided enhanced specifications and privately-developed vendor designs, both of which are based on industry standards for commercial housing. These products do not adequately address all disaster housing needs. As a result, even though manufacturers tailor their commercial products to FEMA specifications, units do not comprehensively address the unique, rigorous requirements of disaster housing.

ii) Provide a scalable product to meet varying disaster requirements, from small rural disasters to catastrophic urban disasters. Standardize inventory for improved logistics, procurement, storage and maintenance. Implement lessons learned and consolidate best practices without changing to an entirely new product and unit design each disaster cycle.

iii) Improve equity of unit placement and distribution among applicants.

The key objective of the original research gap is to develop one or several disaster housing prototype designs that can be produced by multiple manufacturers on a large, cost-effective scale and be appropriately configured for the size and composition of each household. A desired outcome is that the prototype designs will help reduce reliance on industry standards and housing type constraints and will adequately address a capability gap in emergency response and recovery which has been identified by FEMA Region IV and described in Overview: FEMA Region IV Capability Gaps (12 August 2010) as capability

gap number 2010-RCD-004 (Temporary Disaster Housing: Developing a Temporary Housing Unit Design and Prototype).

Located in Appendix D, the original tasks of 2010-RCD-004 were to fully understand the requirements of FEMA THUs, develop prototype designs aligned with these requirements, validate these designs with assigned stakeholders, and document the product in a final report.

1.2 New Path and Direction to Align with FEMA Headquarters

Through valuable conversation with contacts at FEMA Headquarters (HQ), the Gulf Coast Community Design Studio (GCCDS) staff learned that FEMA HQ was engaged in similar research efforts, though at a much larger scope. FEMA HQ staff recognized that the work at GCCDS, if adjusted, could align more closely with their focus. The effort to realign the research began in January 2012 and was completed in the spring of 2012. FEMA employees assigned to provide Technical Assistance (TA) were able to offer support to the GCCDS research team. The GCCDS used this generous assistance as much as it could before entering into the production of the final report.

1.2.1 Technical Assistance

The process the GCCDS used with FEMA TA was to simply provide prompts and information requests to the TA team to gather knowledge and data. Conference calls were scheduled following information requests and provided valuable information to the GCCDS about the proposed issues. The potential is there to create a robust set of focused technical assistance groups, using the expertise of both FEMA and outside professionals. Information gathered from technical assistance groups helps to address the many divergent needs and uses of Temporary Housing Units (THUs).

Scope

The purpose of this document is to outline the findings and information gathered from reports, studies and other documentation of Temporary Housing Units missions from the past six years. These findings also include knowledge, data and feedback for the development of new performance standards from past housing missions and outside research and commentary.

The THU research is shaped by two overarching and related considerations: life-cycle performance factors and life-cycle cost factors. In both considerations, expanding the research to look at the entire life-cycle of temporary disaster housing units is motivated by a goal to design a housing unit that is cost effective and aligns with FEMA's efforts to improve their overall disaster response and recovery efforts.

The two life-cycle considerations lead to the development of four project goals. The life-cycle performance factors lead to two of the goals:

1. Provide temporary disaster housing units that meet the users' living needs.

2. Create housing units that reinforce FEMA's work to improve disaster response and recovery.

Life-cycle cost factors lead to the next goal:

3. Produce housing units shaped by a well-informed understanding of quality.

The intersection of life-cycle performance and cost factors leads to the fourth goal:

4. Create and maintain an inventory of housing units that allows cost-effective, post-disaster alternatives to disposal such as re-useable and semi-permanent housing options.

1.2.2 Knowledge Point

The research has been informed by four main points of knowledge: an exhaustive literature review; a current code and policy review; professional design expertise; and technical assistance from FEMA HQ. Using these points of knowledge has allowed the GCCDS to distill major issues and concerns of the current state of THUs and provide background information to create the framework for new performance requirements.

1.2.2.1 Literature Review

Though there was a shift in the research mid-course to better align with FEMA HQ's related work efforts, the initial review of contemporary research and literature on THU missions and other related documents was critical. The most relevant literature from the last six years was accumulated, focusing on the temporary housing efforts along the United Stated Gulf Coast region following the hurricane season of 2005. Prior to the 2005 hurricane season, literature and documentation regarding temporary housing were scarce and lacked comprehensive, conclusive data. FEMA Building Science also produced a vast set of documents including the National Disaster Housing Strategy and a compendium of instructional documents addressing risk of all forms. GCCDS used this body of knowledge and policy to help understand the landscape of THU.

1.2.2.2 Regulation and Policy

Regulation & Policy areas pertaining to Temporary Housing Units are a major subset of the literature review. The design and manufacturing of a THU or any manufactured housing unit must work within the existing regulatory and policy framework. Currently, all FEMA-procured THUs must meet the Manufactured Home Construction and Safety Standards (MHCSS), more commonly referred to as the HUD Code. The HUD Code affects many aspects of a THU design, from the size of each room to building performance. Though the HUD Code is the regulatory statute for a FEMA THU, there are other relevant regulations along with advancements in building science research, building materials,

indoor air quality, and energy efficiency, which help to create a more complete set of THU performance standards.

The Federal Fair Housing Act and other laws require disaster housing to meet the unique needs of every potential occupant, including those with physical and psychological special needs. The Uniform Federal Accessibility Standards (UFAS) is a standard used by FEMA to regulate accessibility into and within the THU. It is also valuable to reference more recent guidelines such as the Americans with Disabilities Act to help inform accessibility issues.

1.2.2.3 Design Knowledge

As architecture practitioners, GCCDS applied its professional architectural expertise to the research in the context of knowledge and use of building code, building science, structure and design.

GCCDS has been uniquely situated in east Biloxi on the Mississippi Gulf Coast during the last seven years of rebuilding after Hurricane Katrina. Staff was witness to the use of travel trailers and other alternative housing options such as the Mississippi Cottages over the years of recovery which gives an insight that cannot be replaced by anecdote and abstract statistics. Also, throughout the last six-plus years the GCCDS' work has been rooted in developing replacement housing in the coastal communities of Mississippi. Understanding the needs of the occupants and the performance requirements of a hazard prone area gives insight to other design and performance factors beyond the HUD code requirements. This comprehensive understanding of a complex process is vital to developing a successful specification.

1.2.2.4 Technical Assistance

Through dialogue with FEMA HQ staff, Technical Assistance provided a level of detail and understanding that the outside observer or researcher cannot access. This information provided a more detailed understanding of the framework that FEMA plans to work within for future disaster housing efforts, how FEMA finances THUs, and a glimpse of the future needs of THU occupants. Most importantly, this information has allowed GCCDS to align its research product with the efforts already underway at FEMA HQ. GCCDS staff were required to sign Non-Disclosure Agreements with FEMA to protect Federal Procurement sensitive information. For evident reasons the information provided by FEMA Technical Assistance will be excluded from this report.

1.3 Cycle Diagram

The diagram below is comprised of two paths: the THU Cycle and the Occupant Cycle. These paths overlap during the Use stage of the THU. The path of the occupant is linear from displacement through self-sufficiency, while the THU cycle has a range of possibilities including reuse and decommissioning. The diagram is a useful tool to quickly outline a simple overview of a complex process. The diagram also allows for the identification of overlapping requirements. The identification of stages within the context of each cycle allows for targeted input by experts during the creation of performance specifications.

The primary purpose of a THU is to be used by a displaced, recovering family or individual after a disaster. This use is very different from vacation accommodatios in a

recreational vehicle or long-term housing in a full-size manufactured home and should be informed by its unique requirements. It is also very important to understand the need to deploy the units in a quick and organized fashion so that the unit may assist survivors of a disaster as soon as possible. The design of a THU should take each specific stage into consideration within the overall cycle, as explained graphically by the cycle diagram.

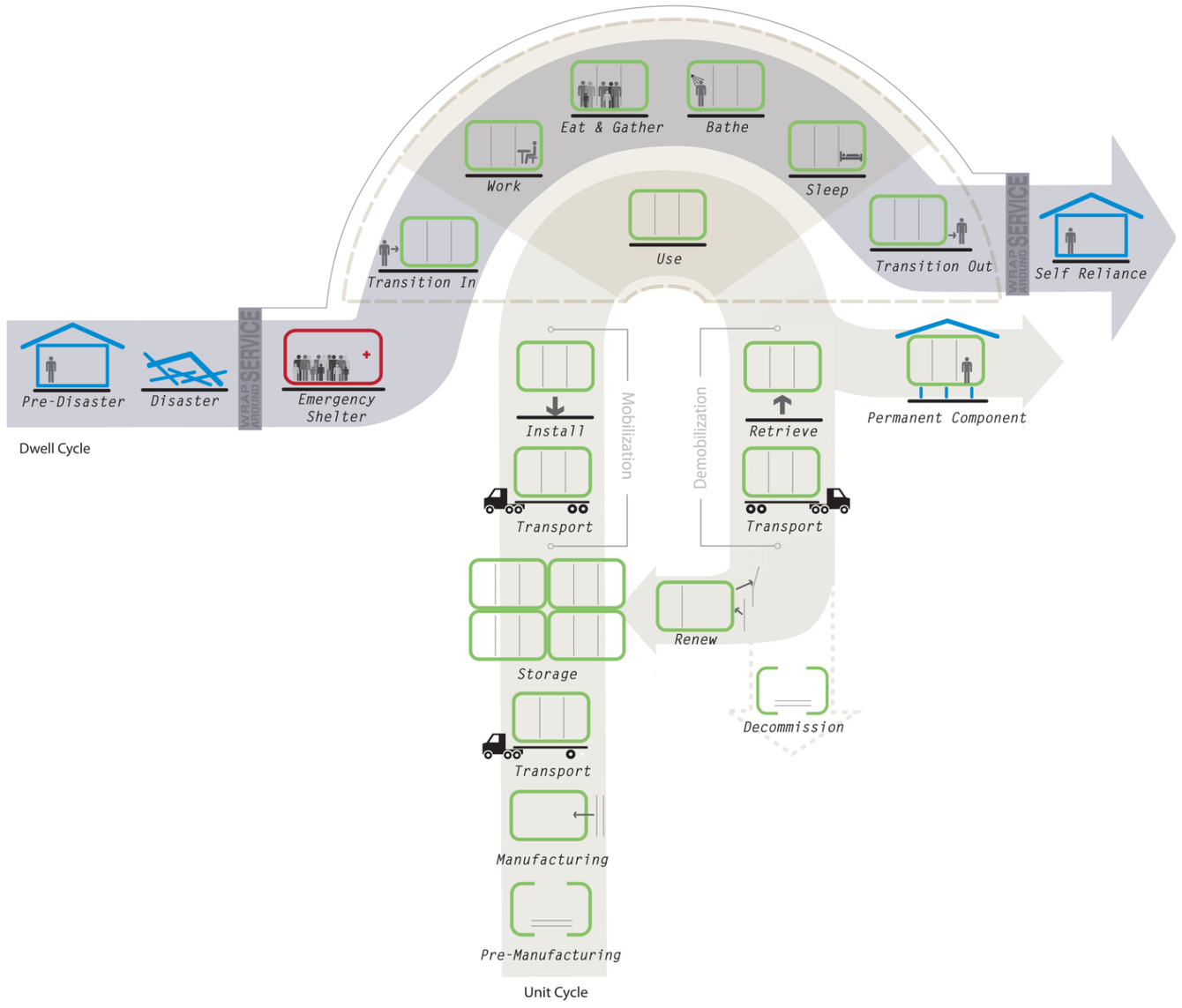


Fig 1: Example of full Life Cycle Diagram

2. PERFORMANCE CONSIDERATIONS

2.1 Introduction

Based on a review of relevant research, GCCDS has designated ten primary performance considerations that affect THUs (Table 1). These ten considerations affect THU at all phases of their development, from procurement and manufacturing, through delivery, installation and use. Each consideration outlined in this chapter will include an overview of research findings and its relevance to temporary disaster housing. In Chapter 3, these considerations will be used to develop more detailed performance criteria.

	Performance Consideration	Section
1	Location and Site Preparation	2.2
2	Safety and Hazards	2.3
3	Access	2.4
4	Participation	2.5
5	Stability	2.6
6	Size and Layout	2.7
7	Storage	2.8
8	Mainten ance and Durability	2.9
9	Indoor Air Quality	2.10
10	Thermal Comfort and Efficiency	2.11

Table 1: Performance Considerations

2.2 Performance Consideration: LOCATION

2.2.1 Purpose

Appropriate THU placement supports rebuilding and minimizes displacement from pre-disaster employment and community resources.

2.2.2 Background

Most disasters do not necessitate FEMA's assistance with temporary housing. When a housing mission is required, there are several options for THU placement. The placement options depend on community acceptance and resources, site conditions, and the viability of unit installation. THU location may allow occupants to remain on their property; alternately, location may distance occupants from their community. Ultimately, displacement can inhibit the pace of recovery and leave lasting effects on occupants.

2.2.3 Research Topics

- Site Placement Options
- Private Property Requirements and Regulations
- Rebuilding
- Displacement
- Occupant Preferences
- Community Acceptance

2.2.3.1 Site Placement Options

FEMA has three options for THU site placement: existing commercial sites, private property, and community sites (FEMA 2009b). The chart below describes the benefits and challenges of each option:

	Benefits	Challenges
Commercial Sites	Minimal site preparation. Use of existing pads and utility connections.	In many cases, not readily available or have access to services.
Private Property	° Allow homeowners to repair or rebuild their homes. ° Minimize displacement and allow residents to stay connected to their community's social and economic resources.	° Minimum unit size requirement per HUD Code. ° Floodplain restrictions.
Community Sites	Last resort option; only when other two options are not viable.	Intensive requirements for site acquisition and a broad range of site and utility work including roads, water and sewer lines, and public transportation.

Table 2: THU Site Placement Options
Data: FEMA 2009d- Graphic: GCCDS

2.2.3.2 Private Property Requirements and Regulations

Effective in 2008, THU's must follow the Federal Manufactured Home Construction and Safety Standard, administered by HUD and commonly referred to as the HUD code. These regulations have a direct effect on the placement of THU's on private property. The code provides standards for housing design and construction including transportability, fire resistance, and energy efficiency (FEMA 2009b). HUD code compliance also affects unit size and thereby impacts site location.

- The 256 square foot FEMA travel trailer fits within a standard driveway and was used extensively prior to 2008 (ABT Associates 2009a). Locating the travel trailer on the property of the user allowed many survivors access to their damaged property to begin the repair or rebuilding process. Adequate room set aside from damaged structures must be available on a property to install and maintain the THU so that repair or rebuilding can proceed while the THU is occupied. Additionally, the foundation system must be compatible with site conditions.

- The HUD code prescribes minimum size requirements for manufactured homes: 320 square feet, or minimum dimensions of eight feet wide or forty feet long (HUD 2009b). HUD code compliant units used for disaster housing are typically much larger and challenge the viability of widespread installation of THUs on private property (FEMA 2009b).

- The 2011 Inspector General report concludes that "…most of the units tested [by FEMA] are too large to replace travel trailers and park models as a compact post-disaster solution for many urban homeowners' sites." (DHS OIG 2011)

2.2.3.3 Rebuilding

An oral interview participant in the Harvard Community Advisory Group study after Hurricane Katrina commented about how site placement impacted their ability to rebuild:

- "When FEMA was able to deliver a trailer we were able to bring the family down here and set up on our property which, you know, made cleanup go much easier. I didn't have to drive 200 miles a day in order to do anything. Granted, the trailers are rather cramped for the number of people we are but it still made it much easier than the drive." (Harvard University 2006)

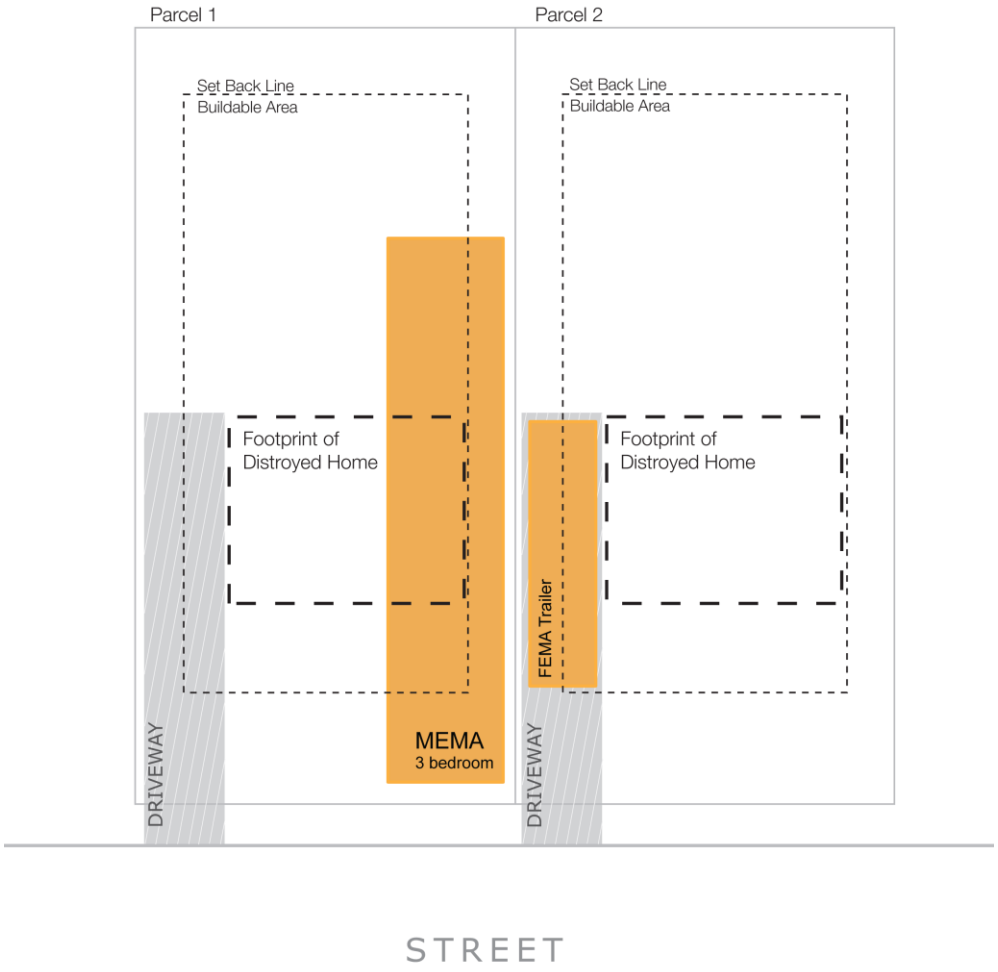


FIG 2: Example Of Travel Trailer VsA MEMA Three Bedroom On A Standard Parcel With A Driveway In Biloxi Mississippi- (50'x100')
Data: FEMA 2009b - Graphic: GCCDS

2.2.3.4 Displacement

When disaster victims are unable to remain on their property and live in their community, their capacity for recovery is inhibited. Research suggests that loss of employment, decreased income, and increased health problems may impede recovery for those displaced from their homes following a disaster (Hori 2009).

