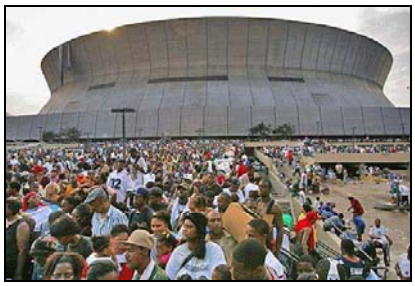

National Study on Carless and Special Needs Evacuation Planning: A Literature Review

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Funded by the Federal Transit Administration

Produced by the University of New Orleans Transportation Center
October 2008

Acknowledgements

The authors would like to thank the Federal Transit Administration for making this study possible. We particularly want to acknowledge Monica McCallum, David Schneider and all others that have worked on this specific grant. We are grateful to the other members of our research team for their input, including Jacky Grimshaw, Pam Jenkins, Shirley Laska, and Brian Wolshon. Graduate assistants Clare Cahalan, Carrie Makarewicz, Robert Peterson, Jason Sappington and Patrick Wontor provided valuable research and assistance with early drafts of this literature review. We would also like to thank Carol Short, Paulette Simon and Robert Peterson for editing this document.

Disclaimer

This report has been prepared under a Federal Transit Administration grant # LA-26-8001, however, the content of this report, including any errors or omissions are solely the responsibility of the authors.

Foreword

The objective of this study is to research how state departments of transportation (state DOTs), metropolitan planning organizations (MPOs), transit agencies, and local governments are considering, in the context of their emergency preparedness planning, the unique needs of minority, low-income, elderly, disabled, and limited English proficient (LEP) persons, especially for households without vehicles (referred to as "carless" in this report).

The evacuations of New Orleans and Houston in fall 2005 due to hurricanes Katrina and Rita were two of the largest evacuations in U.S. history. One of the main shortcomings was the lack of planning to evacuate carless residents, particularly minority, low-income, elderly, disabled, and LEP persons. In a report to Congress, the U.S. Department of Transportation and U.S. Department of Homeland Security revealed that

> [m]ethods for communicating evacuation options by modes other than personal vehicles are not well developed in most cases. A number of jurisdictions indicate locations where public transportation may be obtained, but many have no specific services identified to assist persons in getting to those designated locations. This situation is a particular problem for people with various disabilities (U.S. Department of Transportation in cooperation with the U.S. Department of Homeland Security 2006, p. ES - 5)

New Orleans is not unique. In fact, according to the 2000 U.S. Census, seven cities had carless populations higher than the 27 percent in New Orleans, including New York (56 percent), Washington, D.C. (37 percent), Baltimore (36 percent), Philadelphia (36 percent), Boston (35 percent), Chicago (29 percent), and San Francisco (29 percent). Nationally, approximately ten percent of the population is disabled and many of these individuals cannot drive, even if a car exists within their household. As the population ages, more and more people will become mobility-restricted. Even the elderly who have cars may be reluctant to drive them during a mandated long-distance evacuation. These groups face disproportionate risk and suffered loss of life in the flood of New Orleans. For example, 71% of those who died in Katrina in New Orleans were over the age of 60, and 47% over the age of 75 (AARP 2006a and 2006b).

Perhaps, more alarming than the scope of emergency transport for low-mobility populations is the persistence of the problem. The extra risks that carless households face during an evacuation are well-recognized and have been documented in numerous reports and papers (Bourne, 2004; Fischett 2001). Despite this attention, relatively little has been done to improve the situation and only recently has a concerted effort been made to address this problem. Although some plans call for the use of local resources for the movement of indigent and elderly populations during times of emergency, the strategies remain questionable. Based on the current level of preparedness, it is quite likely that the tragedies seen in New Orleans during and after Hurricane Katrina are bound to be repeated unless best practices can be understood and adopted widely (Jenkins, Laska and Williamson 2007).

This study provides guidance to ensure that future evacuations efficiently and effectively accommodate disadvantaged populations, including people who for any reasons lack access to private automobile transportation. We believe that it can prevent suffering and ensure that all Americans maintain security and dignity during dangerous and difficult times.

Note: This Literature Review was written over the period of 2007 – 2008. Just as the report was about to be released, Hurricanes Gustav and Ike made landfall on the Gulf Coast and Tropical Storm Hanna impacted the East Coast. New Orleans and Jefferson Parish, Louisiana implemented a successful carless evacuation, known locally as the City Assisted Evacuation Plan. This review does not include the 2008 storms, but will hopefully lay groundwork for more scholarship in the area of evacuating vulnerable populations.

Preface

The evacuation of New Orleans during Hurricane Katrina was both a great success and a miserable failure. Years of planning and coordination amongst transportation planners, emergency managers, and police led to an effective contraflow system that enabled anyone with a car the ability to evacuate. Unfortunately, the carless were literally left behind. Our recent experience with Hurricanes Gustav and Ike demonstrated more successes and failures for the evacuation of carless and vulnerable populations; however, this report was not able to include a summary of those evacuations.

In the days following Hurricane Katrina, the world watched in disbelief as all systems indiscriminately failed to respond, affecting young, elderly, poor, and disabled alike. However, seniors living independently were disproportionately victims of the flood. As I evacuated, I recall feeling guilty and somewhat responsible that my profession, transportation planning, failed to deliver an effective plan for a disaster that everyone knew would happen. It became part of my mission to ensure that we do not repeat past mistakes, not only in New Orleans but also across the country.

In the days following Katrina, I launched the *Transportation Equity and Evacuation Planning Program* at the University of New Orleans Transportation Center. The charge of this program is to provide research and outreach to improve evacuation planning and practice for all members of society. I organized the National Conference on Disaster Planning for the Carless Society in February 2007 at the University of New Orleans. This brought together about 200 government officials, professionals, and experts to discuss how we can better prepare for those most in need. Much valuable information was shared.

This literature review is the first product of a four-year national study of carless evacuation planning, sponsored by a grant from the Federal Transit Administration. My goal, with both the conference and research, is to bridge the transportation, emergency management, and health care professions as well as establish a dialogue between local, parish/county, state, and federal government.

In the research I have conducted since Katrina, I have come to learn that New Orleans is not so unique when it comes to its carless population or disaster vulnerability. Cities like New York and Washington, D.C. have no option but to learn from our lessons. And as our population ages, the risks are even greater. This was reflected in AARP's decision to serve as the main sponsor of our conference.

I am grateful to the FTA for also providing the opportunity for this study to move our country in a better direction so we don't repeat the mistake of Katrina. While we cannot control when a disaster is going to occur, we have the power to be prepared.