- In a study following Hurricanes Katrina and Rita, findings showed survivors (in Louisiana) that were displaced from one parish to another experienced greater hardships overall, with higher rates of unemployment, greater proportions of decline in household income, and lower rates of health insurance than those displaced within their parish or not displaced at all (Hori 2009). Results show that in terms of employment, income, health insurance, mental health and access to primary care, the non-displaced were better suited for recovery, followed by those internally displaced (within their parish). The externally displaced (outside their parish) consistently had greater difficulties recovering from the hurricanes.

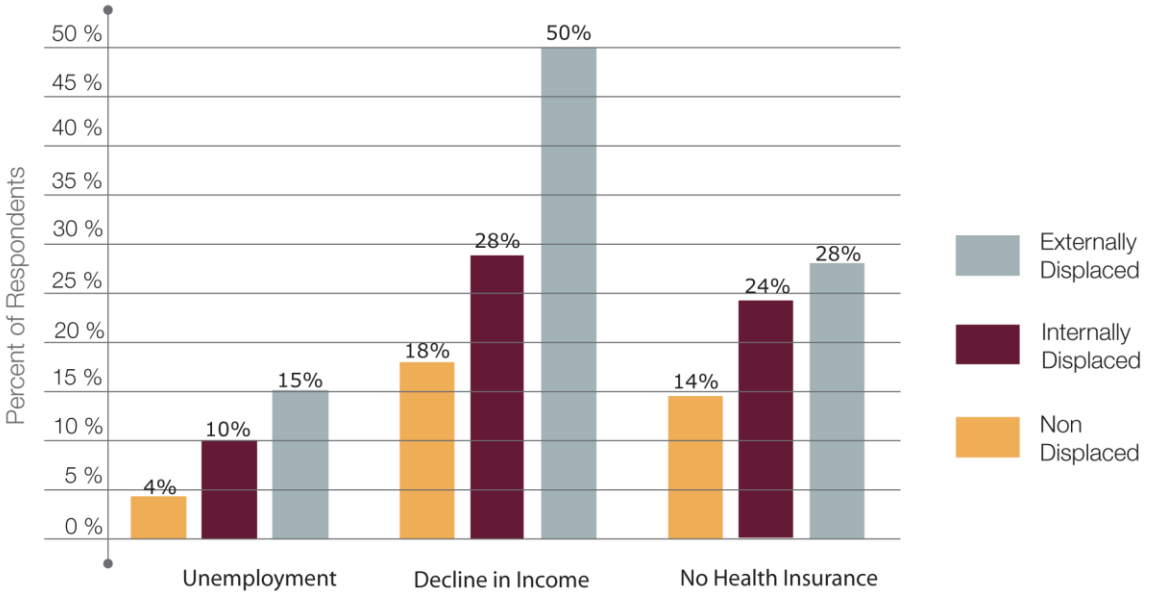


FIG 3: Effects Of Displacement One Year After Hurricanes Katrina And Rita
Data: Hori 2009 - Graphics: GCCDS

2.2.3.5 Occupant Preferences

The following research study demonstrates a preference for THU placement on private property and a change in occupant perception based on the unit's location.

- A survey of 30 travel trailer occupants in 2006 revealed their preferences for THU placement on private property. The top three factors occupants liked about their units were (Verderber 2008):

- Its proximity to community and services (42%),
- It being the main reason they could begin repairs on their flood damaged home (35%),
- The ability it gave them to return to their community (32%)

- Occupants living on single sites, rather than multi-unit sites, varied somewhat in their assessment of the travel trailer: single-site occupants thought the unit size was more adequate for their needs, that the unit was more acoustically effective, and that the neighborhood was more safe (Verderber 2008).

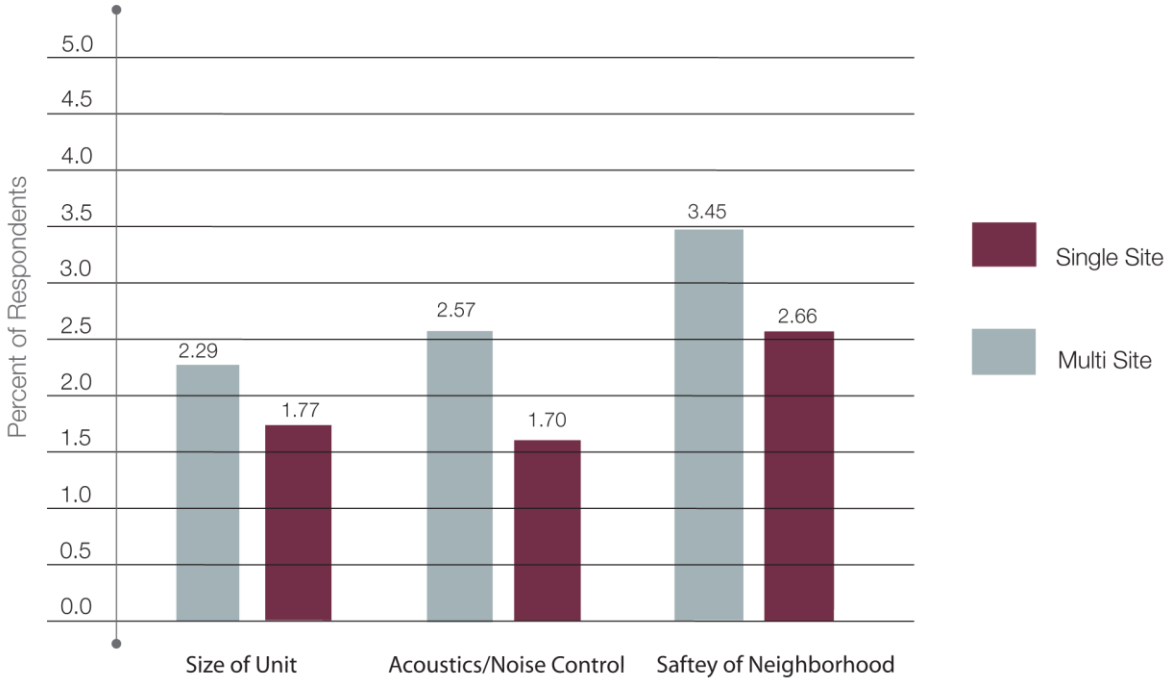


FIG 4: Occupant Assessment of FEMA Travel Trailer (1-low, 5-high)
Data: Verderber 2008- Graphic: GCCDS

2.2.3.6 Community Acceptance

Perceptions about crime, aesthetics and building quality pose significant challenges to the acceptance of THUs by local communities. Local zoning restrictions also affect the viability of unit installation.

- During the MAHP program, some municipalities were resistant to MEMA units because they negatively associated their placement with mobile homes and trailers, especially in multi-unit sites (ABT Associates 2009c). The MAHP program also found that local municipalities became less lenient in zoning and permitting processes as time passed after a disaster (ABT Associates 2009c).

- Above-ground waste lines, visibility of wheels and poorly crafted ramps in some MAHP units contributed to a sense of impermanency and a lack of commitment to a more permanent community recovery (ABT Associates 2009c).

- The Bayou La Batre multi-unit site had some success in fitting in and being accepted by the local community. The homes were single-story, cottage-style homes that reflected local architecture (ABT Associates2009b).

2.2.4 Summary

Unit location plays a significant role in recovery from a disaster, as it determines whether an occupant's social network, community resources, and employment opportunities remain intact during the recovery process. THU location on private property limits the impacts of displacement and allows occupants to continue actively repairing and rebuilding their damaged property. Despite its benefits, there are significant limitations to locating THUs on private property, including site hazards the HUD code size, and occupancy regulations. Group sites are generally less accepted by the community and require major investments in infrastructure. They do however offer an alternative for renters and property owners in the floodplain when commercial properties are not viable.

2.3 Performance Consideration: SAFETY AND HAZARDS

2.3.1 Purpose

Safe and secure units protect both occupants and their belongings.

2.3.2 Background

Temporary disaster housing sites face a variety of threats, from weather events to fire and theft. Occupants may be living in a THU on their own property, or they may be located in multi-unit sites where they are not as familiar with their surroundings. The THU plays a role in protecting occupants and their belongings from harm through a sense of safety, secure entry and structural integrity.

2.3.3 Research Topics

- Crime and Safety of Unit and Environs
- Storm Hazards
- Safety from Storms

2.3.3.1 Crime, Safety of Unit and Environs

When occupants are relocated to a THU group site following a disaster, crime and safety concerns can emerge based on the proximity of displaced occupants. While there are anecdotal accounts of increased crime occurring within group sites following Hurricane Katrina, an analysis of comprehensive data is necessary for a deeper understanding of this topic and its impact on future THU missions.

- The Bayou La Batre Alternative Housing Pilot Program (AHPP) group site was able to provide an increased sense of safety for occupants who worried the site would match the crime and violence experienced in the City's FEMA trailer park (ABT Associates 2009b).

- Travel trailer assessment respondents tended to feel safer in single sites on private property than in group sites (Verderber 2008). Within group sites, almost half of occupants felt unsafe walking outdoors at night or letting their children play outside during the day (Verderber 2008).

- Occupants who moved into MAHP units reported drastically fewer problems with broken locks on doors and windows (3.9%) than in previous emergency housing (38.3%) (ABT Associates 2009a)

2.3.3.2 Storm Hazards

Depending on their climate and location, THUs face a variety of hazards; wind and flood, seismic activity, heavy snow, tornadoes and landslides all contribute a threat to the unit and its occupants. Utilities, foundation systems, attached structures, and surrounding

roads and infrastructure are all vulnerable components of THU design that must be adequately addressed for human safety and unit longevity.

Utilities

- Floodwaters can damage utility systems including: HVAC, propane and fuel tanks, electrical systems, wastewater and water supply (FEMA 1999) (FEMA 2009a).

- Seismic forces may disrupt gas and electric lines, which can potentially ignite a fire, even if there is little damage elsewhere in the home (FEMA 2009a). Heavy items such as hot water heaters and HVAC units are susceptible to movement and damage by seismic forces. (FEMA 2009a).

Attachments

- A 2004 assessment after Hurricane Charley noted extensive damage from structures that are commonly attached to manufactured homes after installation (e.g. carports, decks, porches, awnings) The failure of these attachments created debris and damaged roofs, siding and windows (FEMA 2009a).

Foundations

- Flood hazards provide a wide range of hazards to THU foundations and installation practices, including: buoyancy, lateral movement, pier collapse, erosion and scour (FEMA 2009a).

- Typical seismic damage in design earthquakes includes homes falling off their support systems and foundation piers penetrating through the floor (FEMA 2009a).

Roads & Infrastructure

- Flooding and other hazards can damage roadways and make evacuation or access to community resources difficult (FEMA 2009a).

- In high winds, trees, telephone poles and other large items near the site can damage manufactured homes through falling or becoming airborne debris (FEMA 2009a).

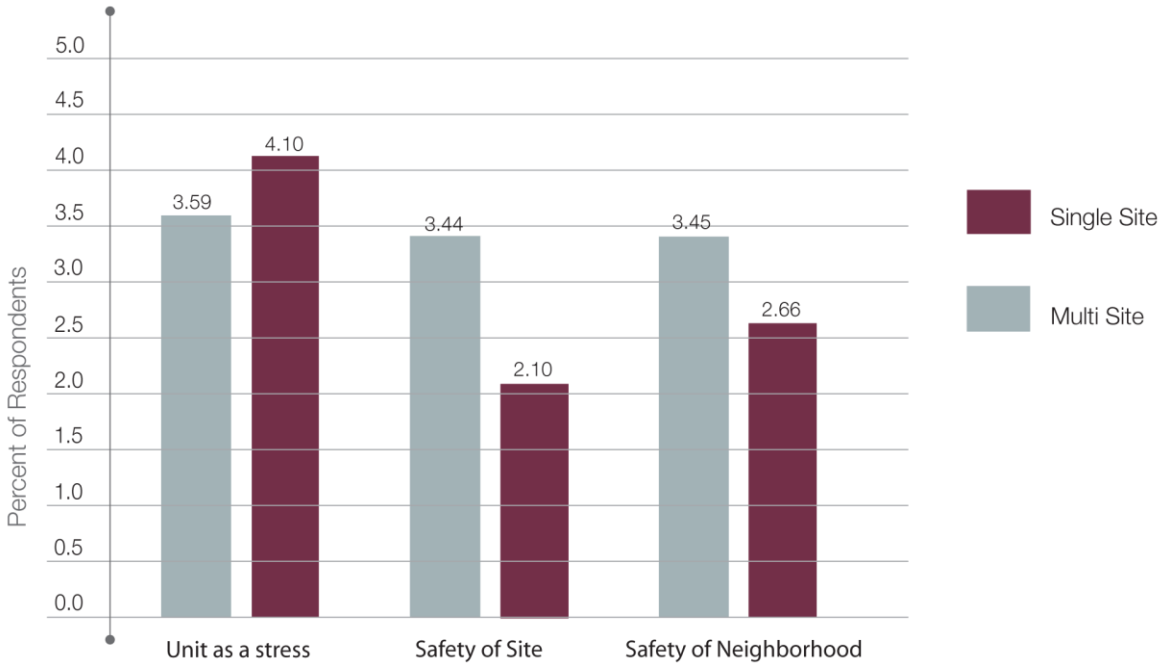


Fig 5: Occupant Assessment of FEMA Travel Trailer: Feeling of Safety
Data: Verderber 2008- Graphic: GCCDS

2.3.3.3 Safety from Storms

After a disaster, occupants may experience severe weather events while continuing to live in the THU. Large storms can threaten an occupant's sense of safety while living in a temporary unit.

- MAHP units provided an improved sense of safety during storms; 97% of respondents felt safer from high winds and flooding than in their FEMA travel trailer or mobile home (ABT Associates 2009a).

- After Hurricane Gustav, participants noted the MAHP unit did not shake or make as much noise as their travel trailer (ABT Associates 2009a).

2.3.4 Summary

Occupant safety encompasses both natural and human hazards. Perceived safety is an important element of the occupant experience, from THU location to the unit's ability to withstand severe weather events. Storm hazards may physically impact the unit, from utilities to foundations and surrounding infrastructure. Human hazards such as theft and intrusion are also a concern for THU occupants. Though anecdotal evidence points to crime issues, more accurate crime data is required to fully assess safety in past THU deployments.

2.4 Performance Consideration: ACCESS

2.4.1 Purpose

Access to, from, and within units for all levels of mobility is a primary requirement.

2.4.2 Background

Temporary disaster housing must meet a diverse range of needs, outlined by the Federal Fair Housing Act and other civil rights laws (FEMA 2010). The potential users or protected classes of a THU include occupants with physical or mental disabilities, limited English proficiency, families with children, minorities, and those with a wide range of other special needs. FEMA's National Disaster Housing Implementation Plan directly addresses the importance of understanding disaster housing needs for a diverse population (FEMA 2010). Physical disabilities in particular have spatial implications inside and outside the unit; from washing the dishes to entering and exiting. The bulk of special needs research in temporary disaster housing is focused on physical disability, and Universal Federal Accessibility Standard requirements are used as a tool for ensuring that occupants can maneuver within the THU and access its features. It is also important to note that visitors, such as family or friends, may be mobility-impaired and require design modifications, even if the occupants themselves do not (Krimgold 2010). The number of unit configurations required to fulfill occupant needs, whether they are fully accessible or adaptable, must be limited to maximize efficient manufacturing and deployment of units.

2.4.3 Research Topics

- Disability Rates
- Accessibility
- Unit Configuration

2.4.3.1 Disability Rates

Disability rates for the national population and past THU deployments provide a sense of the demand for accessible units.

- 11% of all MAHP units were accessible according to UFAS requirements. However even non-UFAS units included some universal design features (ABT Associates 2009a).

- Almost 43% of MAHP households had a member with a physical disability (ABT Associates 2009c). 11.9% of the national population over 5 years of age has a mobility impairment related to the lower body and 8.2% have mobility impairment in the upper body (Britta 2012).

- 30% of MAHP households with a disability reported a member who either rode a wheelchair or could not otherwise climb stairs (ABT Associates 2009c). 1.4% of the national population over 5 years of age uses a wheelchair, while 4.4% use a cane, crutches or a walker (Britta 2012).

2.4.3.2 Accessibility

Using the UFAS's definition of accessibility, a THU can be "approached, entered, and used by physically disabled people" (The Administration 1968). Use may include circulation within the unit, and the ability to use fixtures, appliances and accessories.

- FEMA travel trailers provided only limited access based on occupants' needs. On a 5 point scale (5=high), respondents ranked ingress-egress amenity 2.21 for sites on private property, and 2.35 for group sites (Verderber 2008). One woman interviewed by the MAHP program had "not been able to leave her travel trailer under her own power for more than two years." (ABT Associates 2009c)

- The MAHP program succeeded in making drastic improvements for residents with limited mobility. Less than 75% of respondents in a MAHP evaluation reported that a disabled household member was able to enter and exit their FEMA trailer, move from room to room, and independently access the bathroom (ABT Associates 2009b). In the same study, more than 93% of respondents reported that these activities were possible in their MAHP unit (ABT Associates 2009b).

2.4.3.3 Unit Configuration

Typically, THUs delivered by FEMA are either "Standard" units or UFAS-compliant. It is unlikely that a one-size-fits-all solution could cover the assortment of special needs and family size requirements. In contrast, an abundance of unit types complicate the design, procurement and deployment process.

- An evaluation of the MAHP program suggests possible strategies for meeting users' accessibility needs: maximizing universal design concepts, manufacturing adaptable units, or developing a percentage of fully accessible units (ABT Associates 2009c).

- The Bayou La Batre AHPP cited manufacturer unfamiliarity with UFAS requirements as an impediment to providing accessible units. Construction specifications as detailed as "…adjusting the leveling screws on a refrigerator or placing the edge rather than the center of a toilet paper dispenser at a specified measurement could disqualify a unit from meeting UFAS guidelines" (ABT Associates 2009b)

2.4.4 Summary

Individuals with a variety of special needs require appropriate housing modifications. Occupants may have disabilities such as mobility impairments, visual and hearing difficulties, or other special needs. Occupants may also face temporary injuries and illnesses while they occupy a THU that may affect their ability to maneuver within the unit. A temporary disaster housing program must accommodate as many special needs as possible while simultaneously limiting unit configurations.

Performance Consideration: PARTICIPATION

2.4.5 Purpose

The more input individuals and families have on decisions that affect their future, including temporary housing, the more successful recovery efforts will be.

2.4.6 Background

Options have been limited for disaster survivors, from selecting a THU configuration to making alterations on the interior or exterior of the unit. Applicants are generally required to accept the housing unit assigned by FEMA (McCarthy 2008). Occupants are also prohibited from making interior or exterior modifications (Verderber 2008). For survivors, having a choice in their housing situation or living space empowers them to adapt the unit to their specific needs, and may reduce stress while they live in the THU (Verderber 2008). A sense of control is closely linked with other design considerations that accommodate special needs and support occupants in returning to their everyday activities. There is an important balance that must be struck between offering choices to occupants and maintaining efficient manufacturing, quick response and deployment. Modifications may also have structural or safety implications that must be considered.

2.4.7 Research Topics

- Unit Types
- Exterior and Interior Modifications

2.4.7.1 Unit Type

According to FEMA's regulations, applications may lose their aid benefits if they refuse an offer of housing assistance (McCarthy 2008), even if the assistance wasn't sufficient for their households needs.

- A travel trailer assessment following Hurricanes Katrina and Rita revealed that only 7 of 30 respondents felt they had a reasonable degree of control over their overall housing situation (Verderber 2008).

- MAHP units came in variety of colors to blend into neighborhoods and display a less institutional look, unlike the all-white FEMA travel trailers. The color variations, however, did lead to specific requests from occupants (ABT Associates 2009c).

2.4.7.2 Exterior and Interior Modifications

Once the THU is transferred to an occupant for their temporary use, the unit may not be significantly altered.

- In a diagramming task, respondents to the travel trailer assessment revealed that they had made modifications despite regulations, primarily to the exterior of the unit, including fences, tent-like devices attached to the unit, address signs, and slogans (Verderber 2008).

- In Biloxi, MS following Hurricane Katrina, GCCDS observed that many families added provisions to their unit to accommodate daily needs and activities, such as a mud room or outdoor cooking area.

- 54% of respondents to the travel trailer assessment disliked the inability to alter the exterior or interior of their unit, and chose to go ahead and modify the exterior against regulations (Verderber 2008).

2.4.8 Summary

Occupants may have very little control over their housing situation following a disaster. Where they live and what type of unit they receive may be determined by the temporary disaster housing program. When occupants move into a THU, many alterations will be prohibited, especially if they compromise the unit structurally or require later repair. Participation in some aspect of their housing situation does enable occupants to retain or rebuild some measure of control over their situation. The ability to shape their living experience empowers occupants, as they can make choices and adjustments to fit their needs.

2.5 Performance Consideration: STABILITY

2.5.1 Purpose

Following a disaster, individuals and families need to establish a sense of stability and self-reliance as part of the recovery process.

2.5.2 Background

Experiencing a disaster can have a profound psychological effect on survivors. Long before an occupant moves into a THU, a wide range of stressors may contribute to their mental health. Catastrophic disasters may have lingering periods of distress for survivors and spur a range of "secondary disasters", including unemployment, long-term economic decline, and higher incidences of domestic violence (Noji 1997). Unsurprisingly, mental health may be negatively affected by these intense life experiences. A temporary housing unit can create further barriers for disaster victims to overcome; alternately, it may contribute towards an environment supportive for recovery. The ability of the unit to exacerbate or relieve stress depends heavily on its functionality and the ability of disaster victims to resume everyday activities within the unit.

2.5.3 Research Topics

- Hardship and Mental Health
- Housing Stressors
- Return to Routine

2.5.3.1 Hardships and Mental Health

Interviewees of the Harvard Hurricane Katrina Community Advisory Group in 2006 reveal the extent of hardship that may be experienced after a catastrophic disaster (Harvard 2006):

- 80% of respondents experienced significant financial, income, or housing losses due to Hurricane Katrina.

- Many respondents had to overcome extreme physical and psychological adversity (36.3% and 22.8%, respectively) such as sleeping on the floor, lack of food and privacy, and threats of violence (Harvard 2006).

- Respondents were twice as likely to have diagnosed mental illness 4-7 months after the storm (30%) than before the storm (Harvard 2006).

2.5.3.2 Housing Stressors

Housing can be a significant cause of stress among a population recovering from a disaster:

- Over 40% of respondents in the Harvard study considered their housing situation a stressful experience during and after the hurricane (Harvard 2006).

- 49.6% of respondents in the Harvard study listed housing as one of their top five practical problems caused by Hurricane Katrina, second only to financial issues (Harvard 2006).

- An assessment of FEMA's travel trailers in use after Hurricanes Katrina and Rita reveal a list of stressors cited by respondents including: inadequate size, difficulty in personalizing units, lack of site amenities, little overall privacy, and chronic environmental stress (Verderber 2008)

2.5.3.3 Return to Routine

The ability for disaster survivors to resume everyday life activities, from entertaining guests to taking a bath, can be a powerful catalyst for recovery.

- A return to some sense of normalcy is especially important for children, who depend on routine and consistency to establish their sense of security and identity (Noji 1997). For many Hurricane Katrina survivors who participated in the MAHP, the larger, semi-permanent units felt more like a home where everyday activities could be resumed (ABT Associates 2009c).

- MAHP respondents generally reported feeling more calm and peaceful (39% from 27% baseline), and less hopeless (40% below from 70% baseline) after moving into their MAHP units (ABT Associates 2009a).

2.5.4 Summary

Housing can be a significant source of stress and hardship for survivors following a disaster. Obtaining adequate housing may be the initial challenge, and once a THU is assigned, occupants may struggle with aspects of their new living situation. A temporary housing unit that can accommodate the daily, routine activities of occupants can better serve their recovery process and alleviate stress.

2.6 Performance Consideration: SIZE

2.6.1 Purpose

Adequately sized units allow for occupants to begin their daily and recovery activities following a disaster.

2.6.2 Background

In the emergency shelter phase, survivors may cope with overcrowded living conditions that restrict their everyday activities. Occupants need consistency as time passes after a disaster and as they move into temporary disaster housing. Cleanup and rebuilding as well as work, school, and other life activities must continue in order to facilitate recovery. THU's must accommodate basic activities such as sleeping, preparing food, doing homework, and cleaning. Appropriate occupancy standards ensure that users have the space they need to re-establish a sense of routine. However, most critical to this equation is the balance of interior functionality and overall unit size.

2.6.3 Research Topics

- Size
- Occupancy

2.6.3.1 Size

While THU's are generally smaller than permanent homes, a minimum amount of space is required for occupants to conduct daily activities.

- Occupant studies of those living in FEMA and AHPP units reveal the effectiveness of past sizes and layouts. Over half of FEMA travel trailer assessment respondents disliked the small size of their housing unit (Verderber 2008).

- Bayou La Batre program respondents who had lived in travel trailers for up to three years noted general irritation from living in close quarters for so long. They also noted a lack of adequate space for storage, privacy, and cooking (ABT Associates 2009b).

- Although the one-bedroom MAHP Park Model was only about 50% larger than the travel trailer, its design and layout increased occupants' ability to continue their daily routines. The units included higher ceilings, additional storage, and full kitchens and bathrooms, which were highly valued by occupants (ABT Associates 2009c).

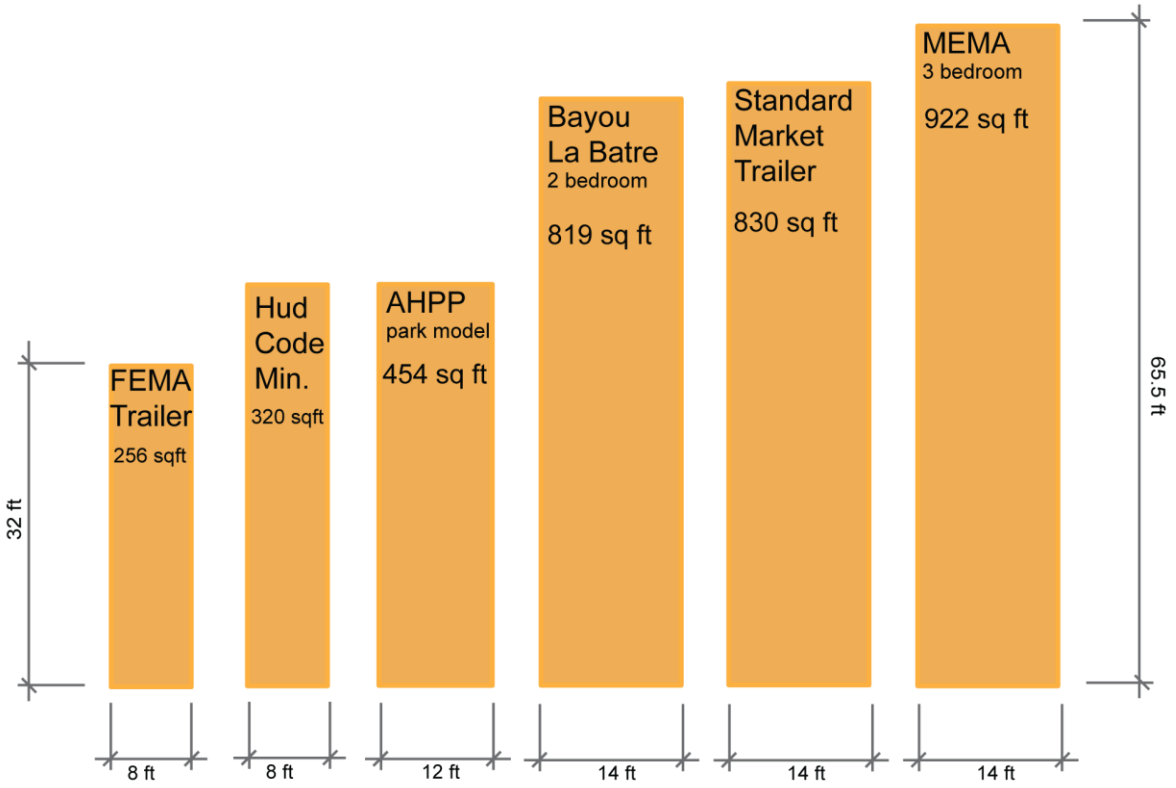


FIG 6: Comparison Of Overall Sizes Of Varying Temporary Housing Solutions
Data: ABT Associates 2009c - Graphic: GCCDS

2.6.3.2 Occupancy

The behavioral activities that are indicators of overcrowding include: if someone in the household regularly sleeps in a room other than a bedroom because there are not enough bedrooms, or if a household member sometimes goes to another house to sleep because there is not enough space in the unit (Blake 2007).

- Overcrowding may have adverse effects on health and well being, such as stress, mental health and spread of illness. Overcrowding can also affect a child's performance in school if they do not have an adequate place to study (ABT Associates 2009a).

- In the MAHP program, up to four-person households were initially assigned to one-bedroom Park models. Tolerance of tight living conditions decreased among occupants after the initial disaster, prompting the program to change its occupancy standards (ABT Associates 2009c).

- The Bayou La Batre AHPP program used "right-sizing" criteria based on HUD guidelines to match occupants to the appropriate unit (ABT Associates 2009b). Units ranged from one bedroom to four bedrooms, with one or two bathrooms,

and took accessibility and number of children into account (ABT Associates 2009b).

2.6.4 Summary

The size of a THU affects occupants' abilities to perform daily activities. Other design aspects, however, such as ceiling height, spacious living areas, and kitchens also contribute to unit functionality. Appropriate occupancy standards ensure that units are not overcrowded; however using permanent unit housing occupancy standards to define occupancy for THUs is not appropriate.

2.7 Performance Consideration: STORAGE

2.7.1 Purpose

Individuals and families displaced from disaster require adequate and appropriate storage.

2.7.2 Background

Depending on their circumstances, occupants may transition into a THU with a wide range of personal belongings. Some households may have donated clothing and valued items salvaged from a disaster, while others may begin their recovery with few belongings and accumulate items as life gradually returns to a routine. There are two types of storage a THU may provide: long-term secure storage and storage for items required for everyday activities. Adequate storage can help remedy clutter, which prevents the unit from functioning properly.

2.7.3 Research Topics

- Storage Space

2.7.3.1 Storage Space

Past THU deployments by FEMA and the AHPP have collected occupant feedback related to storage:

- According to respondents to the FEMA Trailer Assessment, there was not adequate space for personal belongings in the unit (Verderber 2008). From 1 (low) to 5 (high), respondents in autonomous sites ranked the amount of storage space as 1.32 (Verderber 2008).

- MAHP units had more storage space than the FEMA trailers, especially in the attic, which participants appreciated (ABT Associates 2009c). Still, almost half of MAHP respondents felt the storage space was inadequate (ABT Associates 2009a).

2.7.4 Summary

Occupants will arrive with varied storage needs and will accumulate belongings throughout their stay in a THU. The compact size of a THU limits available storage locations, but there is demand among occupants for increased storage capacity.

2.8 Performance Consideration: MAINTENANCE

2.8.1 Purpose

Streamlining and reducing unit maintenance on occupants, FEMA, and its contractors, is critical to long term success of a temporary housing program.

2.8.2 Background

Some amount of maintenance is inevitable in a THU, but minimizing the amount of problems and repairs saves cost, decreases stress and enables residents to continue their daily activities. It is important to define the roles and responsibilities of all parties early on so that maintenance can be reported and performed quickly and effectively. Adjustments related to installation should be minimized and completed prior to occupant move-in. Educating residents at move-in about their responsibilities and demonstrating unit systems and features can reduce unnecessary confusion and communicate clear expectations. Remote monitoring systems may be utilized to collect data; report and prioritize maintenance issues; and create and expedite work orders.

2.8.3 Research Topics

- Occupant Education, Roles and Responsibilities
- Unit Condition
- Repairs
- Remote Monitoring

2.8.3.1 Occupant Education, Roles and Responsibilities

Direction should be provided to occupants at move-in that will guide their ability to clean, maintain and operate the unit.

- The Bayou La Batre program provided in-depth move-in briefings for new occupants. The program case managers ensured occupants understood the lease and covenants, and conducted a detailed walk-through to demonstrate proper use and maintenance of appliances, systems and features in the unit. (ABT Associates 2009b). The case managers worked with occupants to inventory appliances, furniture, and living kits, explaining the occupants' responsibility to return items in good condition (ABT Associates 2009b).

- MAHP staff and participants reported confusion among occupants about how to operate systems and features in the unit, such as air conditioners, microwaves and fire extinguishers. Maintenance personnel and housing advisors suggested the move-in process include resident education on unit systems and features (ABT Associates 2009c).

- The MAHP program expected residents to take responsibility for some maintenance, including reporting issues, cleaning the unit, and taking care of minor items such as changing a light bulb. These responsibilities were new to

some residents since FEMA had previously provided all maintenance (ABT Associates 2009c).

2.8.3.2 Unit Condition

Move-in condition will affect whether immediate repairs are needed or whether features of the unit may experience problems later on.

- Nearly 90% of MAHP respondents reported their unit was in good or excellent condition at move-in. 90% also reported their MAHP unit was in better condition than the FEMA trailer or mobile home they lived in previously (ABT Associates 2009a).

- In the MAHP program, respondents reported fewer problems in their MAHP unit than their travel trailer or mobile home in every category. The largest decreases in reported problems were broken front door locks, bad odors, and electrical problems (ABT Associates 2009a).

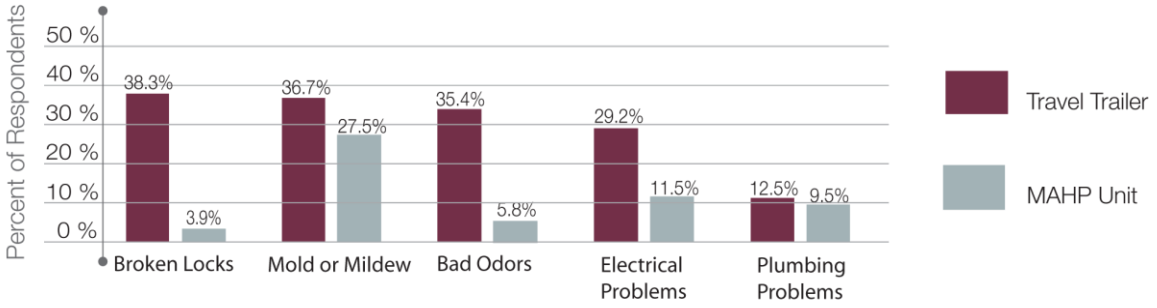


FIG 7: Comparison Of Maintenance Issues In The Travel Trailer And MAHP Units
Data: ABT Associates 2009a- Graphic; GCCDS

2.8.3.3 Repairs

Units may require maintenance visits by the responsible party while occupied.

- 84% of households during the first 20 months of MEMA's program called about a maintenance or warrantee issue. The four most common issues were (ABT Associates 2009b):
    - HVAC repair issues - 30.5%
    - Miscellaneous repairs or adjustments -19.4%
    - Plumbing - 14.4%
    - Electrical - 11.4%

2.8.3.4 Remote Monitoring

Remote monitoring may be used to prevent unaddressed maintenance issues and reduce the necessity of on-site visits:

- Some Bayou La Batre AHPP units were equipped with wireless moisture sensors in walls, ceiling and floors. The sensors transmitted temperature and humidity information to outside evaluators (ABT Associates 2009b).

2.8.3.5 Summary

Unit maintenance may be initiated by remote monitoring, occupant request, or an assessment of the unit's condition prior to occupancy. Occupants should be educated about the unit's features and their roles and responsibilities at move-in. The possibilities of new technology advancements and networks can aid in a new macro level monitoring of THUs from deployment through use and demobilization, with little need for unit by unit in-person monitoring.

2.9 Performance Consideration: INDOOR AIR QUALITY

2.9.1 Purpose

Unit materials and assemblies, especially finishes, contribute to the quality of indoor air and affect occupant health.

2.9.2 Background

Asthma, allergies, headaches and other breathing problems can be triggered by poor indoor air quality. The use of safe finish materials, testing and monitoring are integral to supporting occupants' physical health. Moisture control, proper ventilation, protection from second-hand smoke, safe materials and pest control are all part of maintaining adequate indoor air quality (Energy Star IAQ checklist 2009). Unsafe levels of formaldehyde in FEMA travel trailers after Hurricane Katrina shed light on the importance of specifying materials according to strict regulations, randomly air testing units, and responding swiftly to occupant complaints.