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October 2008

Executive Summary

For this review we scanned several sources including state DOTs, MPOs, transit agencies, and local government emergency preparedness planning for information on the evacuation of carless residents, including minority, low-income, elderly, disabled and residents with limited mobility and health problems. The review includes scholarly, professional, and government sources, highlighting best practices, and identifying areas of weakness within the field of emergency preparedness with respect to the target population of this study. This review discusses different needs for different types of natural and human-induced disasters.[1] It also discusses the role for an integrated, multi-modal approach for evacuation planning so all levels of government can assist with evacuating people in the most efficient manner possible. This literature review serves to characterize the current state of thinking and practice on the subject of carless and special needs evacuation planning.

Our review of the literature starts by examining how disasters are defined in the context of evacuation planning. There has been some related research conducted on the topic of carless evacuations over the past few decades, which provides some useful background. We examine the role of government, the private sector and non-profits (Chapter 3), multimodal evacuation planning (Chapter 4), city and metropolitan evacuation planning (Chapter 5), and conclude with policy recommendations (Chapter 6). Overall, the literature related to carless evacuation planning is multidisciplinary and wide-ranging. To date there has been no exhaustive review of existing research such as that presented here. The process of synthesizing the literature is important for finding gaps in the contemporary understanding of these issues, especially given more recent disaster and evacuation events.

There are many challenges transportation planners, emergency managers and non-profits must face when designing a successful evacuation strategy. Identifying carless populations and being able to gauge their level of transportation mobility may be the greatest obstacle to a successful

[1] The Federal Transit Administration makes a distinction between naturally occurring incidents or accidents ("safety") and acts by humans ("security").

evacuation plan. The literature suggests that a coordinated effort between government agencies and non-profits can create an environment of information sharing that will allow transportation planners to accurately account for carless populations. Additionally, demographic characteristics as well as census data can support the identification process if specific, individual data is not available. Governments can also use registries to catalogue special needs individuals but evidence has shown that few carless individuals are effectively utilizing registry systems.

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Chapter 1:

The Need for Coordinated Carless Evacuation Planning in the United States

The evacuation of New Orleans for Hurricane Katrina was one of the most significant evacuations in U.S. history, with an estimated 1 million people leaving the city over the two days of the exodus (Wolshon 2008; Wolshon and McArdle 2008).[2] This success was based on years of planning to create an effective contraflow highway evacuation system that was part of an overall regional traffic plan. Officials at all levels of government and across state boundaries participated in planning, testing, practicing, coordinating, and educating the public. Unfortunately, much of this hard work went unnoticed because the national attention focused on the significant failures in the evacuation effort, particularly the failure to adequately serve disadvantaged people who were unable to leave the city because they lacked a private automobile. This included the disabled, young, elderly, poor, and many tourists. This situation resulted not from a lack of resources, since hundreds of public transit and school buses sat unused, and were eventually ruined by flooding. Better carless and special mobility needs evacuation planning could have saved lives, equipment, and money and would have resulted in fewer emergency rescues after the storm.

The goal of this report is not to focus solely on New Orleans, as the Crescent City is not unique when it comes to disaster vulnerability or carless and populations with special mobility needs. The goal is to better understand the state of carless and special needs evacuation planning in the United States. This study defines the "carless" broadly and includes anyone, for any reason, that does not have access to an automobile or to use it for purposes of evacuation (no money for gas/lodging, fearful of operating it under stress, etc.). This includes the young, elderly, disabled,

[2] The only available data are for vehicle counts on major routes that were monitored during the evacuation. Vehicles leaving the region totaled about 480,000 over the evacuation period, which was Saturday morning, August 27, 2005 to Sunday evening, August 26, 2005. Obviously, some took routes that were not monitored, some vehicles that were counted may have not been evacuating, and some evacuated after Sunday evening but before the landfall of the storm early Monday. Therefore it is impossible to know precisely how many total "vehicles" (or people) really evacuated. However, even with all this uncertainty, experts have measured typical occupancy rates during an evacuation of 2.2 to 2.5 persons per vehicle, so that is the basis for approximately 1 million people evacuating.

poor, and anyone else that does not drive. In New York City, the carless society represents the majority of the population, as 56 percent of households reported in the 2000 Census as not owning a vehicle. Washington, D.C., Baltimore, Philadelphia, Boston, Chicago, San Francisco, New Orleans, Miami, and Cleveland all had more than 25 percent of households without access to an automobile in 2000, and even people who own an automobile may need to rely on other modes due to mechanical failure, medical problems, limited road space or other constraints. For these reasons, it is important that every community incorporate carless evacuation components in their emergency response plans.

This report reflects one basic principle: that emergency response plans should be evaluated based on the quality of service provided to the most vulnerable and disadvantaged populations. This is a significant shift from conventional transportation planning, which tends to focus on the needs of the majority and often gives relatively little consideration to the needs of disadvantaged populations. Serving disadvantaged populations requires extra effort, since there tends to be limited information about their transport needs and activities, and there are numerous barriers to communicating with and serving these people. This report is a first stop in providing guidance to practitioners on how to overcome these barriers in order to provide truly effective emergency response planning.

This report looks at the relatively new subfield of carless evacuation planning. Chapter 1 provides an outline of this report, discusses issues, challenges facing this new subfield, and highlights major literature on the topic. Chapter 2 examines the classification of disasters. Chapter 3 looks at the role of government and non-profits in carless evacuation planning. Chapter 4 analyzes a multimodal approach to evacuation planning and Chapter 5 discusses city and metropolitan evacuation planning. Finally, Chapter 6 presents policy recommendations for improving carless evacuation planning.

The New Subfield of Carless Evacuation Planning

Emergency management stems from a military background. In recent years, especially since September 11, 2001, transportation engineers and planners have been increasingly involved in evacuation planning and modeling. It was not until the early 2000s that the Transportation

Research Board of the National Academies established a subcommittee on Emergency Evacuation Planning.

> …disaster planning had its roots in civil defense programs developed before and during the Second World War, and during the Cold War (Dynes 1994). These plans totally disregard civilian and non-military needs (such as public transportation). The plans are based upon the notion that a rigid hierarchical command system is needed to handle disasters, as the military functions in war scenarios. … [A]s late as the 1990s it was necessary to have such programming in place for disaster funding to be released. Only in recent years has planning been shifted to civil protection, stressing non-military accidents and their response (albeit still cast in a military mindset) (Levinson and Granot 2002, p. 11).

A *National Review of Hurricane Evacuation Plans and Policies* (Wolshon, Urbina and Levitan 2001) briefly discussed low-mobility groups and the use of public transit but provided virtually no information on the topic. They pointed out that in most cities, public transit would only provide a fraction of the capacity to transport all of the low-mobility evacuees. Pre-Katrina, Wolshon (2002) writes in an article titled "Planning for the Evacuation of New Orleans,"

> Of the 1.4 million inhabitants in the high-threat areas, it is assumed only approximately 60 percent of the population or about 850,000 people will want, or be able, to leave the city. The reasons for this are numerous. Although the primary reasons are a lack of access to transportation (it is assumed that 200,000 to 300,000 people do not have access to reliable personal transportation), an unwillingness to leave homes and property (estimated to be at least 100,000 people) and a lack of outbound roadway capacity (p. 45).