2.9.3 Research Topics

- Environmental Health
- Indoor Air Quality
- Mold and Moisture
- Respiratory Health

2.9.3.1 Environmental Health

THU's have a significant effect on human health. The extent to which a unit supports occupant health and recovery shapes the perception of units both locally and nationally.

- One of the top three aspects of the FEMA travel trailer that respondents felt negatively about was the health problems experienced by the occupants themselves, and their friends, or health problems they heard about in the media (Verderber 2008).

2.9.3.2 Indoor Air Quality

Materials with high levels of formaldehyde or other chemicals, poor ventilation, and indoor smoking all contribute to poor indoor air quality with associated health impacts.

- Three months after Hurricane Katrina, the media was already highlighting formaldehyde as an environmental problem (ABT Associates 2008c). Some residents complained of headaches and nosebleeds upon moving into their FEMA travel trailer (Verderber 2008).

- A study by the Sierra Club in 2006 found levels of formaldehyde in the FEMA trailers as high as .34 parts per million (PPM). Forty out of 44 trailers had levels

high enough to be considered an "elevated" level by the EPA, or .1 ppm. This concentration was capable of causing respiratory problems, burning in the eyes and throat, and nausea. (Verderber 2008). FEMA now requires less than .016 ppm in THUs (FEMA 2009b).

- Second hand smoke is a concern within THUs, as evidenced in the FEMA trailers and MAHP units. About half of MAHP respondents that smoked, smoked in both their MAHP unit and FEMA trailer (ABT Associates 2009a). 18% of all adults in the United States smoke cigarettes (ABT Associates 2009a).

2.9.3.3 Mold and Moisture

Moisture problems impact both unit durability and human health.

- About 20% of MAHP respondents reported mildew, mold, or water damage in their unit; this was the most common maintenance problem with the units (ABT Associates 2009b).

- After Hurricane Gustav in 2008, over 200 MAHP units were declared uninhabitable because of wet flooring insulation and projected mold growth (ABT Associates 2009b).

2.9.3.4 Respiratory Health

Indoor air quality within a THU directly affects respiratory health for occupants of all ages.

- "MAHP units may have contributed to improvements in respiratory problems. They are roomier than FEMA trailers and have more windows and higher ceilings, which can improve air circulation (ABT Associates 2009a)." MAHP units have a greater air volume, and larger windows which helps create a larger air exchange rate.

- About one third of MAHP respondents with respiratory breathing problems such as asthma, emphysema or allergies reported that their condition was diagnosed after Hurricane Katrina (ABT Associates 2009a).

- Of MAHP participants who had children with breathing problems, about half reported that the child was diagnosed after Hurricane Katrina, but prior to moving into their MAHP unit (ABT Associates 2009a).

- "Ninety-two survey respondents (32.7 %) indicated that they had at least one child age 17 or under living with them (ABT Associates 2009a)." 92 respondents with children, 54 % indicated that at least one child had a breathing problem, with allergies the most common cause. Figure 9 shows the timing of children's breathing problem diagnoses compared to Hurricane Katrina. Among all their diagnoses - asthma, allergies, and other breathing problems - over half of MAHP respondents reported that a child in their household was diagnosed after the hurricane, but before moving into the MAHP unit (ABT Associates 2009a).

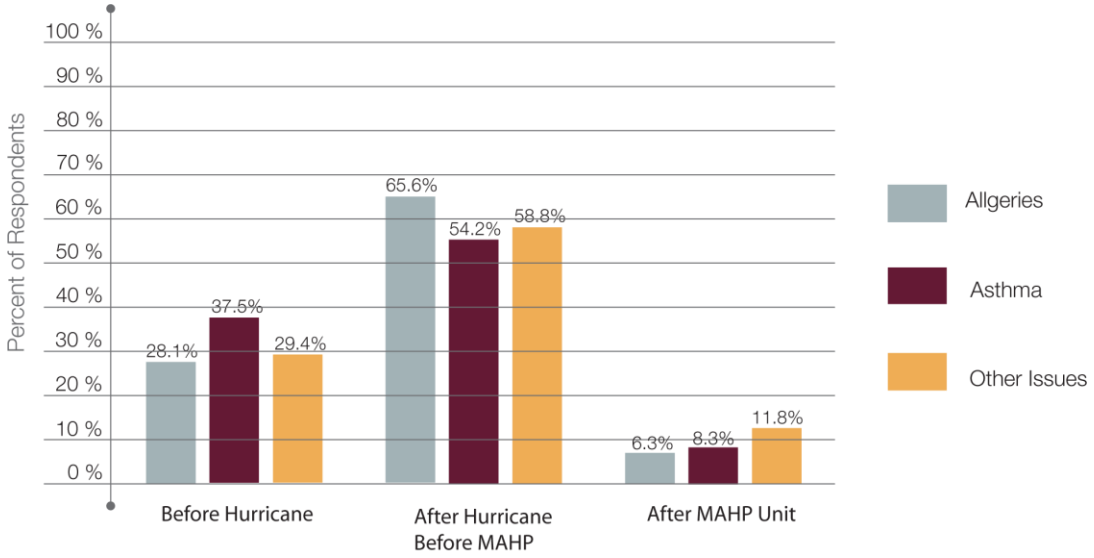


FIG 8: Timing of Breathing Problems among Children Living in MAHP Units
Data: ABT Associates 2009a- Graphic: GCCDS

2.9.3.5 Summary

Occupants who live in temporary housing with poor indoor air quality may be left with lasting respiratory problems, even after transitioning out of the unit. In addition to negatively impacting human health, moisture problems can create maintenance problems or in severe cases render a unit inhabitable. Indoor air quality shapes occupant perception of THU's and affects local and national perception of a temporary disaster program more generally.

2.10 Performance Consideration: THERMAL COMFORT AND EFFICIENCY

2.10.1 Purpose

Energy efficiency and thermal control can reduce utility costs, affect occupant comfort, and reduce unit maintenance issues.

2.10.2 Background

Indoor thermal comfort allows occupants to focus on their daily activities and gives them a sense of control over their living environment. Control over temperature and humidity also impact human health, indoor air quality, and affects the cost of utilities. Most people prefer an indoor air temperature of 65 °F to 85 °F, and maintaining air temperatures can account for up to 70% of a home's annual energy consumption (Krigger 2004). Temperature affects relative humidity, as warmer air can hold more moisture. Humidity that is too high can cause moisture problems, while humidity that is too low can damage building materials and create static electricity charges (Lstiburek 2002). Energy efficiency and water conservation reduce the cost of utilities and overall consumption.

2.10.3 Research Topics

- Comfort
- Humidity
- Energy Efficiency and Water Conservation

2.10.3.1 Comfort

The ability to control indoor temperature and humidity affects occupant comfort.

- According to the FEMA Trailer Assessment, occupants were not satisfied with their ability to control indoor thermal comfort (Verderber 2008). From 1 (low) to 5 (high), respondents at single sites ranked their ability to control indoor temperature and humidity a 1.72 (Verderber 2008).

2.10.3.2 Humidity

There is an ideal range for humidity levels for preventing issues related to occupant and comfort and unit maintenance.

- Relative humidity should not exceed 60% to prevent physical discomfort and an array of moisture problems (i.e. including mold, rot, and decay), that can affect the durability of building materials and cause health problems. Some building materials and finishes are particularly susceptible to high humidity. Moist carpets and fabrics can lead to dust mite infestations and mildew (Lstiburerk 2002).

- Relative humidity that is too low can also cause physical discomfort and affect the building itself. Wood shrinkage, paint cracks, and static electricity may occur

at low levels (Lstiburek 2002). Breathing difficulties have been reported below 15% relative humidity, as mucus linings dry out (Lstiburek 2002).

2.10.3.3 Energy Efficiency and Water Conservation

Energy efficient, water conserving units help to reduce consumption and lower utility costs.

- MAHP park models featured ENERGY STAR heating, ventilation and air-conditioning systems and no roof penetrations (FEMA 2011).

- The Mississippi Eco Cottages which were part of the MAHP program were designed to reduce energy consumption and serve as a cutting-edge example of green housing (FEMA 2011). Features in the specifications included Structurally Insulated Panels (SIP) for walls and roof, ENERGY STAR appliances, and ENERGY STAR doors with low-e glazing. The specifications also include measures for preventing air infiltration (Washer Hill Lipscomb Architecture 2008).

2.10.3.4 Summary

Thermal comfort depends both on the systems installed in the unit and occupant control of temperature and humidity. There is a range of relative humidity that is ideal for indoor air quality and unit durability. Energy efficient systems, lighting and appliances reduce energy while low-flow fixtures reduce water consumption and help to lower utility costs.

2.11 Summary

The 10 performance considerations presented in this chapter represent a broad scope of research related to the development of temporary disaster housing units. Each consideration impacts both the responsible parties that provide the units and the occupants who use the units during the recovery process.

The performance considerations presented in this chapter highlight the importance of eliminating distractions for occupants to be able to focus their energy on the recovery process. The sooner occupants can access information, return to their daily routine, and participate in their pre-disaster community and family activities, the more quickly they can make progress towards achieving self-reliance. Stressful distractions may include traveling long distances to rebuild and repair property, excessive maintenance visits, and deteriorating health impacts. Many of the stresses occupants experience relate directly to unit quality, from indoor air quality and moisture issues to the functionality of appliances and equipment. Occupant recovery is also affected by initial program decisions such as unit configuration and sizing and occupancy requirements that accommodate a range of special needs from accessibility to family size.

The performance considerations presented in this chapter provide a contextual understanding of the major issues confronting the THU program and occupant recovery. Chapter 3 will introduce the life cycle diagram and review each phase of the unit and occupant recovery process. Using the performance considerations as a framework, detailed performance criteria will be presented according to each phase in the life cycle.

3. LIFE CYCLE DIAGRAM

3.1 Introduction

The primary purpose of a temporary housing unit is its use by displaced individuals or families following a disaster. The unit plays an important role in occupant recovery and its performance requirements are informed by this unique purpose. It is important to consider each stage of the unit cycle, to be able to deliver a THU that is efficient, cost effective and quickly deployed. The following diagram is an aid in understanding the interrelated needs of occupants and the goals of a temporary disaster housing program. The life cycle diagram provides a graphic framework for organizing performance requirements and identifying relationships and overlaps within a complex process.

As the diagram illustrates, temporary disaster housing programs encompass two interrelated processes: the lifetime of the unit from pre-manufacturing through demobilization, and the occupant's passage from pre-disaster conditions to self-reliance. The Dwell Cycle outlines the phases of recovery for temporary housing occupants. The occupancy phases (Work, Eat & Gather, Bathe and Sleep) include the routine daily activities that individuals and families perform on their path to recovery. Likewise, the Unit Cycle outlines the phases of a temporary housing program. After the unit is used as temporary housing, it can be renewed, decommissioned, or become a permanent component after a transfer of ownership. The two cycles overlap particularly while the units are deployed and in use by occupants.

This Chapter applies performance considerations developed by GCCDS in Chapter 2 to each applicable phase throughout the THU life cycle. Not every performance consideration applies to each stage; nor does each stage directly impact the development of performance requirements. Where relevant, performance considerations are identified and developed into criteria, to be used in the further development of specifications. A full table of performance criteria can be found in Appendix B.

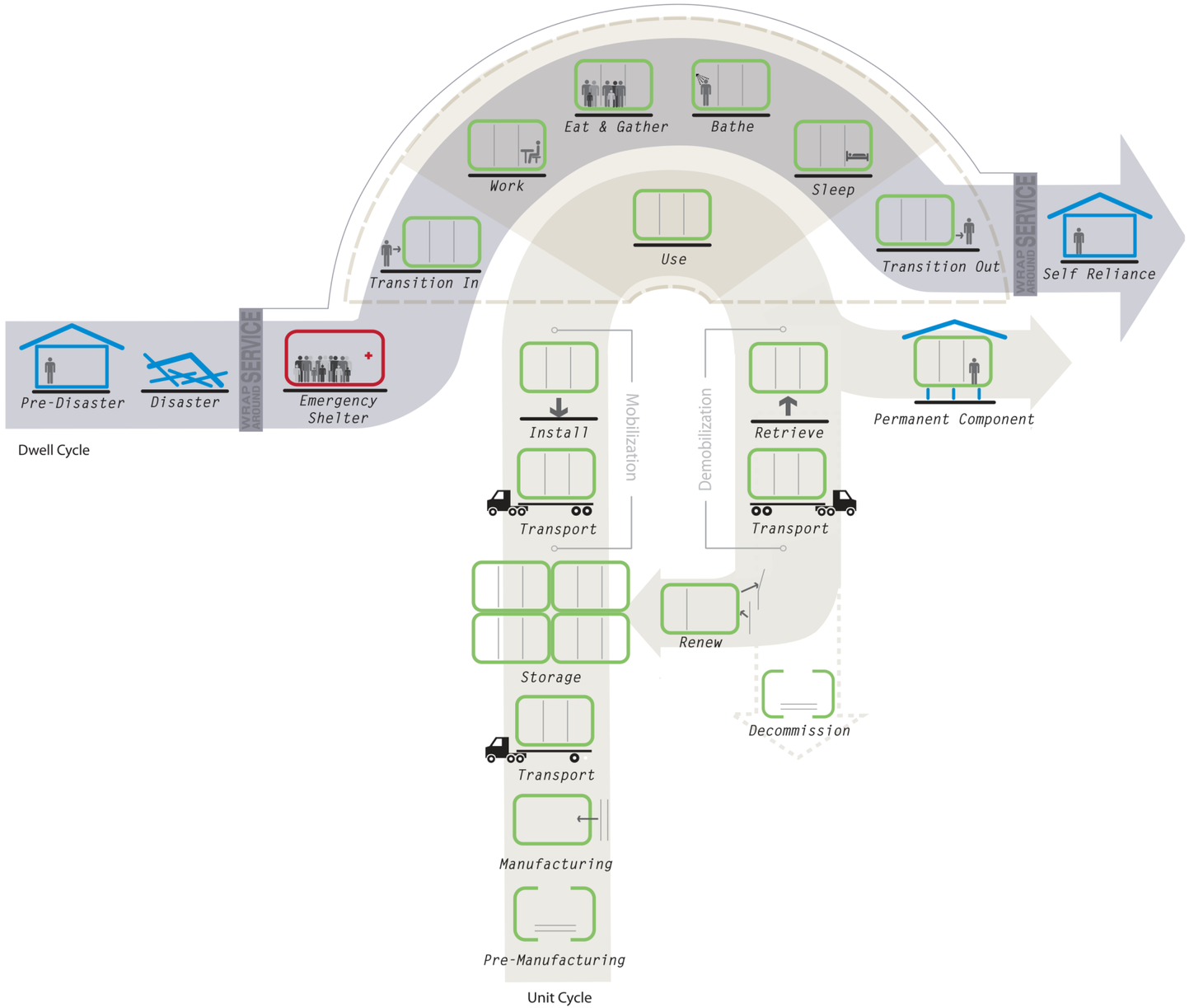


FIG 9: Life cycle Diagram

3.2 Pre-Manufacturing

The pre-manufacturing phase encompasses all the preparatory work leading to the production of units including the development of unit configurations, performance specifications and procurement. Programmatic decisions are made by responsible parties during this planning phase to guide the design and production of THU's.

Prior to the manufacturing process, unit types and configurations are developed to meet a range of household sizes and special needs. The range and number of unit types impacts the logistics of storage and deployment, as well as the assignment of appropriate units to occupants. The strategy for how to incorporate accessible units is critical, as it has major implications for both occupant use and the manufacturing process. In addition to UFAS and non-UFAS units, adaptable units may service a broad range of occupants with special needs that do not qualify for a fully accessible unit. The cost of implementing selected accessible design features ranges considerably and warrants further analysis.

Performance specifications are developed for each unit type, optimizing unit quality, manufacturing efficiency, and cost. All phases of the Unit and Dwell Cycles must be taken into account in order to develop requirements that promote innovative design solutions. Comprehensive specifications should tie into overall project management objectives over the unit's lifetime.

Procurement includes a strategy for where and how units will be manufactured and stored. Selected manufacturers must have the capacity to produce high quality units quickly and to provide innovative solutions to meet performance specifications. Manufacturers must also have the ability to produce units at a pace that will meet the needs of disaster survivors. Units may be stored long-term or deployed immediately, and missions may range in unit demand from minor events to catastrophic disasters that displace large populations. The location of preferred manufacturers may depend on their proximity to a long or short-term storage area or proximity to a disaster.

The manufactured home industry has been the primary source of temporary disaster housing units. The industry has a familiarity with the regulatory requirements of the HUD Code and of housing in general. The industry also has limitations based that include standard construction assemblies and methods of construction. It is critical that the manufacturers selected to produce THU's have the capacity to meet innovative performance requirements.

3.3 Manufacturing

The manufacturing process encompasses the production of THU's. During this phase, the manufacturer produces and assembles the unit's components, with oversight from responsible parties. Requirements set forth in the performance specifications define outcomes of the manufacturing process. Quality control during this phase is critical, as it prevents maintenance problems that may emerge in all other phases of the Unit Cycle, such as moisture issues or broken equipment (FEMA 2011).

3.4 Transport

Each THU must withstand the loads of transportation forces multiple times during its lifetime. Each unit must also comply with regulations that govern its transport. At a minimum, units will be transported from the manufacturing facility to a storage area and again to the installation property. After they are used for disaster housing, most units are retrieved for decommissioning or returned to a storage site for renewal. Units that are used permanently after an initial disaster may require relocation if they are sold or donated. Considering each unit will make multiple trips over its lifetime, THU's must sustain travel without damaging the structural integrity of the unit or requiring excessive repairs.

3.4.1 Location

3.4.1.1 Transport Regulations

Transport regulations vary from state to state and make highway travel challenging for THU's that need to be quickly deployed over long distances. In particular, the size of units and whether they are transported in one or more section may constrain interstate travel.

In Alabama, for example, AHPP units were manufactured in Florida and shipped in two sections on a single truck. The Florida Department of Transportation impounded several units in transit as they were four feet longer than the maximum and not allowed to be divisible. The transportation problems delayed the units by about three weeks, until FEMA personnel was able to get special permission for the units to continue on their journey (ABT Associates 2009b) (FEMA 2011).

3.4.2 Safety and Hazards

3.4.2.1 Cumulative Transportation Impacts

To preserve the THU's structural integrity throughout its intended lifetime, the transportation system should be integrated with the unit design. System components must be engineered to withstand dynamic highway forces. They must also be securely fastened and accessible for repair and maintenance. Potential problems with weather and technical issues must also be taken into consideration. For example, high winds and repeated tire blow-outs delayed Alabama AHPP units as they traveled to Bayou La Batre from Florida. (ABT Associates 2009b).