Fortunately, Wolshon's projections were overly conservative and many more people evacuated New Orleans during Katrina than the models predicted. Litman (2006) criticizes public officials who knew prior to Katrina that many residents did not have access to cars, but failed to utilize public modes (such as buses and trains) to move people out of New Orleans. He suggests

planning for evacuations using a multi-modal approach, to take full advantage of rail and bus systems. Zelinsky and Kosinski (1991) present a cross-national historical and geographical study in *The Emergency Evacuation of Cities.* They report the mode of transport used by evacuees in 27 different disasters. Table 1 depicts the importance of **all modes** of transport during previous evacuations.

Table 1: Mode of Transport Used by Evacuees

X: No data; 0: None; 1: Used by Some; 2: Used by Many; 3: Used by Most; 4: Used by Nearly All							
Event	**By Foot**	**Animal-Drawn Vehicle**	**Ship or Boat**	**Rail**	**Private Auto or Bicycle**	**Bus or Other Public Transport**	**Air**
Anchorage	0	0	X	0	2	X	3
El Asnam	2	X	0	X	1	1	0
Belize	X	X	1	0	2	2	1
Bhopal I	2	2	0	1	1	1	0
Bhopal II	2	2	0	2	1	2	1
Chernobyl (Kiev)[1]	0	1	0	2	1	3	1
Darwin	0	0	0	0	2	X	3
France I	0	0	0	3	1	1	0
France II	2	2	0	2	2	2	0
Germany I	0	0	0	3	0	1	0
Germany II	1	0	0	3	1	2	0
Gulf Coast Hurricanes	1	X	0	1	3	1	X
Japan	1	X	0	2	2	2	2
Leningrad	0	1	2	3	0	2	X
Managua	2	1	0	X	1	3	0
Mississauga	0	0	0	0	4	1	0
Ohio River Flood	2	X	1	2	2	2	1
Skopje	2	1	0	2	1	2	1
La Soufrière	1	1	1	0	1	2	X
Three Mile Island	0	0	0	0	4	1	0
United Kingdom I	0	0	2	2	3	1	0
United Kingdom IIa	0	0	1	4	X	1	1
United Kingdom IIb	0	0	1	4	X	1	1
USSR	1	1	2	3	0	1	0
Warsaw I	2	2	0	2	1	1	0
Warsaw II	1	1	0	3	0	0	0
Winnipeg	0	0	0	2	2	2	0

[1]Rail, and possibly air and water, transport were used in the partial evacuation of Kiev.
Source: Zelinsky and Kosinski 1991, Table 6-6, p. 255

Acknowledgement of the Need for Carless Evacuation Planning

In the wake of hurricanes Katrina and Rita, numerous articles and studies were published which discuss the inadequacy of current evacuation planning for carless populations and the need for better planning. While the focus of this study tends to lean towards large cities with high levels of carless populations, a recent study revealed that carless evacuation planning is important in the smaller cities and towns of our country as well. For example, Hess and Gotham (2007) studied counties in rural upstate New York and found:

> The share of households without vehicles in most upstate MSAs is similar to the share of households without vehicles nationally. Perhaps surprisingly, the central cities of Albany, Buffalo, Rochester, and Syracuse have more than double the share of households without vehicles—at 28 percent, 31 percent, 25 percent, and 27 percent, respectively—than the national average (10 percent). Furthermore, the share of households without vehicles in Albany, Buffalo, and Syracuse also meet or exceed the share in New Orleans (27 percent) when Hurricane Katrina struck (U.S. Census, 2000) (Hess and Gotham 2007, p. 9).

Hess and Gotham (2007) found that most evacuation plans do not seriously consider multimodal evacuation planning. Some plans state that while public transportation is an option, most people prefer their own vehicles, although the plans fail to address the segment of the population that cannot drive. Renne (2006) wrote a personal account about the lack of information given to carless residents during the Katrina evacuation, and Litman wrote "Lessons from Katrina and Rita: What Major Disasters Can Teach Transportation Planners." These highlighted the important role that public transportation can play in emergency response planning. Most of those stranded in New Orleans could have been evacuated had a plan been in place. Planning and coordination led to a successful contraflow system allowing anyone with access to an automobile the ability to evacuate. Those without vehicle access, including the poor, elderly, and tourists had to rely on family, friends or other social support systems or else they were stranded. Litman's paper examines failures in Hurricanes Katrina and Rita emergency response and their lessons for transportation planning in other communities. Evacuation plans in Texas failed during Rita because of excessive reliance on automobiles, resulting in traffic congestion and fuel shortages. It has been frequently suggested that the reasons for this were that the

evacuation rate was double or triple the expected level. Equitable and compassionate emergency response requires special efforts to address the needs of vulnerable residents. Improved emergency response planning can result in more efficient use of available resources. Litman (2006) identifies various policy and planning strategies that can help create a more efficient, equitable and resilient transport system.

Other reports include a joint study released by the U.S. Department of Transportation and Department of Homeland Security in 2006 called *Catastrophic Hurricane Evacuation Plan Evaluation: A Report to Congress*. It found that plans for evacuating people with special needs are mostly non-existent. Also in 2006, the United States Government Accountability Office (GAO) published *Transportation – Disadvantaged Populations: Actions Needed to Clarify Responsibilities and Increase Preparedness for Evacuations.* Both of these reports highlight the need for the research that inspired this literature review. As might be expected, numerous publications are appearing that are adding a greater range of perspectives on the Hurricane Katrina experience. This review synthesizes academic literature as well as reports from planning agencies. We hope that this review will serve to illuminate key dimensions of evacuation planning for carless persons.

Accommodating Special Needs

Little dialogue exists regarding the medical needs of the carless society as it pertains to evacuation planning. This area of study deserves considerable attention because a significant portion of carless individuals also have serious medical conditions requiring medication, medical attention, or other special support. A substantial portion of the carless society is elderly and disabled, whom in the event of an evacuation would be forced between two potentially life threatening decisions: (1) remain in place hoping that the ensuing disaster will not render an intractable environment or (2) heed the advice of authorities and evacuate with little guarantee that their medical condition(s) will be properly tended to. This is likely to increase in the future due to an overall aging population, and the increasing effectiveness of medical treatments which allow more people with medical problems to live longer and live independently.