The HUD Code requires a THU's transportation system be designed so that the unit can safely withstand regular highway conditions such as high speeds, braking and traffic. (HUD 2009b). Components regulated in the HUD Code are the following:

- Drawbar
- Coupling mechanism

- Chassis
- Running gear assembly
- Spring assemblies
- Axles
- Hubs and bearings
- Tires, wheels and rims
- Brake assemblies
- Lights and associated wiring (HUD 2009a)

3.4.3 Maintenance and Durability

3.4.3.1 Secure Interior Components

Freestanding items such as furniture and appliances are vulnerable to dynamic forces and subject to damage during the transportation process. Construction assemblies, doors, windows, and installed equipment must also withstand dynamic transportation forces. All components of the THU must be secured prior to shipment.

3.4.3.2 Maneuverability

THU's must have integrated provisions for moving the unit both vertically and laterally, such as pick points and forklift points. Maneuverability is essential in the transport process, but also in the installation, retrieval and storage phases where the unit must be repositioned accurately and without damage.

Transport I		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location & Site Preparation	Transport Regulations	ABT Associates 2009b
		FEMA 2011
	• **The unit should comply with regulations that allow it to travel through the contiguous 48 states.**	
Safety & Hazards	Cumulative Transportation Impacts	HUD 2009b
		ABT Associates 2009b
	• **The unit should withstand the impacts of multiple transports.**	
	• **The unit should have an integrated transportation system.**	
Maintenance & Durability	Secure Interior Components	ABT Associates 2009b
	• **The construction assembly should be appropriate for withstanding dynamic forces.**	
	• **Interior components should be secured prior to transportation.**	
	Manueverability	
	• **The unit should have multiple, integrated points for manueverability.**	

Table 3: Transport

3.5 Unit Storage

A unit may be in storage for several different purposes and lengths of time: short-term storage at a staging area for immediate deployment, long-term inventory, or storage post-retrieval, as well as in preparation for reuse. In each scenario, units must be logistically prepared for transport, maintained and repaired. Storage sites may handle from dozens to thousands of units, with a range of logistical requirements including movement of units, equipment and staff.

3.5.1 Location

3.5.1.1 Storage Sites

Staging areas must be efficient for complex operations, including the arrival and departure of units, accommodation of work crews and infrastructure including lighting, utilities and parking (MEMA2009b). Long-term storage requires efficient land use that supports quick deployment, long-term maintenance, and structural safety of the units.

MEMA's Haul-Install Technical Requirements specify group staging area tasks to be completed by the contractor. These include details such as disposal of garbage, parts repair and storage, and job site offices (MEMA 2009b).

3.5.2 Safety and Hazards

3.5.2.1 Storage Site Security

Both security and maintenance programs must be in place to keep units in good condition in preparation for installation and future occupancy. Whether in short or long-term storage, units must be stored safely from damage, weather hazards, and theft.

3.5.3 Durability and Maintenance

3.5.3.1 Long-term Maintenance

Units must perform well with minimal active controls in all climates and seasons. Deterioration of units in storage is a major problem. Units may be damaged at any stage and may require repair prior to deployment. There must be adequate room for both minor and major repairs.

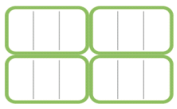
Storage		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location & Site Preparation	Storage sites	MEMA 2009b
	• **The unit should be able to be accessed and deployed quickly, regardless of short-term or long-term storage.**	
Safety & Hazards	Storage Site Security	
	• **Units should be secure in short-term or long-term storage.**	
	Long Term-Maintenance	
	• **Storage sites should accommodate the requirements of unit maintenance.**	

Table 4: Storage

3.6 Install

The installation process begins with site evaluations and ends with a THU that is ready for occupancy. Initially, feasibility of installation must be determined based on site characteristics such as soil bearing capacity and utility locations. Water, electric and sewer service will be operational before this phase is complete. Unit foundations and anchoring systems will also be installed and secure. Contractors will assemble, test and repair systems, appliances and accessories in the unit. Occupants will be able to access the unit using ramps or stairs in preparation for move-in.

3.6.1 Location

3.6.1.1 Site Evaluation

A thorough evaluation of each site is necessary to determine whether it is appropriate for THU installation, including an assessment of hazards and logistical requirements.

To facilitate the installation of MAHP units, MAHP representatives conducted initial site visits to determine site feasibility, that include the following factors:

- Level site or grading required
- Local zoning laws
- Existing utilities
- Soil bearing capacity (minimum 1200 psf) (MEMA 2009b)

Additional site considerations also include:

- Overall site size in relation to unit
- Adequate space for views, air and circulation/access
- Condition of driveway and other hardscape
- Extent of site debris and any other potential hazards
- Space to continue repair and rebuilding of damaged property
- Space for construction equipment and activity

3.6.1.2 Site Preparation

A number of preparatory tasks must be completed prior to foundation installation and anchoring, including leveling and grading, utility preparation, and clearing a path for THU delivery (MEMA 2009b).

The MAHP program found that sewer systems were more challenging than other utilities to install due to slope requirements (FEMA 2009a). In areas where sites did not have public utilities or septic systems already in place, MEMA installed septic systems before the unit was placed on the site (FEMA 2009a). The MAHP program also experienced some delays related to final electrical connections due to late occupant deposits and company scheduling (ABT Associates 2009c).

3.6.2 Safety and Hazards

3.6.2.1 Utility Protection

Storm hazards, including floodwaters and seismic events, are a threat to utility systems and pose danger to both occupants and the unit's longevity. Even if the unit survives a storm event with little to no structural damage, utility damage such as a broken gas line can cause a fire. Protection of utility systems may include waterproof risers downstream of projected flow and anchored or elevated fuel tanks (FEMA 2009b).

3.6.2.2 Site Built Components

Site built components must be safely secured to the unit without reducing the THU's structural capacity. At unit installation, any site built components attached to the unit must preserve the THU's structural integrity. It is recommended that attachments be freestanding.

The HUD Code addresses unit attachments through several requirements: the attachment must not impose additional loads unless they are approved by a licensed professional (architect or engineer) or are included as part of the manufacturer's design (HUD 2009b).

3.6.2.3 Foundations

Foundations placed on a property must withstand loads including gravity, snow, wind and seismic forces. Anchoring systems must likewise prevent the THU from overturning and lateral movement (HUD 2009b)(The Administration 1968). Foundations located in floodplains are especially vulnerable to storm hazards, and sites in certain zones may have minimum elevation requirements. Foundations should be temporary in nature, integrated into the unit, and adaptable to meet ground conditions.

3.6.2.4 Steps, Platforms and Ramps

Prior to occupancy, any steps, platforms or ramps that allow entry and exit from the THU will be installed. Attached components may be partially or wholly integrated into the unit design, although some site-built labor may still be necessary depending on the unit's elevation and specific site characteristics. Steps, platforms, and ramps should be freestanding.

3.6.3 Durability and Maintenance

3.6.3.1 Commissioning, Testing and Repairs

A contractor may perform a variety of tasks prior to occupancy, including installing accessories and testing appliances. At this stage, the unit is assessed for any damage done during the haul-install process and final repairs are made. Thorough procedures during this process will help eliminate later maintenance problems and ensure that the occupant is transitioning into a functional unit.

MEMA's Haul-Install Technical Requirements provide a detailed list of items that must be performed by the contractor before the unit is ready for occupancy (MEMA 2009b). Requirements include:

- Assembly and installation of accessories, such as cabinets and light fixtures.
- Activation of utility systems and minor repairs, including heating, cooling and electrical systems.
- Testing of appliances, including kitchen features, smoke detectors and exhaust fans.
- Final cleaning, including floors, kitchen and bathroom equipment (MEMA 2009b).

3.6.3.2 Warranty

A warranty by the contractors responsible for hauling and installation protects both the occupant and FEMA from problems related to transportation and unit preparation. For example, MEMA required a one-year warranty starting at occupancy from the contractor. Coverage included re-leveling and all electrical and plumbing connections (MEMA 2009b).

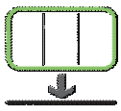
Install		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location	Site Evaluation	MEMA 2009b
	• Unit location should support and accommodate recovery efforts while safely housing occupants.	
	Site Preparation	MEMA 2009b
		ABT Associates 2009c
		FEMA 2009b
	• Water supply, electrical and sewer utility connections must be prepared prior to unit installation.	
Safety & Hazards	Utility Protection	FEMA 2009a
	• Utilities must be protected from weather hazards.	
	Site Built Components	HUD 2009b
	• Site built components cannot compromise the integrity of the unit or pose additional hazards.	
	Foundations	
	• Foundations must withstand loads and hazards to preserve the unit's structural integrity.	
	• Anchoring systems must be appropriate for site and soil conditions.	
	• Foundations should be adaptible to ground conditions.	
	• Foundation system should be temporary in nature.	
	Steps, Platforms and Ramps	HUD 2009b
	• Whether components are site built or integrated in the unit is a decision that will have serious implications throughout the lifecycle of the unit.	
Durability & Maintenance	Testing and Repairs	MEMA 2009b
	• Thorough commissioning, testing and repairs performed during the installation process reduce maintenance during occupancy.	
	Warranty	MEMA 2009b

Table 5: Install

3.7 Use

Once the unit is installed, it is transferred to occupants and the occupancy portion of the Dwell Cycle begins. While the THU is in use by occupants, the responsible party still has continued involvement in the management and maintenance of the unit. The responsible party also assists occupants on the road to recovery through case management and continued wrap-around services.

3.7.1 Size and Layout

3.7.1.1 8′-0″ Minimum Ceiling Height

A minimum of 8′-0″ ceiling heights are standard in residential construction. Lower ceilings will feel cramped to occupants, regardless of the size of the unit. The HUD Code requires a minimum ceiling height of 7′-0″ for at least half of the floor area, and 5′-0″ for the remaining area (HUD 2009a). MAHP units had 8′-0″ ceiling heights, and occupants appreciated ceiling heights taller than in the FEMA trailers (MEMA 2007) (ABT Associates 2009a).

3.7.2 Stability

3.7.2.1 Wrap-Around Services

As occupants transition into a THU, wrap-around services are initiated that guide the recovery process and provide access to critical services. Housing advisors will provide case management and assist occupants on their path towards recovery. Recovery services should be the primary reason for responsible parties to visit the unit. Reducing maintenance visits lessens a burden on occupants and allows them to focus exclusively on recovery.

In the MAHP program, housing advisors reached out to households once a month to make referrals for services, check in with occupants about their progress towards recovery, and evaluate any maintenance issues of the unit (ABT Associates 2009c). Some MAHP staff felt unable to help households with intensive needs that surpassed their training (ABT Associates 2009c).

3.7.3 Thermal Comfort and Efficiency

3.7.3.1 Energy Efficiency and Water Conservation

There is incentive for both FEMA and the future resident of the THU to reduce utility costs of a THU through energy efficient design, from appliances to heating and cooling systems. The cost impact over time of employing an efficient design can be tracked and measured in terms of utility data. Water conservation measures can likewise be measured during occupancy, and low-flow fixtures and aerators are widely available.

ENERGY STAR checklists, including the Thermal Bypass Checklist, provide criteria for the installation and verification of energy efficient construction methods. The MAHP Park Models used ENERGY STAR labeled heating, ventilation and air-conditioning systems (FEMA 2011). The US Green Building Council's LEED for Homes guidelines likewise provide water conservation parameters for fixtures and appliances (US GBC 2008).

3.7.3.2 Lighting

THU's must have windows to provide natural daylighting, views to the outdoors and egress in an emergency. The HUD Code provides several requirements for unit lighting, including an 8% glazing minimum in each habitable room and egress for each bedroom. Artificial light is allowed in place of windows in kitchens, bathrooms and laundry areas (HUD 2009b).

Artificial lighting is necessary to support daily activities, and fixtures should meet ENERGY STAR qualifications, which save 75% or more over traditional lighting (US EPA 2009). ENERGY STAR'S Advanced Lighting Package for new construction requires a minimum of 60% ENERGY STAR fixtures and 100% ENERGY STAR ceiling fans (US EPA 2009).

3.7.4 Safety and Hazards

3.7.4.1 Fire Prevention

Fire prevention must be integrated into a THU for occupant safety. In group sites, units may be in close proximity and at higher risk of flame spread. Interior finishes must be specified with appropriate flame spread ratings to protect occupants, in addition to smoke detectors as required by code. The HUD Code provides material requirements to limit flame spread in high-risk locations, including walls next to cooking ranges, kitchen cabinets, and walls containing equipment (HUD 2009b).

3.7.5 Maintenance and Durability

3.7.5.1 Finishes & Materials

The durability of finishes and materials is crucial to the long-term use of the unit. If finishes are easy to clean and maintain, there will be less refurbishment, replacement or disposal necessary by FEMA after a single use. Appropriate durability standards should specify resilient materials and connection details.

3.7.5.2 Fixtures, Accessories and Hardware

High quality and durable fixtures, accessories and hardware provide a lasting benefit for both occupants and the responsible party. Components must be able to withstand normal wear and tear in addition to transportation stresses and long-term storage.

3.7.6 Systems Monitoring

During the manufacturing process, sensors may be installed to monitor systems and gather data remotely. Systems monitoring prevents unaddressed maintenance concerns and helps the responsible party to prioritize work orders. Monitoring systems may collect data, from moisture levels to indoor air pollutants. Some monitoring was employed on select MAHP units. MAHP staff installed sensors in some units during the construction phase that measured moisture in the floors, walls and ceilings (ABT Associates 2009c).

Data gathering may reduce reliance on the occupant to provide information about the condition of the unit. Many occupants may not be aware of a problem before a sensor alerts FEMA to a potential problem. Unit monitoring may also reduce trips to the unit that are unrelated to case management or wrap around services.

Potential monitoring may include:

- Moisture, temperature and humidity
- GPS location tracking (i.e. deployment, possible theft)
- Level and plumb (i.e. structural problems, weather events)
- Appliance working status
- Indoor air quality, smoke and carbon monoxide
- Fuel levels
- Utility usage

Use		
		
Performance Consideration	**Performance Criteria**	**Reference**
Size	8'-0" minimum ceiling height	MEMA 2009a
		ABT Associates 2009c
Stability	Wrap Around Services	ABT Associates 2009c
		ABT Associates 2009c
	• Units must support the ability for occupants to access wrap-around services and communicate with case managers.	
Thermal Comfort & Efficiency	Energy Efficiency & Water Conservation	FEMA 2011
	• Units should meet appropriate performance criteria, for example the Energy Star program for energy efficiency and LEED for Homes for water conservation.	
	Lighting	HUD 2009b
	• Natural and artificial lighting should support daily activities.	
	• Artificial lighting should follow ENERGY STAR guidelines for efficiency.	
Safety and Hazards	Fire Prevention	
Durability & Maintenance	Finishes and Materials	
	Fixtures, Accessories and Hardware	
	Systems Monitoring	ABT Associates 2009a
	• Data monitoring by a responsible party identifies unit problems remotely, reduces the need for maintenance related site visits, and reduces the burden of maintenace on the occupant.	

Table 6: Use

3.8 Transition In

By the time occupants transition into their unit, the THU has been installed, assigned, and is ready for occupancy. At this point, the unit is transferred to the occupant. The responsible party will provide the occupant with direction on how to use and maintain the unit's features, appliances and equipment. During this phase, occupants will be able to securely enter the unit, move in their belongings and organize their living space.

3.8.1 Storage

3.8.1.1 Overall Storage Capacity

At move-in, occupants may arrive with a range of items that require safe, dry and secure storage. Some occupants may only have small personal items, while others will bring larger items salvaged from a disaster site.

In the past, the storage capacity of both FEMA trailers and MAHP units was insufficient; despite additional attic storage in MAHP units, nearly half of respondents felt there wasn't enough storage in their unit (ABT Associates 2009a).

3.8.2 Safety

3.8.2.1 Integrated Locking System

As they transition in, occupants must have a method of securely entering and exiting their THU. Over its life cycle, each THU may pass through many hands, including multiple occupants and responsible parties that require secure access. While the HUD Code requires only a key-operated lock and deadbolt for each exterior door, other solutions may simplify the management of unit access (HUD 2009b). Locking systems used for institutions, such as magnetic cards and numeric codes, can be reset multiple times and integrated into the responsible party's management system.

3.8.3 Stability

3.8.3.1 Living Kit

Occupants may move into their THU without access to basic necessities or furniture. The living kit provided by the responsible party gives occupants the ability to clean the unit, cook and rest immediately after move-in. Basic furnishings give occupants the ability to resume their daily activities quickly and to resume their focus on recovery.

Prior FEMA and AHPP units came equipped with basic necessities. FEMA required that MEMA units be furnished with at least a sofa, dining table, chairs, bed frames and mattresses, as well as a "living kit" that contained linens, dishes, silverware and cleaning supplies (ABT Associates 2009c). Bayou La Batre AHPP units likewise came equipped with basic furniture and a "living kit" of furniture and linens (ABT Associates 2009b)

3.8.4 Maintenance

3.8.5 Occupant Education and Training

Unit orientation is a time to comprehensively train occupants how to use and maintain their unit, including all its systems, features and appliances. At this time, occupants must be made aware of their maintenance responsibilities while living in the unit. After Hurricane Katrina, FEMA and the AHPP programs varied in their approach towards occupant responsibility for minor maintenance, even for minute repairs such as changing a light bulb (ABT Associates 2009c).

The Bayou La Batre AHPP program had an extensive orientation that included: move-in briefings to explain the lease and covenants; walk-through to review operation and maintenance (ABT Associates 2009b); inventory of appliances, furniture and living kit, and an explanation of the household's obligations and responsibilities (ABT Associates 2009b).

3.8.5.1 Signs and Graphic Communication

Permanent signs and graphics in each THU could communicate operation and maintenance instructions throughout the unit, preventing confusion for those unfamiliar with unit features. Occupants with young children, limited English proficiency, or other special needs could especially benefit from graphic instructions.

Transition In		
		
Performance Consideration	**Performance Criteria**	**Reference**
Storage	Overall Storage Capacity	ABT Associates 30 2009
	• **Units must have adequate storage space for occupant belongings.**	
Safety	Integrated Locking System	HUD 2009a
	• **Integrated locking systems simplify unit access for multiple deployments, storage, and general maintenance.**	
Stability	Living Kit	ABT Associates 2009a
		ABT Associates 2009a
	• **Basic necessities including furniture and a "living kit" must be provided to occupants.**	
Maintenance	Occupant Education and Training	ABT Associates 2009b
		ABT Associates 2009b
	• **Occupants must receive a comprehensive orientation to the THU, including a walk-through and training for operations and maintenance.**	
	• **Maintenance duties must be made explicit to occupants.**	
	Signs and Graphic Communication	ABT Associates 2009c
		ABT Associates 2009c
	• **Unit signage should communicate basic operations and maintenance.**	

Table 7: Transition In

3.9 Work

The Occupancy phase begins after occupants have settled into their THU. The Occupancy phase consists of four components to daily life: Work, Eat & Gather, Bathe and Sleep. Occupants engage in a variety of work activities within their THU, from children's homework, to job applications, household finances, and housing and recovery paperwork. Occupants must clean the unit, report problems, and perform minor maintenance, per the responsible party's management strategy.

3.9.1 Layout

3.9.1.1 Transition Area

Some occupants will likely be engaged in the repair and rebuilding of their damaged property. A transition area for occupants coming in from outdoor work prevents dirt from entering the unit. Options include a mud room, an entry mat, or a dedicated place for shoe removal and storage. In addition, a covered exterior area should be provided (Krimgold 2010).

3.9.2 Stability

3.9.2.1 Washer and Dryer

A washer and dryer is a highly valued amenity in a THU. In addition to routine household laundry, some occupants require additional capacity as they repair damaged property. In Bayou La Batre, AHPP occupants were doing loads of laundry almost immediately after moving in (ABT Associates 2009b).

3.9.2.2 Space for Work

A dedicated location for paperwork and homework within the unit assists occupants in completing their daily responsibilities and moving towards recovery and self-reliance. This may include an adequate counter surface with phone and internet connections.

3.9.2.3 Communication

Occupants must remain connected to the outside world and receive updates in news, weather, and personal communications. Occupants should be able to receive mail from the Postal Service as well as access the internet from their THU. Direct and integrated access to FEMA and/or other responsible parties can also facilitate wrap-around services, recovery support and unit maintenance.

3.9.3 Maintenance

3.9.3.1 Reporting Maintenance Problems

The ability to swiftly report maintenance to FEMA is important for the long-term durability of the unit. Occupant responsibility for maintenance and reporting varies according to the management strategy.

Work		
		
Performance Category	**Performance Criteria**	**Reference**
Layout	Transistion Area	Krimgold 2010
	• **Unit should accommodate occupants who are actively working on repairing and rebuilding property through providing an easily maintained transition space.**	
Stability	Washer and Dryer	ABT Associates 2009a
	Space for Work	ABT Associates 2009c
	Communication	
	• **The unit should faciliate occupants' connection to the outside world including news, weather, and connection to family and friends.**	
	• **The unit should facilitate a direct connection with recovery support services including case management, wrap-around services and unit maintenance**.	
Maintenance	Reporting Maintenance	ABT Associates 2009c

Table 8: Work

3.10 Eat and Gather

Much of the occupant's social life occurs in the eating and gathering area. The space must accommodate food preparation, eating, and hosting guests. Eating and gathering is a large part of reestablishing daily routines and maintaining connections to friends and family during the recovery process. An appropriate food preparation area, appliances and storage all assists occupants in regularly preparing meals.

3.10.1 Storage

3.10.1.1 Kitchen and Living Storage

The living area and kitchen in a THU require the storage of personal belongings, toys, cookware, dishes, groceries, and pantry items.

3.10.2 Stability

3.10.2.1 Accommodate Guests

The viability of entertaining visitors depends on the size and layout of the eating and gathering space. Increased living space and full-size kitchens provided in AHPP units were appreciated by occupants as they reestablished their daily routine (ABT Associates 2009c). MAHP respondents appreciated being able to engage in activities such as hosting a family occasion or a bridge club meeting (ABT Associates 2009c). Bayou La Batre occupants also noted they were able to entertain guests and host grandchildren (ABT Associates 2009b).

3.10.2.2 Full-Size Kitchen Appliances

Full-size appliances allow occupants to prepare meals regularly for their household and for special events with visitors. In the MAHP units, full-size appliances led more than 90% of respondents to identify their kitchen appliances as attractive features of their unit (ABT Associates 2009a). One MAHP respondent explained, "It has an actual, full size stove. A turkey fits in the oven!" (ABT Associates 2009c). In addition to their small overall size, most travel trailer kitchens were only equipped with compact models of stoves, ovens and refrigerators, which made food preparation more challenging (ABT Associates 2009a).

3.10.2.3 Counter Space

Occupants require adequate counter space in order to prepare meals effectively.

3.10.2.4 Play Area for Children

A hazard free play area for children should be established in the eating and gathering area (Krimgold 2010).

3.10.3 Access

3.10.3.1 Circulation

Occupants and visitors with mobility impairments must be able to navigate the eating and gathering space as well as use the cooking area. UFAS requirements provide guidelines for accessible living spaces. For instance, UFAS requirements note a 40" minimum clearance between all opposing cabinets, appliances or walls, and 60" minimum clearance in U-shaped kitchens (The Administration 1968). In addition, the UFAS requires stable, firm, and slip resistance floor surfaces (The Administration 1968). Changes and level should be no greater than 1:2 (The Administration 1968).

3.10.3.2 Counter Height

Wheelchair riders need lower or adjustable counter space to use the kitchen effectively. Per UFAS requirements, at least a single 30" section of counter must be a maximum height of 34" with knee clearance below.

3.10.3.3 Accessible Appliances

Certain appliance features make it easier for mobility-impaired occupants to cook meals:

- Self-cleaning, side-opening ovens with front controls and a shelf under the door to rest heavy items
- Range with front controls and insulated if there is knee space below
- Vertical side-by-side or over-under refrigerator with accessible freezer space.
- Refrigerator door should swing back 180 degrees for wheelchair users (The Administration 1968).

Eat and Gather		
		
Performance Category	**Performance Criteria**	**Reference**
Storage	Kitchen and Living Storage	
	• **Unit should provide adequate kitchen and living area storage.**	
Stability	Accommodate Guests	ABT Associates 2009a
		ABT Associates 2009b
		ABT Associates 2009a
	• **Living area should accommodate large households and visitors.**	
	Full-size Kitchen Appliances	ABT Associates 2009a
		ABT Associates 2009c
	• **Unit kitchens should include full-size kitchen appliances for ease of food preparation.**	
	Counter Space	
	• **Unit kitchens should provide adequate counter space for daily food preparation.**	
	Play Area for Children	Krimgold 2010
Access	Circulation	The Administration 1968
		The Administration 1968
		The Administration 1968
		HUD 2009b
	• **Units should provide adequate circulation space per UFAS requirements for disabled occupants or visitors.**	
	Counter Height	The Administration 1968
	• **Accessible or adaptable units should include UFAS compliant 34" counter heights**.	
	Accessible Appliances	The Administration 1968
	• **Appliances should be easy to use for disabled occupants.**	

Table 9: Eat and Gather

3.11 Bathe

As occupants return to a daily routine, they need a private space for bathing and personal hygiene. Surfaces must be moisture resistant with adequate ventilation to prevent indoor air quality problems. Easy-to-clean surfaces and adequate storage for personal items and supplies keep the bathroom more orderly and free of clutter. Appliances and fixtures should be durable, well maintained, and water conserving. Bathroom requirements are especially important for disabled occupants who may need features such as roll-in showers, grab bars, knee clearances, and easy to use levers.

3.11.1 Size

3.11.1.1 Bathroom Size

Bathrooms must be an adequate size for basic functionality. AHPP models varied in bathroom size, from 40 square feet in the MAHP Park Model, to 61 SF in the MAHP Cottages, and up to 120 SF in Bayou La Batre two-bedroom units (ABT Associates 2009b). Bathrooms in the MAHP units were highly valued: 95.8% of MAHP respondents cited bathroom facilities as an attractive feature of their unit (ABT associates 2009c).

3.11.2 Storage

3.11.2.1 Storage for Personal Items

Storage for personal items such as a medicine cabinet, or shelf and cabinet to assist in reducing clutter in shared bathrooms. Larger bathrooms may include additional shelving or a linen closet. Accessories such as storage hooks and towel holders provide additional storage and reduce moisture issues. UFAS MAHP cottages included a 2'-0" wide storage cabinet above the toilet with an open shelf below (MEMA 2007b).

3.11.3 Access

3.11.3.1 Circulation

The bathroom is an important amenity for both occupants and visitors. Sufficient circulation space is critical for the bathroom to be usable by disabled friends and family. UFAS requirements note a 5'-0" diameter or T-shaped turnaround for wheelchairs. Clear spaces around toilets, sinks and showers also ensure adequate circulation (The Administration 1968).

3.11.3.2 Appliances, Fixtures and Accessories

Accessible bathroom plumbing fixtures include toilets with 17"to 19" seat heights and sinks with easy to use levers and knee clearance below. Roll-in showers with an integrated seat, grab bars, easy-to-reach controls and hand-held showerheads make bathing easier for disabled or elderly occupants. Placement and operation of accessories such as toilet paper

dispensers, mirrors and medicine cabinets also impact the usability of a bathroom (The Administration 1968).

3.11.4 Indoor Air Quality

3.11.4.1 Moisture Resistant Materials

Moisture resistant materials are critical in the bathroom, where mold and moisture induced air quality problems can impact both human health and the durability of the THU. The ENERGY STAR Water Management Checklist prohibits carpet within 2.5 ' of toilets, tubs, and showers (US EPA 2009). The checklist also specifies moisture-resistant backing material behind tub and shower enclosures, and prohibits paper-faced backerboard (US EPA 2009). The ENERGY STAR airPLUS checklist also specifies moisture-resistant materials (US EPA 2009).

3.11.4.2 Exhaust Venting

Proper exhaust venting prevents mold and moisture issues and reduces odors. The HUD Code requires mechanical ventilation to the outside for each bathroom (50 cfm). In some cases, operable glazed areas can substitute mechanical ventilation (HUD 2009b). The ENERGY STAR Indoor airPLUS Checklist likewise specifies exhaust venting in bathrooms to the outdoors (USA EPA 2009).

Bathe		
		
Performance Consideration	**Performance Criteria**	**Reference**
Size	Bathroom Size	ABT Associates 2009c
	• **Bathrooms should provide enough space for circulation and personal hygiene.**	
Storage	Storage for Personal Items	MEMA 2007a
	• **Bathrooms should include storage for personal hygiene items and supplies.**	
Access	Circulation	The Administration 1968
	• **Accessible circulation space should follow UFAS guidelines.**	
	Appliances and Fixtures	The Administration 1968
	• **Accessible appliances, fixtures and accessories should follow UFAS guidelines.**	
Indoor Air Quality	Moisture-Resistant Materials	US EPA 2009
		US EPA 2009
	• **Mold and moisture should be avoided through moisture resistant materials and adequate ventilation.**	

Table 10: Bathe

3.12 Sleep

A good night's sleep is improved by privacy, acoustic separation, and appropriate furnishings. Occupants must have an area to both store their clothes and get dressed. Furniture may be fixed or freestanding, with varied flexibility for the occupant to arrange their sleeping area. Guests may be accommodated through the provision of additional sleeping spaces.

3.12.1 Layout

3.12.1.1 Sleeping Area

Occupants need a private and quiet area to sleep. The HUD code requires bedrooms with a minimum of 50 square feet for one occupant or 70 square feet for two occupants (HUD 2009b). When it comes to large households, units can become very large based on sleeping occupancy requirements. Flexible sleeping areas, as an alternate to traditional bedrooms, may reduce the overall size of the unit while using space efficiently.

3.12.2 Storage

3.12.2.1 Closet storage

Occupants require a place to store clothing and personal belongings near their sleeping area. Closets are required per the HUD Code, but there may be additional locations available for storage. The HUD Code requires that each bedroom have a 22" deep closet (HUD 2009b). In Bayou La Batre AHPP units, additional bedroom storage was provided through drawers beneath closets and built-in bed platforms (ABT Associates 2009b). Alternatively, more space-efficient applications exist for clothing storage.

3.12.3 Stability

3.12.3.1 Accommodate Visitors

Extra sleeping spaces can accommodate visitors such as grandchildren spending the night. Full-sized sofa beds in the MAHP units were helpful in cases where occupants or visitors were sleeping in the living room area (ABT Associates 2009a).

3.12.4 Participation

3.12.4.1 Bedroom Furniture

Freestanding furniture empowers occupants to rearrange their space, while fixed furniture can reduce costs and increase storage options. As an example, Bayou La Batre AHPP units had built-in furniture in the master bedroom, including bedside tables and a platform bed; replacing freestanding furniture with built-ins which reduced overall furniture costs for the units (ABT Associates 2009b). Both options can be provided for units to maximize cost efficiency while still providing some level of occupant freedom.

3.12.5 Energy Efficiency and Thermal Comfort

3.12.5.1 Privacy

A functional sleeping area must be private and block unwanted sound and light. FEMA trailers had very little privacy, while MAHP units had HUD Code compliant, private bedrooms. MAHP units included private bedrooms instead of sleeping alcoves with curtains, which was a significant improvement for occupants (ABT Associates 2009b). Over 90% of MAHP respondents felt that increased privacy was an attractive feature of their unit (ABT Associates 2009b).

Sleep		
		
Performance Consideration	**Performance Criteria**	**Reference**
Layout	Sleeping Area	HUD 2009b
	• **Sleeping areas must be private, quiet and secure.**	
	• **Sleeping areas should include a space for occupants to get dressed.**	
	• **Efficient sleeping areas may not fulfill the minimum requirements of a bedroom per HUD code.**	
Storage	Closet Storage	ABT Associates 2009b
		HUD 2009b
	• **Provide closet storage for each sleeping area.**	
Stability	Accommodate Visitors	ABT Associates 2009a
	• **Extra sleeping areas accommodate overnight visitors.**	
Participation	Bedroom Furniture	ABT Associates 2009b
	• **Freestanding and built-in bedroom furniture provide various levels of flexibility and storage.**	
Comfort	Privacy	ABT Associates 2009b
	• **Sleeping areas should block sound and light.**	

Table 11: Sleep

3.13 Transition Out

At the Transition Out Phase, occupants move out of their THU and the unit returns to the responsible party for evaluation and retrieval. Occupants will clear the unit of their personal belongings, leaving behind components that came with the THU, including the living kit and freestanding or built-in furniture. A checkout process may entail a move-out checklist, key collection, and feedback mechanism.

3.13.1 Stability

3.13.1.1 Checkout

The checkout procedure establishes the end of the occupant's time in the THU as it is returned to the responsible party. The occupant may need to complete move-out tasks such as removing all of their belongings and returning keys (or other access equipment). The unit itself may facilitate a way of collecting feedback from occupants before they depart from the unit.

Transistion Out		
		
Performance Consideration	**Performance Criteria**	**Reference**
Stability	Checkout	
	• **Procedure should be outlined for occupant move-out, including a walk-through and collection of keys (or method of entry).**	
	• **Feedback mechanism should be in place for occupants who are moving out of the unit.**	

Table 12: Transition Out

3.14 Retrieve

After occupants have moved out of their unit, the responsible party must retrieve the THU and transport it to its next destination. There are several outcomes for a THU at this point, including decommissioning and reuse. Certain units may be slated for a specific outcome from the outset, depending on performance specifications. Alternately, units may be assessed for their partial or total reusability at the retrieval stage.

3.14.1 Location and Site Preparation

3.14.1.1 Site Cleanup

After a unit is removed from the site, the area must be cleaned up and cleared of any debris or construction elements. Foundation removal may require additional site work during this phase.

3.14.2 Maintenance and Durability

3.14.2.1 On-site Assessment

A comprehensive assessment of the unit should be completed to catalogue its condition. Depending on whether the THU will be decommissioned, it can be inventoried for reusable construction materials, appliances, furniture and accessories.

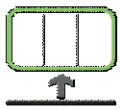
Retrieve		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location	Site Cleanup	
	• **Site should be cleared of debris or construction elements.**	
Maintenance & Durability	On-Site Assessment	
	• **Unit assessment will determine whether unit will be repaired and renewed or decommissioned.**	

Table 13: Retrieve

3.15 Renew

Reusable THU units extend the benefits of a high-quality unit for multiple occupants. A highly durable, well-maintained unit that can withstand transportation and storage stresses may offset high initial costs. The useful life of a THU can vary widely and must be specified in terms of expected usage, from several months to several years.

Some units may be able to go back into the field during another disaster. This was attempted on a small scale through several AHPP programs: In March 2010, when Mississippi tornado survivors required housing assistance, MEMA was able to relocate unoccupied units within 25 days (FEMA 2011). The Alabama AHPP program constructed 10 of their 100 units to be re-deployable. These units were built in single-sections that could be removed and relocated if necessary (ABT Associates 2009b).

Certain components may need to be replaced after each use, even if a unit is reused. For instance, all soft-goods couches, mattresses and other furniture may only be used for a single deployment. There are other items that may or may not require replacement depending on their condition, including built-in components and appliances.

3.16 Permanent Component

Although permanent housing is not part of FEMA's mandate, some units in the AHPP program were designed to transition into permanent housing (FEMA 2011). The question of permanent units is fraught with higher costs and a limited ability to fulfill a large and urgent need following a disaster (FEMA 2011). On the other hand, permanent units are not decommissioned and prevent the waste and costs associated with short-term use.

In converting a unit from temporary to permanent, there may be site work that must be completed prior to the transfer of ownership. There may also be costs associated with unit modifications. The MAHP program experienced unanticipated installation costs, as many owners were unable to cover this expense (FEMA 2011). MAHP lacked income information as well as permanent housing expertise (ABT Associates 2009c). The cost of converting units to permanent housing averaged at $15,000 per unit (FEMA 2011).

Occupants may vary in their desire to stay permanently in a THU. Their interest must be gauged by the responsible party if a permanent component is to be offered. MEMA utilized a "permanent housing survey" to see which occupants would prefer to own their units. Occupants who met requirements were able to purchase the units for a price depending on their income (FEMA 2011).

3.17 Decommission

Some units may be produced with the intention that they will be decommissioned after one use. Some units may have been damaged beyond repair, and others may have already been reused multiple times and cannot withstand another deployment. If decommissioned, the units must be disposed of in a manner that yields the least amount of waste possible. Even if a unit is decommissioned, there may be reusable components that can be dismantled and salvaged for use in other THU's.

3.18 Summary

The performance criteria introduced in this chapter have been developed using both the framework of the Life Cycle Diagram and the performance considerations discussed in the Chapter 2. The performance considerations provide a context for the unit's role in the recovery process; the health and safety of occupants; and the functionality of a temporary disaster housing program. A contextual understanding of the THU is critical for making informed decisions that support both occupant recovery and programmatic goals. The Life Cycle Diagram provides a framework to review each specific phase in detail, as well as to examine relationships between cycles.