The needs of those with special needs are not uniform. Some individuals simply require transportation whereas other individuals may require a significant amount of assistance to be safely and effectively transported. It is the latter of the two groups that will be considered in this section. Some local governments have difficulty providing for the needs of its infirm individuals. Calcasieu Parish, located about 20 miles from Louisiana's Gulf Coast reminds its special needs citizens that, "A caregiver must accompany you and remain with you during your stay in the evacuation center… medications, 24-hour skilled nursing care and life support equipment, including oxygen, are not available in hurricane evacuation centers, and continuous electricity cannot be guaranteed" (http://www.cppj.net/dept/ocs/snapp.asp). Though characteristic of the evacuation centers' capabilities, it is nonetheless easy to understand why a potential evacuee may be discouraged from evacuating.

According to Dr. Carl T. Cameron of the Center for Disability and Special Needs Preparedness, a multitude of various physical and mental conditions will render a person in need of special attention in the event of an evacuation (Cameron 2007). Many of these are not obvious, and impairments extend beyond the stereotypical identity of a disabled person. Individuals with complications such as diabetes, seizure disorders, as well as those with conditions that are less tangible such as severe emotional, mental and intellectual impairments can often go unplanned for by transportation planners and emergency management officials.

Exacerbating the predicament of disabled individuals in the event of an evacuation is a lack of resources compared to those individuals without a disability. According to census data, individuals with a severe disability earn only $12,800 per year compared to $25,000 for individuals without a disability (US Census Bureau 2007). Therefore, many low-income disabled people are more prone to living in areas which lack critical infrastructure and are at higher risk for an emergency. They face additional difficulties, such as lacking adequate housing, telephone and Internet service, automobile transportation and credit cards (Cameron 2007; Cutter, Mitchell, and Scott 2000).

Carless people's medical needs have often been overlooked during previous disasters. Efforts to evacuate medically vulnerable people during recent hurricanes relied upon city officials, police

officers, and sheriff deputies who were unable to provide assistance to health care officials (Bryan and Kirkpatrick 2007). This lack of support puts lives at risk and discourages people from evacuating when instructed, since they may feel safer staying at home. Altman et al. (2006) concluded that a vast amount of post-Katrina evacuees were unwilling to leave due to health care concerns. A lack of health-care coverage coupled with a dependency on local charity hospitals meant that evacuation for many would mean compromising their availability to health care.

Another important concept to be considered in the evacuation dialogue is the demographic characteristics of future elderly populations. In 2000, population estimates pegged the 65 and over population in the US at 34 million people, or about 12% of the total population (US Census Bureau 2007). Census data predict that by the year 2030, the number of 65 and over individuals will increase 104% to 71.5 million individuals, or about 20% of the total population. Moreover, Zimmerman et al. (2007) found that "7.3 million [20 percent of the elderly population in the United States] reside in counties in which at least one hurricane or tropical storm occurred during [the 1995-2005 period]." (p. 39) This suggests an increasing need for the elderly population to be considered in evacuation planning.

Unfortunately, recent events have showed evacuation planners and local authorities that plans are not enough. Illuminating this concept were the evacuation procedures that took place leading up to Katrina. Many of the plans regarding the evacuation of medically dependent populations proved to be impractical as evacuation strategies relied upon local government cooperation, city officials, police officers, and sheriff deputies who were unable to provide assistance to health care officials (Bryan and Kirkpatrick 2007). However, in spite of the many failures, there were also success stories. Researchers Bryan and Kirkpatrick (2007) highlighted a number of strategies and actions that can lead to more successful evacuations among home health care providers:

Early evacuation – Evacuating before local government announces a mandatory evacuation order was the most important attribute of a successful evacuation. Those agencies that evacuated patients 72 hours ahead of the storm were able to avoid evacuation traffic and found accommodations for their clients with greater success.

Shelter identification – outside the high-risk areas – Being able to identify special needs shelters early proved crucial for evacuation success as hesitation meant the amount of shelters available would decrease, along with the ability to provide care to people with special needs.

Implementing a volunteer communication system – One agency recruited volunteers to find transportation assistance for its clients which greatly improved evacuation success.

Conducting mock evacuation practice drills – conducting regular mock evacuation drills better prepared agencies to manage evacuation difficulties when they arose.

Yet, assuming an evacuation plan could account for all of its special needs individuals, there is little discourse regarding the maintenance of their conditions after a massive dislocation. Based on information gathered post-Katrina from Houston-area evacuation shelters, healthcare concerns including insurance coverage and access to services often inhibit some from evacuating during (Altman et al. 2006). In New Orleans, a lack of health-care coverage coupled with a dependency on local charity hospitals meant that evacuation for many would mean compromising their availability to health care.

Multimodal Emergency Response Planning

Much of the current evacuation literature focuses on automobile-based evacuations. Some studies focus on traffic models and the pros and cons of various strategies for dealing with massive volumes of congestion during an emergency (Wolshon 2001; Dow and Cutter 2002; Wilmot and Mei 2004). Other studies focus on the decision to evacuate or not (Lindell, Lu and Prater 2005; Willgen, Edwards, Lormand, and Wilson 2005; Bateman and Edwards 2002; Chakraborty, Tobin and Montz 2005) while others call for a more comprehensive model that includes alternative modes of evacuating (Litman 2006; Hess and Gotham 2007).

A national survey of hurricane evacuation found that state departments of transportation (DOTs) largely ignored low mobility and special needs groups (Wolshon et al. 2001). States may view evacuation as a local issue and not own transport assets, buses, etc. The report notes that most

cities do not have a sufficient number of buses to evacuate all low-mobility evacuees. Ironically, hundreds of transit and school buses were flooded in New Orleans during Katrina. The survey also found that no plans were in place to use rail as a means of evacuation. Historically, trains and buses have played an important role in the evacuation of cities. In an international study, trains and buses were important modes in 20 of the 27 evacuations. In ten of these, the majority of people used trains and buses (see Table 1) (Zelinsky and Kosinski 1991).

The *Report to Congress on Catastrophic Hurricane Plan Evacuation* (USDOT & USDHS 2006) found that most evacuation plans were underdeveloped and ineffective, especially with respect to persons with special mobility needs. Multiple federal agencies, including the U.S. Government Accountability Office, the U.S. Department of Transportation, the U.S. Department of Homeland Security, as well as Senate and House Committees found that transportation planners, providers, health care agencies, and emergency management officials need to be better coordinated and communicating on this issue long before any disaster.

In an examination of the evacuation failures during Hurricanes Katrina and Rita, Litman suggests that many of these failures can be attributed to a lack of resilience; the ability to absorb unexpected circumstances through redundancy within the transportation system. Littman notes that the tragedies of Katrina are "simply extreme examples of the day-to-day problems facing non-drivers due to inadequate and poorly integrated transportation services" (Litman 2006, p.18).

Many evacuation plans simply suggest that during evacuations, carless residents should seek assistance with friends or neighbors who do own cars. Raphael and Berube (2006) point out, however, that due to the socioeconomic and racial segregation existing in most American cities, the lack of an automobile is often a condition shared among neighbors. Cameron (2006) also suggests that emergency planning should involve the disabled community, and recommends that local governments create a registry of all members of the community with special needs.

Many examples and case studies show the importance of multimodal emergency response planning. For example, one of the main lessons learned from Hurricanes Katrina and Rita is the importance of deploying buses to evacuate large numbers of people, including those who lack

automobile transport (Litman 2006). It is therefore important that emergency response and evacuation plans be multimodal.

Carless Needs Assessment

Having the capability to accurately assess both the population of carless individuals as well as their potential need is critical in the event of an evacuation. This information allows transportation planners and emergency managers to deliver the necessary services to those in need. Without such, a deflated special needs population estimate can strain service quality and create a fatality-prone environment whereas overestimating can allocate unnecessary resources that few communities can do without.

Inventorying a jurisdiction's special needs population can be a daunting task. Information about special needs populations were not centrally collected and their needs can be extremely diverse (GAO 2006). For example, some citizens may merely require evacuation assistance to temporary safe housing while other individuals can require substantial, specialized assistance (National Council on Disability 2005). Measures can be taken to ensure that evacuation plans are inclusive of all citizens regardless of need.

Special needs populations are not only very diverse, but also increasingly abundant. According to the U.S. Census, 2002 figures reveal that 51.2 million people or about 18% possessed some level of disability (U.S. Census Bureau 2007). This means that potentially 1 in 5 individuals will require some sort of assistance in the event of an evacuation, not to mention those individuals without transportation for other reasons such as economic or a lifestyle choice.

Due to recent storms, Gulf Coast states are arranging, or have already arranged provisions to assist special needs citizens in the event of an evacuation (Moore 2005). Evacuation assistance registries are available to citizens of many disaster prone locations. Their information is catalogued by local governments or non-profits to be used in the event of an evacuation. The registry typically records the type of disability and need for special medical and/or transport needs. Albeit an important step for managing special needs citizens, in some areas evacuation

planners are not getting the response they hoped for. Despite Hurricanes Katrina and Rita, people with special needs have been reluctant to sign up with the statewide 311 hotline that assists them in the event of an evacuation (Hughes 2007). Harris County, TX alone is planning to evacuate 65,000 in the event of an impending disaster. That said, only 4,000 persons signed up indicating a substantial disconnect between authorities and special needs persons.

Katrina has been a wakeup call for many coastal and threat prone areas of the country, although carless and special needs evacuation is not just a post-Katrina phenomenon. An executive order signed in 2004 by the President (Executive Order 13347) requires cities to address individuals with disabilities in emergency preparedness. This order mandated that people with disabilities be considered by all levels of government and that the Department of Homeland Security create an Interagency Coordinating Council on Emergency Preparedness and Individuals with Disabilities (ICCEPID). This Council includes members from fifteen named executive departments, four federal agencies, and six other invited members. The purpose of the council is to:

- Consider, in their emergency preparedness planning, the unique needs of agency employees with disabilities and individuals with disabilities whom the agency serves;
- Encourage, including the provision of technical assistance, consideration of the unique needs of employees and individuals with disabilities served by state, local, and tribal governments, and private organizations and individuals in emergency preparedness planning; and
- Facilitate cooperation among federal, state, local, tribal governments, private organizations and individuals in the implementation of emergency preparedness plans as they relate to individuals with disabilities (ICCEPID 2008, website)

Unfortunately, the most up-to-date annual report on the ICCEPID's website as of the writing of this report was for 2005. While the existence of this Council demonstrates federal recognition of these issues, it's too early to judge the effectiveness of the ICCEPID. Furthermore, no literature was found that evaluates the outcomes.

In the wake of Hurricane Katrina, the demographics of evacuees residing in shelters across the country (particularly in the Houston area) were studied. Results from the studies underscore

important socio-economic traits among evacuees. In one study of Houston area shelters, Altman et al. (2006) revealed that many were from disadvantaged social and economic groups:

- 93% African American
- 39% reported making less than $10,000
- 59% reported making less than $20,000
- 62% relied on the Charity Hospital System
- 54% did not have health care
- 42% said there was no possible way to leave
- 41% had chronic health conditions

Another study, focusing on the disabled population in the shelters (Houston area as well as other areas in the country) reported (Burke et al. 2007):

- 40.7% had some type of physical disability
- 65.9% of the disabled had no evacuation plan compared to 59.6% of non-disabled
- 42% of the disabled population made < $10,000 compared to 33.9% for non-disabled
- 64.3% of the disabled population made < $20,000 compared to 51.2% for non-disabled

The results of both studies not only reach similar conclusions but also allow professionals to begin creating a profile of potential carless evacuees. Based on both studies, noteworthy demographic qualities can be extracted from the data. Race, income, disability, and health care status were all attributes associated with an inability to evacuate.

In a case study of Georgetown County, South Carolina, researchers were able to create a model for determining hazard vulnerability among its populations. Among its most important findings was the correlation between hazard vulnerability and certain demographic characteristics including, but not limited to, age, race or ethnicity, income, and gender. Researchers were able to conclude that the "structure of vulnerability may be dependent upon the underlying social

conditions that are often temporally and geographically remote from the initiating hazard event" (Cutter et al. 2000, p.715). In other words, while proximity to a potential hazard is important, the prevailing social conditions may be more important.

The example above shows how demographic data can reveal vulnerability; similarly, this technique can be used to identify potential carless populations in the absence of individually specific data. The coupling of census data or demographic data pertaining to carless populations can provide disaster planners with essential information regarding potential carless prone areas. This information can then be quantified and mapped where disaster planners can decide where focusing services will be most useful.

According to the U.S. GAO, a coordinated effort to track the carless is suggested not only between government agencies but also between government, non-profit, and special needs transport providing agencies (Cutter et al. 2000). Many advocacy groups, non-profits, and transportation providing agencies possess detailed information regarding their clients' geographic location as well as their type of disability which is vital to emergency planners seeking to estimate potential needs for individuals requiring transportation assistance. Unfortunately, privacy laws act as a barrier for information reaching emergency planners. Furthermore, a non-centralized information gathering and management system and lack of coordination among government agencies makes coordinating efforts on behalf of the carless and special needs populations a very ornate process.

In summary, tracking carless and special needs individuals is difficult for evacuation planners. Not only is collecting information about these individuals challenging, it also requires innovative thinking married with unorthodox techniques for estimating need and developing evacuation strategies. Fortunately, technology can greatly assist planners provided government and corresponding agencies can circumvent some of the hurdles preventing open communication. Moreover, government agencies must overcome institutional barriers and work together despite different agencies having different roles and responsibilities.