The performance criteria highlighted in this chapter provide a basis for the development of performance specifications for a purpose-built THU. The performance criteria, compiled in Appendix B, illustrate the complex processes that occur before and

after a THU is in use, from pre-manufacturing through decommissioning or renewal. Performance criteria impact a unit long before occupancy, from the prevention of initial manufacturing problems to protecting the unit's structural integrity through the cumulative effects of transport. By occupancy, the unit will have passed through several challenging phases of its lifecycle. Performance specifications must ensure that the unit is in good condition at this point to successfully facilitate occupant recovery. After occupancy, the THU must continue in its lifecycle with maximum usefulness and minimum waste, as it is retrieved and either renewed or decommissioned.

It is critical that during the pre-manufacturing process, unit specifications are developed according to a THU's specific and long-term needs. Program decisions by responsible parties that include unit configuration; size and occupancy requirements; and manufacturing capacity and innovation impact the THU for the duration of its lifecycle and have serious implications for both unit quality and occupant recovery. Many of these initial decisions are necessary for performance specifications to be developed. The performance criteria presented here provide a tool for developing comprehensive specifications that simultaneously deal with overall program issues, occupant recovery, and unit specific requirements for the duration of the lifecycle.

4. CONCLUSION

The report's three conclusions are summarized below. Each conclusion is explained and next steps are proposed.

1. In order to design a useful, effective and reusable THU, a unit's entire cycle must be considered and used to inform the THU design as part of the disaster housing system.

2. Performance specifications for THU's should be developed and used for a purpose-driven design because the unique requirements of temporary disaster housing cannot be met with standard manufactured housing or traditional RVs.

3. Using the Manufactured Home Construction and Safety Standards (HUD Code) limits innovation and is a barrier to designing functional and cost-effective units for two reasons: first, the size requirements result in a unit that is too large; and second, the HUD Code's established role within the manufactured housing industry puts other potential manufactures at a disadvantage and leads to a dependency upon an industry that normally produces low-cost housing that is not durable enough for reuse.

4.1 Life Cycle View of Temporary Disaster Housing

The Life Cycle Diagram of a THU presents a complete view of the stages of a THU before, during and after its use and aligns with the occupants' dwelling use. When considering the lifespan for any manufactured product, it is useful to consider the complete costs and benefits of the product. A typical lifespan for a product includes its material; manufacturing and delivery costs; suitability and longevity for use; repair and maintenance costs; and eventual disposal cost. The Life Cycle Diagram can be used to increase the lifespan of a product by considering how it can be reused as a product or recycled as components or materials. Sustainability leads to a Life Cycle view of products with the goal of minimizing waste throughout the life of the product.

Waste is a product of poor design and can be minimized with a well-informed process. Poor design can lead to waste in several ways. A product might be disposed of because it fails to meet functional needs and is eventually replaced by a better product. A product might break or wear out, which can be especially unsatisfactory if a relatively small product failure leads to the disposal of a majority of good material. A product might be removed from service before necessary because someone decided to stop using the product or upgrade to a better model. Each of these reasons for waste applies to THU's. A balance, however, must be reached between the need for durable housing with a maximized lifespan and the *temporary* aspect of a THU. The ultimate goal with any housing mission is for the THU occupant to return to permanent housing as soon as possible. There are few manufactured products for which the aim for its period of use is to be as short as possible. Therefore, waste for a THU is most often the third type of waste – someone decides to stop

using the unit, and the obvious place to reduce waste is to extend its life is by using it for more than one disaster.

When determining the feasibility of reusing THU's, the administrative costs throughout the entire program should be taken into consideration. The Life Cycle of a THU starts before its production, and pre-production considerations significantly affect the overall handling costs of the unit. The research to date outlines the phases of an expanded life cycle; however, the costs of each phase have not been fully explored.

The next step to developing well-informed performance specifications is to be given access from FEMA to program expenses associated with the pre-manufacture phase in order to devise a cost-driven formula that will factor transportation, refurbishing and storage costs into the overall Life Cycle costs of the THU. The added level of durability necessary to enable the units to be reused will require an additional cost that can be factored into an equation to determine how manufacture and handling costs can work together for the most cost-efficient and sustainable Life Cycle.

Next Step: Obtain and review cost information from FEMA to develop a cost-factor for a more complete Life Cycle analysis.

4.2 Purpose-Driven Design

There are three inherent conditions that set THU's apart from RVs and typical permanent housing. First, the units are produced, managed and maintained under the direction of FEMA. Second, the occupants are in an unexpected and demanding situation in which they have lost their homes and are working to get out of temporary housing and back into permanent housing. Third, the units are transported multiple times and are installed on a variety of sites with workers that have a wide range of building skills. These three conditions combine to point to several reasons that the unique requirements of THU's cannot be met with manufactured housing or RV products that are produced for other uses.

One reason is size; both in terms of the size of the unit in relation to the size of the property and of the space requirements for the interior of the unit. Previous research has found that people are more successful at disaster recovery when they are able to live on their property. A well-informed disaster housing program should have units that are small enough to fit in a driveway or in the front yard of a typical single family lot. Travel trailers work well in regards to the size requirement for the unit placement on the property. However, the rooms in a travel trailer are significantly smaller than the average room in a house. This is understandable because a travel trailer is designed for occasional use in which sleeping is the main program so the kitchen and bathroom of a travel trailer are too small for everyday use. The occupants of a THU are already in a stressful situation, which is increased if the THU makes daily activities such as preparing meals and bathing difficult. The size needs for a temporary housing unit are simple to state, but require good design to accomplish. The goals are for a THU to be as small as possible, to give the greatest application for the wide range of sites, but also to be as roomy as possible for day-to-day use.

Durability is another reason the unique requirements of temporary disaster housing cannot be met with existing manufactured housing or travel trailers. Durability is required at each phase of the THU lifecycle. The unit must withstand being transported several times and is often installed on a less-than-ideal site. If it is not durable it will suffer damage during such handling. Once installed, the unit is subject to the day-to-day use of a family, often with children, during which time the THU is not being maintained per manufacturer standards. Normally, houses are maintained by the homeowner, the people the homeowner employs, the property owner for rental housing or the people that the property owner employs. In each case maintenance is localized and the arrangements are within reasonable control by the occupant. THU's are not maintained by the occupant. The THU is maintained by people working under multiple contracts and ultimately under the direction of the federal government. The administrative cost of maintenance is high and highlights the need for a durable unit that will minimize maintenance. After its use the unit should be durable enough to be relocated, refurbished and stored for the next disaster. Common building materials are too susceptible to the effects of moisture to be stored in an unconditioned state; however, Life Cycle durability could be specified in the performance requirements. Such a high level of durability does not currently exist in the manufactured housing market.

Community acceptance is another reason a purpose-driven design is recommended. The most negative perception associated with the use of travel trailers and manufactured housing as THU's is that people in need are being put in a low-quality product. Other than some of the Alternative Housing Programs that are discussed above, the federal government does not claim authorship of THU designs. The fact that THU's are low-cost products reinforces a stigma and continues to communicate the incorrect message that FEMA has a low regard for the people that need assistance after a disaster. Our consumer society is well attuned to the fact that the initial impression of a manufactured product instantly communicates the value and quality of a product. THU's are perceived by the users and by the general public as an indication of FEMA's values. A purpose-driven design has the potential to match FEMA's values with the products of their programs. FEMA's work is driven by a deep commitment for the well-being of the public. It would be beneficial for FEMA's temporary housing program to develop strategies that help communicate these values so they are not lost amongst the negative perception that the public has developed of low-cost manufactured housing.

Next Step: Continue to work with FEMA to produce performance specifications for purpose-driven temporary disaster housing.

4.3 Temporary Housing Units and the HUD Code

The Manufactured Home Construction and Safety Standards (HUD Code) is the regulatory document for the construction of homes built in the controlled environment of a manufacturing plant and are transported in one or more sections on a permanent chassis. These units are sold in the permanent housing marketplace.

At the time of this report publication, FEMA required all THU's used in direct housing missions following a disaster to be HUD Coded units. Only following catastrophic events does FEMA consider requests from states to use smaller units such as travel trailers. While this is not a complete ban of non-HUD Coded units, it does have similar consequence. This analysis can serve as a basis for understanding some of the current challenges facing the successful direct housing efforts from procurement through disposition and reuse.

There are multiple issues with using the HUD Code to select THU's for use after a disaster. The issues are as follows: size, use, maintenance, durability, environmental quality, industry capacity and diversity. Each of these issues are explored below.

4.3.1 Size

The HUD Code sets out specific size minimums for living space and bedrooms:

- 50 sq.ft. for 1 person bedroom plus closet storage
- 70 sq.ft. for 2 person bedroom plus closet storage
    - +50 sq.ft. for each additional person
- 150 sq.ft. for living area

The average size of a manufactured home in the market place is 830Sq.Ft. and the minimum allowable HUD Coded unit is 320 sq.ft. for a 1-bedroom. The travel trailers used in the 2005 hurricane season averaged 256 sq.ft., though larger units were provided when needed. This requirement has a huge effect on the ability to site THU's on private property, allowing a survivor to be closest to their property, workplace and community to help aid recovery.

FEMA is aware of the restrictions that the HUD Code places on THU's. "The units we reviewed are significantly more expensive than FEMA's traditional temporary units and will sharply increase the cost of post-disaster housing programs. In addition, most of the units tested are too large to replace travel trailers and park models as a compact post-disaster solution for many urban homeowners' sites" (DHS 2011). While FEMA has acknowledged the problem, steps have not yet been outlined to develop a viable solution.

4.3.2 Use, Maintenance and Durability

Manufactured homes obtained either directly "off-the-lot" or through a direct FEMA contract are built to a government regulated permanent housing standards. The assumption of private ownership of these units is an important factor in both the unit's design and construction. The manufactured home marketplace is often perceived as being near the bottom of the housing ownership ladder. To stay competitive in the homeowner marketplace the manufactured housing industry strives for extreme efficiency in resource, construction and material to develop a competitive product. For example, units are attached to a chassis; however they are not easily moved from place to place and often suffer damage from transport due to the nature of their construction and the constant

vibration of over road transit (ORT). This example of the disconnect between the quality of the product and its intended use highlights the fundamental differences in the needs and long-term uses of a THU and a traditional manufactured home. It will be important to include FEMA, its contractors, and any others partners that should be considered "users" of a THU in addition to disaster survivors, to help pinpoint those differences and help to outline a potential solution. The maintenance and durability question must first be thought of as a total Life Cycle from initial transport, storage, staging, use, relocation, repair, reuse and ultimate disposition. The higher the quality of construction, materials, and equipment, the less likely there will be costly maintenance needs during the unit's lifespan. There is potential to develop and incorporate technology that will allow the units to communicate with FEMA maintenance contractors so that major maintenance issues can be remotely monitored and prioritized.

4.3.3 Environmental Quality

Though FEMA has provided a much more stringent formaldehyde requirement for any of its THU's than those specified in the HUD Code, this does not address the myriad of other Indoor Air Quality (IAQ) issues found in THU's in recent missions. Moisture problems constitute a large segment of all building maintenance issues and are the root cause of a number of IAQ problems. HUD coded units are not free of these issues. The units' thin wall construction is often vulnerable to thermal performance problems which lead to moisture problems. Because this is a current issue, the building materials marketplace is moving towards a neutral IAQ. There is also a wealth of knowledge within the green building community that can help forward the development of better IAQ standards for THU construction.

4.3.4 Industry Capacity and Diversity

The Mississippi Alternative Housing Pilot Program (MAHPP) illustrates the challenges of promoting competition and innovation in THU system design. The program also highlights how certain project goals can limit an otherwise qualified, yet non-traditional manufacturer list.

MAHPP planned to double code the Mississippi Cottages, meaning the units would be both HUD Code and International Residential Code (IRC) compliant. The program was a clear attempt to make a temporary-to-permanent strategy possible for THU's and created an uncommon situation where a manufacturing site would have to master both the HUD code and IRC code. The manufacturers had to scramble to develop proper practices, and more importantly obtain the required HUD and IRC certifications. The choice to double code units created many unforeseen challenges and increased costs in time, money and resources. The most important lesson learned was that due to the restrictions created by having to double code units, the pool of possible manufactures was restricted to a very small lot, thus limiting competition and innovation in exchange for a post-service disposition goal.

While it is important to have building standards for THU's, HUD Code requirements do not allow for much diversity within the potential manufacturing pool. The unique use and

need for a THU should strive to attract a more varied pool of design-build manufactures that includes teams from different industries. Taking advantage of a wider range of design expertise and material selection would help FEMA produce a more purpose-built product that would likely perform better in both short- and long-term use scenarios than a HUD Coded, off-the-lot unit.

Next Step: Outline the unnecessary restrictions the HUD Code places on THU's and evaluate the possibility of removing the requirement for THU's to be HUD Coded in order to promote further innovation.

4.4 Summary

The research of FEMA's Temporary Disaster Housing programs and needs shows the limitations of utilizing available travel trailers and manufactured housing products. Such commercially available housing units do not meet the demands of a cost efficient and sustainable THU program because they are not durable enough for reuse. Following the HUD Code has addressed some of the problems with function and health issues, but reliance upon the HUD Code and the way it is administered within the manufactured housing industry will likely inhibit much needed innovation.

The primary recommendation of the research is for FEMA to follow a purpose-driven design approach to THU. Such an approach would start with detailed performance requirements that are produced in coordination with contracting procedure. A well-developed set of performance requirements would enable FEMA to design a Temporary Disaster Housing program that would be more cost-efficient, less wasteful, and do a better job of demonstrating FEMA's commitment to serve the community.

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APPENDIX A. ANNOTATED REFERENCE

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Federal Standards and Guidelines

Uniform Federal Accessibility Standards

Congress of USA
August 12, 1968

24 CFR 3280-3800: Manufactured Home Construction and Safety Standards...

HUD
June 15, 1976 (Revised April 2006 & April 2009)

Protecting Building Utilities from Flood Damage

FEMA
November, 1999

24 CFR 3280-904 Specific Requirments for Designing the Transportation System

HUD
June 15, 1976 (Revised April 2006 & April 2009)

Foundation Standards and Guidelines

Protecting Manufactured Homes from Floods and Other Hazards

FEMA
November, 2009
(Revised from 1985)

Recommended Performance Based Criteria for the Manufactured Home Foundations Systems to Resist Wind and Seismic loads

National Institute of Standards and Technology
August, 1995

Guide to Foundation & Support Systems for Manufactured Homes

Systems Building Research Alliance
2002

Research and Analysis for Manufactured Housing Foundations: Ground AnchorVerification Testing

Steven Winter Assoc.
June 2008

Disaster Housing

Draft Environmental Assessment: Bayou Estates Emergency Temporary Housing Site

FEMA
November 8, 2005

FEMA Disaster Housing and Hurricane Katrina: Overview, Analysis, & Congressional Issues

Congressional Research Service
August 8, 2008

National Disaster Housing Strategy
FEMA
January 16, 2009

National Disaster Housing Strategy Implementation Plan

FEMA
March, 2010

Furture Directions of FEMA's Temporary Housing Assistance Program
FEMA
2011

Alternative Housing Pilot Program (AHPP)
Policy and Case Studies

Final Approval Agreement Articles: Alternative Housing Pilot Program

Congress of USA
June 21, 2007

Evaluation of FEMA's AHPP [selection process within]

Richard Skinner: *Inspector General of DHS*
April 20, 2007

Implementation of FEMA's AHPP Provides Lessons for Improving Future Competitions

Government Accountability Office
August 31, 2007

Developing a More Viable Disaster Housing Unit: A Case Study of the Mississippi AHPP

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Topic Key

- Congress
- Independent Research
- Dept. of Homeland Security
- FEMA
- HUD
- MEMA
- Modular Home Industry

$ Funding Source

- Specifications
- Tests/Observations
- Policy/Authoritative Guide
- Recommendations

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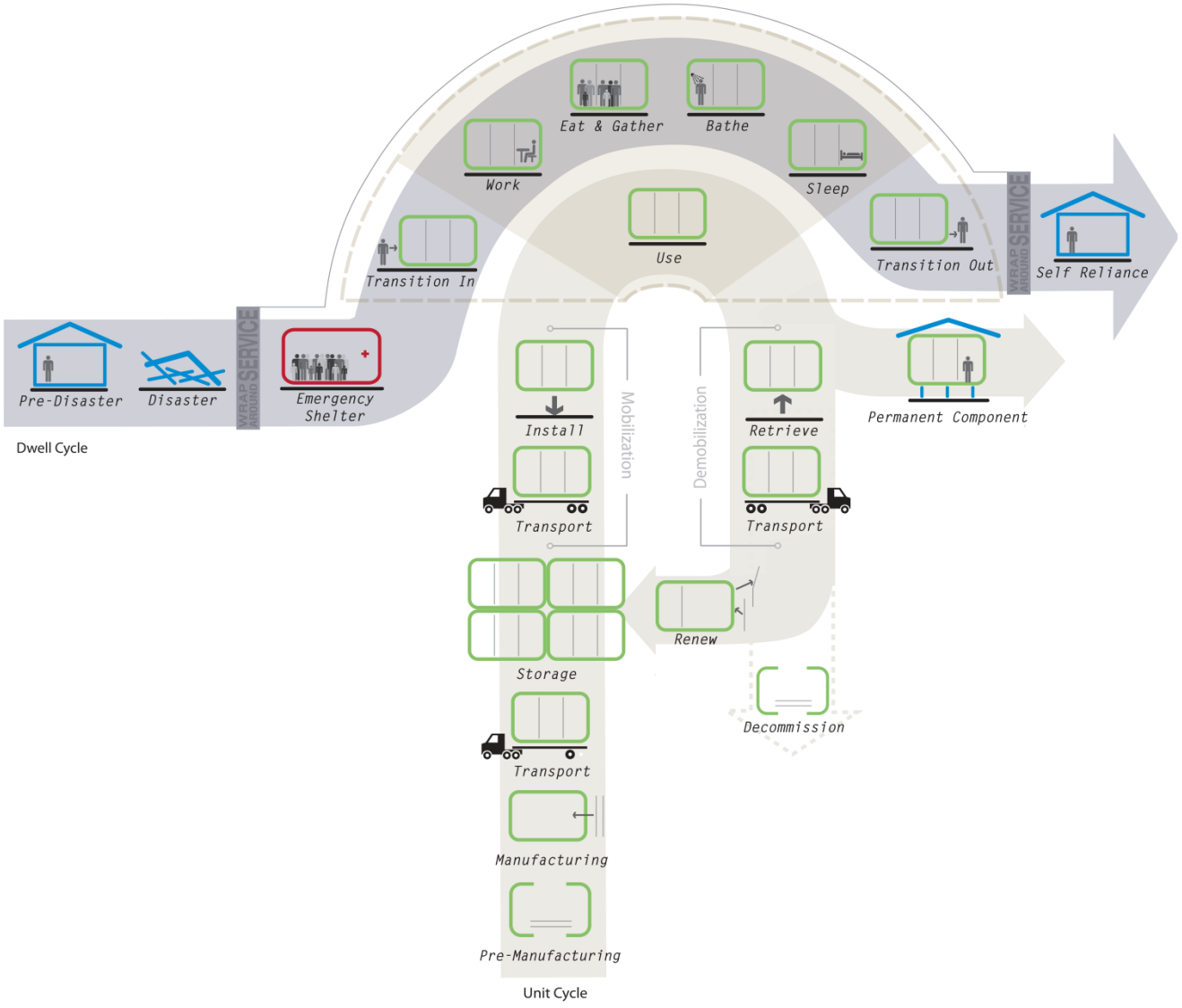
Susan Brita-Chair
2012

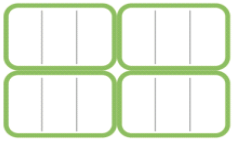
APPENDIX B. PERFORMANCE CRITERIA WORKSHEETS

APPENDIX B. PERFORMANCE CRITERIA WORKSHEETS

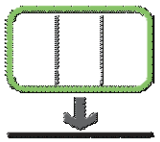


Transport I		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location & Site Preparation	Transport Regulations	ABT Associates 2009a
		FEMA 2011
	• **The unit should comply with regulations that allow it to travel through the contiguous 48 states.**	
Safety & Hazards	Cumulative Transportation Impacts	HUD 2009b
		ABT Associates 2009c
	• **The unit should withstand the impacts of multiple transports.**	
	• **The unit should have an integrated transportation system.**	
Maintenance & Durability	Secure Interior Components	ABT Associates 2009b
	• **The construction assembly should be appropriate for withstanding dynamic forces.**	
	• **Interior components should be secured prior to transportation.**	
	Manueverability	
	• **The unit should have multiple, integrated points for manueverability.**	

NOTES :

Storage		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location & Site Preparation	Storage sites	MEMA 2009b
	• **The unit should be able to be accessed and deployed quickly, regardless of short or long term storage.**	
Safety & Hazards	Storage Site Security	
	• **Units should be secure in short or long term storage.**	
	Long Term Maintenance	
	• **Storage sites should accommodate the requirements of unit maintenance.**	

NOTES :

Install		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location	Site Evaluation	MEMA 2.2.3 2009b
	• Unit location should support and accommodate recovery efforts while safely housing occupants.	
	Site Preparation	MEMA 2009b
		ABT Associates 2009c
		FEMA 2009a
	• Water supply, electrical and sewer utility connections must be prepared prior to unit installation.	
Safety & Hazards	Utility protection	FEMA 2009a
	• Utilities must be protected from weather hazards.	
	Site Built Components	HUD 2009b
	• Site built components cannot compromise the integrity of the unit or pose additional hazards.	
	Foundations	
	• Foundations must withstand loads and hazards to preserve the unit's structural integrity.	
	• Anchoring systems must be appropriate for site and soil conditions.	
	• Foundations should be adaptable to ground conditions.	
	• Foundation systems should be temporary in nature.	
	Steps, Platforms and Ramps	HUD 2009b
	• Whether components are site built or integrated in the unit is a decision that will have serious implications throughout the lifecycle of the unit.	
Durability & Maintenance	Testing and Repairs	MEMA 2009b
	• Thorough commissioning, testing and repairs performed during the installation process reduce maintenance during occupancy.	
	Warranty	MEMA 2009b

NOTES :

Use		
		
Performance Consideration	**Performance Criteria**	**Reference**
Size	8'-0" minimum ceiling height	MEMA 2009a
		ABT Associates 2009c
Stability	Wrap Around Services	ABT Associates 2009c
		ABT Associates 2009c
	• Units must support the ability for occupants to access wrap-around services and communicate with case managers.	
Thermal Comfort & Efficiency	Energy Efficiency & Water Conservation	FEMA 2011
	• Units should meet appropriate performance criteria, for example the Energy Star program for energy efficiency and LEED for Homes for water conservation.	
	Lighting	HUD 2009b
	• Natural and artificial lighting should support daily activities.	
	• Artificial lighting should follow ENERGY STAR guidelines for efficiency.	
Safety and Hazards	Fire Prevention	
Durability & Maintenance	Finishes and Materials	
	Fixtures, Accessories and Hardware	
	Systems Monitoring	ABT Associates 2009a
	• Data monitoring by a responsible party identifies unit problems remotely, reduces the need for maintenance related site visits, and reduces the burden of maintenace on the	

NOTES :

Transition In		
		
Performance Consideration	**Performance Criteria**	**Reference**
Storage	Overall Storage Capacity	ABT Associates 30 2009
	• **Units must have adequate storage space for occupant belongings.**	
Safety	Integrated Locking System	HUD 2009a
	• **Integrated locking systems simplify unit access for multiple deployments, storage, and general maintenance.**	
Stability	Living Kit	ABT Associates 2009a
		ABT Associates 2009a
	• **Basic necessities including furniture and a "living kit" must be provided to occupants.**	
Maintenance	Occupant Education and Training	ABT Associates 2009b
		ABT Associates 2009b
	• **Occupants must receive a comprehensive orientation to the THU, including a walk-through and training for operations and maintenance.**	
	• **Maintenance duties must be made explicit to occupants.**	
	Signs and Graphic Communication	ABT Associates 2009c
		ABT Associates 2009c
	• **Unit signage should communicate basic operations and maintenance.**	

NOTES :

Work		
		
Performance Category	**Performance Criteria**	**Reference**
Layout	Transistion Area	Krimgold 2010
	• **Unit should accommodate occupants who are actively working on repairing and rebuilding property through providing an easily maintained transition space.**	
Stability	Washer and Dryer	ABT Associates 2009a
	Space for Work	ABT Associates 2009c
	Communication	
	• **The unit should faciliate occupants' connection to the outside world including news, weather, and connection to family and friends.**	
	• **The unit should facilitate a direct connection with recovery support services including case management, wrap-around services and unit maintenance**.	
Maintenance	Reporting Maintenance	ABT Associates 2009c

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Eat and Gather		
		
Performance Category	**Performance Criteria**	**Reference**
Storage	Kitchen and Living Storage	
	• **Unit should provide adequate kitchen and living area storage.**	
Stability	Accommodate Guests	ABT Associates 2009a
		ABT Associates 2009b
		ABT Associates 2009a
	• **Living area should accommodate large households and visitors.**	
	Full-size Kitchen Appliances	ABT Associates 2009a
		ABT Associates 2009c
	• **Unit kitchens should include full-size kitchen appliances for ease of food preparation.**	
	Counter Space	
	• **Unit kitchens should provide adequate counter space for daily food preparation.**	
	Play Area for Children	Krimgold 2010
Access	Circulation	The Administration 1968
		The Administration 1968
		The Administration 1968
		HUD 2009b
	• **Units should provide adequate circulation space per UFAS requirements for disabled occupants or visitors.**	
	Counter Height	The Administration 1968
	• **Accessible or adaptable units should include UFAS compliant 34" counter heights**.	
	Accessible Appliances	The Administration 1968
	• **Appliances should be easy to use for disabled occupants.**	

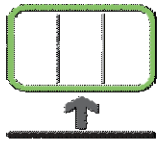
NOTES :

Bathe		
		
Performance Consideration	**Performance Criteria**	**Reference**
Size	Bathroom Size	ABT Associates 2009c
	• **Bathrooms should provide enough space for circulation and personal hygiene.**	
Storage	Storage for Personal Items	MEMA 2007a
	• **Bathrooms should include storage for personal hygiene items and supplies.**	
Access	Circulation	The Administration 1968
	• **Accessible circulation space should follow UFAS guidelines.**	
	Appliances and Fixtures	The Administration 1968
	• **Accessible appliances, fixtures and accessories should follow UFAS guidelines.**	
Indoor Air Quality	Moisture Resistant Materials	US EPA 2009
		US EPA 2009
	• **Mold and moisture should be avoided through moisture resistant materials and adequate ventilation.**	

NOTES :

Sleep		
		
Performance Consideration	**Performance Criteria**	**Reference**
Layout	Sleeping Area	HUD 2009b
	• **Sleeping areas must be private, quiet and secure.**	
	• **Sleeping areas should include a space for occupants to get dressed.**	
	• **Efficient sleeping areas may not fulfill the minimum requirements of a bedroom per HUD code.**	
Storage	Closet Storage	ABT Associates 2009b
		HUD 2009b
	• **Provide closet storage for each sleeping area.**	
Stability	Accommodate Visitors	ABT Associates 2009a
	• **Extra sleeping areas accommodate overnight visitors.**	
Participation	Bedroom Furniture	ABT Associates 2009b
	• **Freestanding and built-in bedroom furniture provide various levels of flexibility and storage.**	
Comfort	Privacy	ABT Associates 2009b
	• **Sleeping areas should block sound and light.**	

NOTES :

Transition Out		
		
Performance Consideration	**Performance Criteria**	**Reference**
Stability	**Checkout**	
	• **Procedure should be outlined for occupant move-out, including a walk-through and collection of keys (or method of entry).**	
	• **Feedback mechanism should be in place for occupants who are moving out of the**	
Retrieve		
		
Performance Consideration	**Performance Criteria**	**Reference**
Location	Site Cleanup	
	• **Site should be cleared of debris or construction elements.**	
Maintenance & Durability	On-Site Assessment	
	• **Unit assessment will determine whether unit will be repaired and renewed or decommissioned.**	

NOTES :

APPENDIX C. FEMA REGION IV CAPABILITY GAP 2012-RCD-004

APPENDIX C. FEMA REGION IV CAPABILITY GAP 2012-RCD-004

Table 6-1: [Recovery] R&D Capability Gap/Mission Needs Statement

Question	Response
Capability Gap Statement Tracking Number	2010-RCD-004
2010 Priority Number	1
Is this submission a Modeling, Simulation, and Analysis (MS&A) Mission Need?	No
Proposed Title of Requirement	**2010-RCD-004: Temporary Disaster Housing: Developing a temporary housing unit design and prototype**
Goal/Objective/Driver to which Requirement Responds	The specific objective is to design a temporary housing unit that is tailored to the unique requirements of disaster response and recovery in order to provide safe, fast, and cost-effective disaster housing to individuals displaced by a natural or manmade disaster so that they can recover from the event and seek permanent housing. This unit can be entirely new in design and/or based on existing commercially available products, but will address specifically and by design the unique challenges of disaster housing.
Theme	Response and Recovery Tools, Human and Social Issues
Sector Risk or Threat Identification	This need statement emphasizes the importance of providing safe, fast, and cost-effective disaster housing to individual and household survivors in order to ensure continuity of services by allowing workforce members to sustain and rebuild their impacted communities.
Gaps of Existing Capabilities	Providing disaster housing has been a continual challenge because traditional temporary housing units consist of either modified recreational vehicles or manufactured homes, neither of which was designed specifically for the unique challenges of disaster response and recovery. The Federal government has never had the in-house architectural and engineering services or capabilities to design the ideal disaster housing solution, relying instead on open market research that has yet to yield the perfect answer. Recent costly and time-consuming traditional housing unit performance related problems have highlighted the Federal government's need to: • efficiently and effectively respond to future design and performance problems by more rigorously ensuring that proposed housing design specifications and purchased units' construction meet the unique requirements of disaster housing by bringing HUD, FEMA HQ, FEMA Regions, and additional stakeholders together with industry experts • streamline the disaster housing lifecycle by:

	○ providing a scalable product to meet varying disaster requirements (from small rural disaster to catastrophic urban disaster) ○ standardizing inventory for improved logistics, procurement, storage, and maintenance ○ allowing lessons learned to be implemented, and best practices to be consolidated, without changing to an entirely new product and unit design each disaster cycle • improving equity of unit placement and distribution among applicants Housing design and performance problems may be due to, in part, the fact that the Federal government's current approach to disaster housing operations relies on using only enhanced specifications and privately-developed vendor designs, both of which are based on industry standards for commercial housing. These products do not adequately address all disaster housing needs. As a result, even though manufacturers tailor their commercial products to FEMA specifications, these units purchased do not comprehensively address the unique, rigorous requirements of disaster housing.
Description of Required Operational Capability	The desired outcomes include: • Developing one or several disaster housing prototype designs that can: ○ Be produced by multiple manufacturers on a larger and more cost-effective scale. ○ Be appropriately configured for the size and composition of each household. • Reducing reliance on industry standards and housing type constraints. The outcome is not limited to a completely new design, and suggestions for adapting commercially available technologies will be equally weighted. The outcome is not intended to create a new market, but to ensure that temporary housing options fully provide for the needs of disaster survivors while expanding manufacturing capacity and stimulating innovation.
Identification of the End User	Natural and manmade disaster survivors
Identification of Existing Related Capabilities or Technology	Presently, no existing capabilities or technologies exist. FEMA's Housing Branch and the Joint Housing Solutions Group, along with the Policy and Planning Division of the US Department of Housing and Urban Development, have conducted extensive research on potential solutions, but without the in-house engineering and architectural services have never been able to develop their own technology. These groups will be integral in assisting a satisfactory design and prototype.
Identification of Possible	Architectural design services combined with federal, regional, and local emergency management and building science expert collaboration
Approaches/Solutions	aimed at developing, for the first time, a temporary housing unit prototype to meet the specific needs of a disaster response.

APPENDIX D. STATEMENT OF WORK

Statement of Work

The Company hereby tasks the Seller to conduct research to design a temporary housing unit (THU) that is tailored to the unique requirements of disaster response and recovery in order to provide safe, fast, and cost-effective disaster housing to individuals displaced by a natural or manmade disaster so that they can recover from the event and seek permanent housing. This unit can be entirely new in design and/or based on existing commercially available products, but will address specifically and by design the unique challenges of disaster housing.

Task 1: Align Prototype Designs with Well-Understood Customer Requirements

The Seller shall ensure the products of this research and design effort are aligned with well-understood customer requirements. To this end, the Seller shall collaborate with FEMA Region IV, other stakeholders and prospect end-users in assessing, articulating and pinpointing their capability gaps and requirements. The Seller shall use the information in the document Overview: FEMA Region IV Capability Gaps (12 August 2010) as a starting point for this research but shall examine other resources to ensure meaningful design products are developed.

Task 2: Develop Prototype Designs

The Seller shall conduct research to develop prototype designs for temporary disaster housing …using 2010-RCD-004 … as initial design requirements. The Seller shall develop prototype designs through an iterative process and through consultation with FEMA Region IV and other potential stakeholders.

Task 2.1: Develop Prototype Designs for Temporary Disaster Housing (2010-RCD-004)

The Seller shall consider Task 2.1 to be the primary effort. The Seller shall conduct research to design a temporary housing unit that provides safe, fast, and cost-effective disaster housing to individuals displaced by a natural or manmade disaster so that they can recover from the event and seek permanent housing. The prototype design should aid in streamlining the disaster housing lifecycle by:

i) Providing a scalable product to meet varying disaster requirements;

ii) Standardizing inventory for improved logistics, procurement, storage, and maintenance;

iii) Allowing refinements to be easily integrated without requiring an entirely new product each disaster cycle.

Task 3: Confirm/Validate Prototype Design Products

The Seller shall confirm/validate the design products of this research effort with FEMA Region IV and other potential stakeholders. The Seller shall verify that the products of this research effort are useful design products for temporary disaster housing.

Task 4: Document Research Products

The Seller shall develop a final report describing the design products of this research. The Seller shall seek opportunities to ensure the knowledge gained, the models and data resources developed, and the science-based solutions are integrated into homeland security operations for appropriate end-users and stakeholders at the federal, state, and/or local levels.

Key Deliverable – Final Report

The Seller shall develop and submit a final report describing key activities, findings and results. The report shall define the features and capabilities of the prototype solution; the results of operational tests; feedback from prospect end-users; new knowledge and insights gained that will improve homeland security operations; and other pertinent discoveries and recommendations.

APPENDIX E. MEMA HAUL-INSTALL TECHNICAL REQUIREMENTS

APPENDIX E. MEMA HAUL-INSTALL TECHNICAL REQUIREMENTS

3.9 Ready for Occupancy (RFO). The Contractor's responsibilities include the following work items:

3.9.1 Assemble and install accessories and arrange for use:

1. All furniture for occupancy;
2. Clean and mount storm window panels;
3. Install drawers;
4. Remove window clips; travel blocking and protective taping;
5. Hang fire extinguisher (report low charge to MEMA inspector);
6. Mount exterior light fixtures, and install bulbs;
7. Install interior light globes and covers;
8. Install screens;
9. Re-install any mini-blinds;
10. Install cabinet door panels and other knockout panels;
11. Install commode tank lid;
12. Repair, if necessary, any cabinet/door/drawer hardware;
13. Repair any damage to the Modular Home caused during the installation process.

3.9.2 Activate Utility Systems and Make Minor Repairs (all replacement parts shall equal or exceed the manufacturer's factory installed parts) including:

1. Test water system and make minor repairs (i.e., tighten, adjust, or replace fittings, flare nuts, faucet washers, ball cocks, shower diverters, faucet sets, etc.);
2. Verify hot/cold water lines, reverse if required;
3. Tighten or replace loose drain line connections (traps, strainer assemblies, etc.);
4. Replace commode wax ring and tank gaskets, as needed;
5. Tighten loose connections in electrical system;
6. Test electrical circuits and replace bulbs, breakers, switches, or receptacles, as needed; and
7. Test heater and air conditioner Modular Home for proper operation and thermostatic control.

3.9.3 Test Appliances and Appurtenances including:

1. Activate, test and make any necessary minor repairs to the refrigerator, range, furnace, air conditioner, and water heater for proper operations;
2. Test smoke detector and replace if faulty. Defective smoke detectors shall be provided by the manufacturer upon receipt of damaged one; and
3. Test exhaust fans for proper operation and repair as needed.

3.9.4 Final Clean-Up and Readiness including but not limited to:

1. Clean floors, counters, kitchen equipment, bath fixtures and window as needed;
2. Perform any other minor work required to prepare the Modular Home for occupancy (i.e., door adjustments, refasten moldings and panels, etc.);
3. Remove Modular Home packing debris and excess set-up material from premises and dispose of it off site in accordance to local and state laws; and report major discrepancies or missing items to the MEMA inspector; and
4. Repair any damage to the Modular Home caused by the Contractor during the haul and install process

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