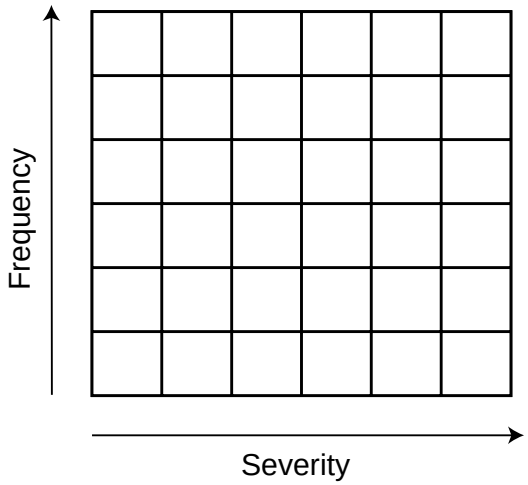
Chapter 2:

Classifying Disasters

It is important for planners and emergency response agencies to understand the range of possible disaster types. The following chapter focuses on previous research and literature that have classified disasters based on identifiable characteristics related to risk, predictability, and source. These characteristics are useful in constructing a typology of disasters as they relate to evacuation activities. Most importantly, a typology of disaster types is useful so that planners can help decision-makers prioritize resources for maximum protection and benefit.

There are many types of disasters which are associated with a broad range of possible types of responses. In most locations, if not all, there are risks posed by multiple hazards. This means that planning can be quite complex and multi-dimensional, especially given the uncertainty of each particular type of disaster. Therefore, classifying disasters based on common characteristics can be a valuable step in preparedness planning. As will be discussed, classification schemes range from being simple with as little as two-dimensions or quite complex. In addition, classifying disasters and responses is further complicated when factoring in the role of individual perceptions and human responses. For example, Long and John (1985) use a two dimensional risk matrix to characterize disasters (see Figure 1).

Figure 1. Risk Matrix

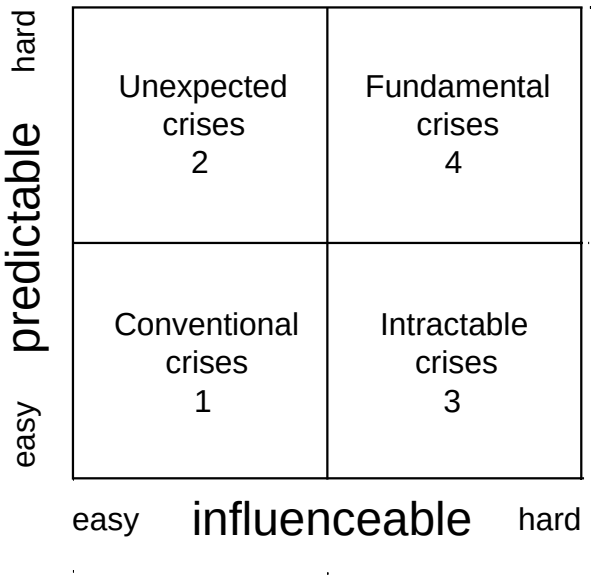


Source: Adapted from Long and John (1985)

Frequency and severity are important determinants of not only the potential for damage and loss, but also for the level of planning resources that can or should be devoted to them. Obviously, infrequent, low impact events receive less attention, while severe events, whether infrequent or not, require more resources to avoid significant negative impacts. Locations with frequent and severe events will not likely be suitable for urban development unless there are other factors that outweigh the costs, such as areas where valuable natural resources are extracted or even areas with high tourist attraction (e.g., island resorts on volcanoes or steep sloped areas for winter recreation).

Gundel (2005) also used a matrix to characterize disasters with two dimensions, a) predictability and b) influence possibilities. Similar to Long and John (1993) these dimensions directly related to the likelihood of anticipating and mitigating disasters (see Figure 2).

Figure 2. Crisis Matrix



Source: Adapted from Gundel (2005)

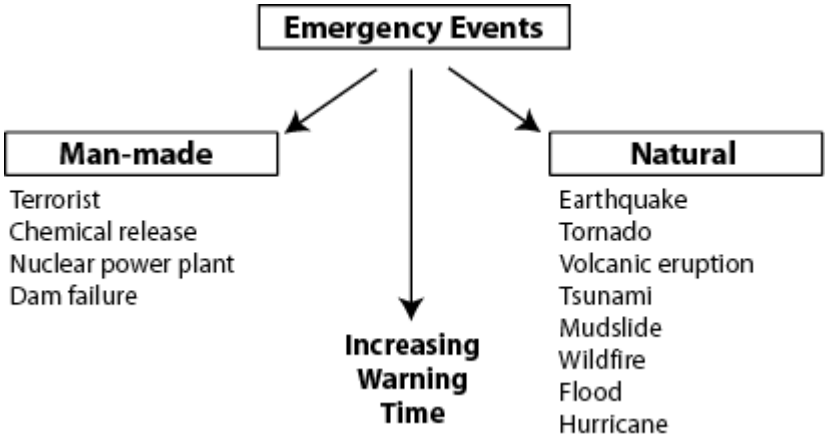
Disasters falling into Quadrant 1, which are predictable and can be easily influenced or mitigated do not have the levels of impact compared to those falling into Quadrant 4 which cannot be predicted and cannot be influenced through planning strategies or preparedness measures. This is not to say that we cannot prepare for unpredictable natural disasters because historical records may provide evidence about future probabilities. Earthquakes, for example, fall into this category; however, impacts can be influenced to a certain degree through building standards and other precautionary actions.

Gundel also discusses two other factors related to disaster types and responses. "Permanence" and "distance" are added to the first two, predictable and influenceable, and are partly a function of severity, which Long and John identified as primary considerations of disasters. Permanence relates to the potential duration of damage and the time that may be needed for system restoration. Some disasters may lead to permanent damage while others may have short-term impacts that can be more easily and quickly resolved. In addition, distance relates to the geographic impacts of disasters. Evacuation and relocation activities will be greater for large magnitude events with wide-spread negative impacts. Both permanence and distance also relate

to the roles of evacuation and relocation processes in response to disasters. Evacuation will be discussed in a later section.

Other classification schemes for disasters and emergencies have been presented which more specifically identify events and relative warning or response timing. Wilmot (2004), for example, distinguishes man-made from natural emergencies or disasters (see Figure 3). His diagram also attempts to show relative warning time (or predictability). Wilmot's scheme does not explicitly characterize the severity or extent of potential damage, nor does differentiating man-made from natural help to understand the planning implications for disasters. A.J.W. Taylor (1989) also provides a similar typology, as far as distinguishing man-made from natural, but provides a more extensive list of disasters and causes (see Table 2). Taylor's research also includes a focus on psychological stress resulting from disaster events.

Figure 3. Disaster Types



Source: Wilmot (2004)

Table 2. Typology of Disasters

Causes:	**Natural**	**Industrial**	**Human**
Elements:			
Earth	Avalanches Earthquakes Erosions Eruptions Toxic mineral deposits Volcanoes Landslides	Dam failures Ecological neglect Outer-space debris fallout Radioactive pollution Toxic waste disposal	Ecological irresponsibility Road and train accidents
Air	Blizzards Cyclones Dust Storms Hurricanes Meteorite and planetary activity Thermal shifts Tornadoes	Acid rain Chemical pollution Exposions above-and below-ground Radioactive cloud & soot Urban smog	Aircraft accidents Hijacking Spacecraft accidents
Fire	Lightening	Boiling liquid/expanding vapor accidents Electrical fires Hazardous chemicals Spontaneous combustion	Fire-setting
Water	Drought Floods Storms Tsunamis	Effluent contamination Oil spills Waste disposal	Maritime accident
People	Endemic disease Epidemics Famine Overpopulation Plague	Construction accidents Design flaws Equipment problems Illicit drug-making, -taking Plant accidents	Civil strife Criminal violence Guerilla warfare/terrorism Sports crowd violence Warfare

Source: Taylor (1989)

Disasters and Types of Evacuations

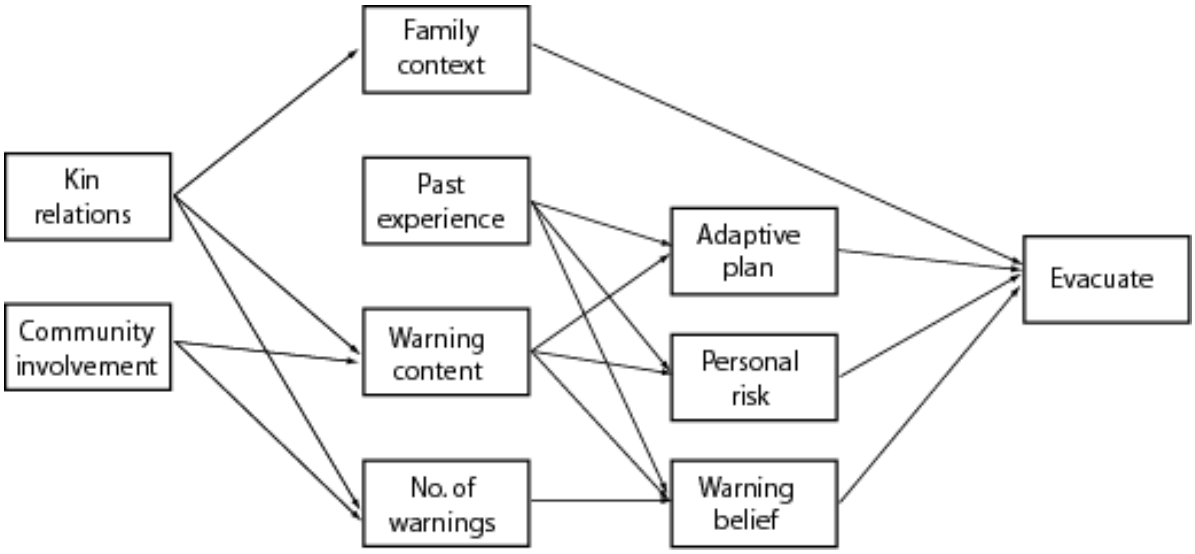
Such classification frameworks attempt to categorize disasters to find commonalities that will assist in organizing response planning efforts. For instance, disasters or emergencies with similar frequencies and impacts could involve similar planning strategies and resources. This of course would depend on the nature of the events being air, water, geological, or other climatological events. These classifications can also help to understand the potential urgency and associated response actions including evacuation and recovery. There do not appear to be any particular guidelines or rules of thumb applicable to all types of evacuations because the severity, extent, and consequences of certain types of disasters vary significantly across events. Within certain categories there are commonalities, for example, minor flooding usually does not involve evacuation while extreme events, such as large hurricanes may require a mass relocation of residents.

Evacuation activities involve both individual and organizational risk perception and decision-making. The literature on risk perception and decision-making attempts to identify individual elements and processes to be adapted in planning and responses to emergencies and disasters. Several researchers have identified socio-economic differences in risk perception. Differences have been observed by race, age, and gender (see for example Perry and Green 1982; Fothergill 1996; Flynn and Slovic 1994; Phillips 1993). Fothergill (1996) identified nine different factors that influence how individuals and groups respond to disasters. These include:

1. Exposure to risk
2. Risk perception
3. Preparedness behavior
4. Warning communications and response
5. Physical impacts
6. Psychological impacts
7. Emergency response
8. Recovery
9. Reconstruction

For individuals, several factors affect how they perceive risk, which then determines evacuation behavior. Perry and Greene (1982) describe the decision-making process for evacuation with direct and indirect influences for past experiences, along with familial and household structure, risk and emergency communications, and other knowledge and belief systems (see Figure 4). In other words, individuals and households will link their current circumstances with past experiences related to emergencies, as well as how they assess the risk to themselves, their families, and physical assets.

Figure 4. Decision-making for Evacuation



Source: Perry and Greene (1982)

The Perry and Greene model assumes that a decision to evacuate is associated with the actual means or ability to evacuate. But as noted by Morrow (1999), access to either public or private transportation not only has consequences during an evacuation, but also after, when persons need access to assistance centers and services, especially if they have been displaced. The experience of low-income persons during Hurricane Andrew and Hurricane Katrina were strikingly similar. Morrow (1997) notes that, "the poor have less access to transport to heed evacuation warnings. There were reports of public housing residents being left to walk or hitchhike out of evacuation zones before Hurricane Andrew" (Morrow 1997, p.4).

This issue of transport mobility and evacuation for low-income persons in the United States was discussed in the literature as long as fifty years ago (see for example Bernert and Ikle 1952). This research came out of experiences with hurricanes and the realization that long distance and high speed evacuations can only occur through some mode of transport – usually private. This obviously represents a challenge for households without access to automobiles, especially in absence of a well-coordinated mobilization during an emergency or disaster. More recently, social, economic, and geographic factors have been analyzed to assess social vulnerability to

disasters (see for example Fothergill and Peek 2004; Cutter, Boruff, and Shinly 2003; Cutter 2005; Laska and Morrow 2007). Like other public services, low income neighborhoods have been discriminated against in the processes of emergency response planning, either in terms of information, communications, public involvement, and actual assistance (Hartman and Squires 2006). For example, emergency information and services are often difficult to access without telephone or Internet service, a mailing address, or an automobile.

Social vulnerability to natural disasters has also been shown to have a spatial dimension (Morrow 1999). Particular social, economic, and health characteristics of resident populations can be mapped to highlight such areas of social vulnerability along with scenarios of disaster events, impacts, and potential evacuation routes. Sophisticated methods are available that can model and visualize disaster responses (both in-flow and contraflow) along transportation networks (Cova and Church 1997). The majority of evacuations occur along these networks because they include the common and most accessible modes of travel; foot, bike, private automobiles, bus, and rail. Other modes of evacuation such as helicopter, plane, and boat are not network-bound, however, it is likely that access to these modes occurs by way of street networks or other defined paths. The type of mode needed for evacuation is a function of the urgency and distance away from danger that persons must be transported. Urgency and distance relate to the dimensions of disasters discussed earlier.

Litman (2006) summarizes the relationship between transportation issues and disaster type in Table 3 below. His report provides a detailed analysis of how disasters should be classified according to their transportation need, which includes the geographic scale, warning period, feasibility of evacuation, and post-disaster response such as need for emergency services, search and rescue, quarantine, and need for infrastructure repair.

Table 3: Transportation Issues based on Disaster Type

	Geographic Scale	Warning	Evacu-ation	Emerg. Services	Search & Rescue	Quar-antine	Infrast. Repair
Hurricane	Very large	Days	√	√	√		√
Earthquake	Large	None	√	√	√		√
Tsunami	Very large	Short	√	√	√		√
Flooding	Large	Days	√	√	√		√
Forest fire	Small to large	Usually	√	√	√		√
Volcano	Small to large	Usually	√	√	√		√
Blizzard/ice storm	Very large	Usually		√	√		√
Building fire	Small	Seldom		√	√		
Explosion	Small to large	Seldom	√	√	√		√
Bus/train/aircraft crash	Small	Seldom		√	√		√
Radiation/toxic release	Small to large	Sometimes	√	√	√	√	
Plague	Small to large	Usually		√		√	
Riot	Small to large	Sometimes	√	√			
War	Small to large	Usually	√	√			√
Landslide/avalanche	Small to medium	Sometimes	√	√	√		√

Source: Litman 2006

Summary

Looking at the literature related to types of disasters has important implications for evacuation planning and strategies for carless persons. Classifying disasters so that particular circumstances can be associated with the most appropriate evacuation method helps to narrow the range of alternatives that need to be considered in the planning process. Drawing on prior research (especially from past disasters) also helps to better understand the continuum of risk involved with different categories of natural disasters because different intensities will involve different types of evacuation responses. As discussed, disasters are multidimensional and complex. Therefore it stands to reason that planning efforts will involve significant amounts of information, not only about emergency preparedness, but also public information and education.

Chapter 3:
Institutional Issues in Carless and Special Needs Evacuation Planning

This chapter summarizes the research on the role of government and nonprofit organizations in evacuating households and individuals who are carless, particularly minority, low-income, elderly, disabled, and limited English proficiency (LEP) persons. An extensive search of the literature reviewed information on disasters and emergencies, from planning, preparation, mitigation and developing institutional capacity to operations during the disaster, to recovery after the event. Relevant areas of the literature include assisting and caring for individuals with disabilities; communications with low income, minority, and LEP households; transportation and urban planning; and public administration.

The literature on specific evacuation procedures for carless households is fairly recent, primarily in response to the evacuations of Hurricanes George and Floyd in 1998 and 1999 and the terrorist attacks of September 11, 2001. The increase in the literature since these events is due in part to the transportation and urban planning communities' realization there was a need to include emergency planning within their planning scope and activities. Transportation has often played a key role in emergency services, but public transport's role has often been established by emergency managers during the emergency with an expectation that transport professionals will respond and do so immediately. Planning, operations, and documentation of public transport's role during emergencies are largely overlooked (Scanlon 2003). Emergency planning or research documents that acknowledge the existence of carless populations generally stop short and do not provide operational plans for their evacuation without personal vehicles (Urbina and Wolshon 2002; Scanlon 2003; Liu and Schachter 2007).

General themes for government's role in emergency planning for carless households have emerged. This review is organized around the following six major themes:

1. Engage the private sector and non-profit organizations through inclusion in the emergency planning agencies and by providing them with communication and outreach tools, training on emergency procedures, and direct or in-kind financial support;
2. Support research to better understand the size, location and specific needs by gender, race, ethnicity, geography, age, income, language, and disability of the carless population to aid in their preparedness and evacuation;
3. Improve and tailor public education materials on disaster preparedness and evacuation;
4. Facilitate the use and development of existing and new technologies to aid in the planning and operations of emergency evacuations;
5. Increase focus on the institutional, operational, and technological aspects of emergency planning and operations by documenting existing resources and gaps, and setting standards, mandates, and models for evacuation plans and capacity. (Prior emphasis has been on the infrastructure and enforcement aspects of emergency planning); and
6. Facilitate interaction between emergency management agencies and other government agencies, including transportation, human services, and public health.

Private Sector and Non-Profit Organizations

The private and nonprofit sectors have expressed their interest in having a larger, planned role in the provision of services in preparation, evacuation, mitigation, and recovery from emergencies and disasters. The American Bus Association, which includes private charter coaches and tourism operators, through their sponsorship of the 2006 report card by the American Highway Users Alliance, pointed out a role for private coaches in moving large groups of people to diverse destinations during a disaster. They add that private coaches, unlike school buses, have room for luggage and personal belongings, without loss of seat space (AHUA 2006).

At a January 2007 conference, the Business Executives for National Security (BENS) released their report to outline a framework for involving the private sector in emergency plans, training, and response. With the private sector owning or operating 85 percent of the US infrastructure, they point out that a community cannot return to normal after a disaster without their involvement. The goal would be to involve them with more foresight and awareness of the specific ways they can contribute. To institutionalize their involvement, they recommend giving

the private sector a seat within Emergency Operation Centers (EOCs). They also suggest the private sector should maintain parallel structures to EOCs, referred to here as "Business Operation Centers (BOCs)" that can plug-in to government operations and "scale up" in a parallel and coordinated manner with government coordination. Employers, retailers, and distributors have key advantages. Employers should be encouraged to develop programs that help their employees stockpile personal emergency supplies; this may also help employees return to work more quickly. The public sector can use public sector transport to ensure delivery of goods to retailers providing key supplies before or after the event. Safe Harbor and Good Samaritan Acts, which relieve individuals who come to the aide of others from liability, should be explored by Congress through hearings in order to produce legislation for a nationwide body of "Disaster Law" (Business Executives for National Security 2007).

White et al. in their 2007 report on the impact of Hurricane Katrina on persons with disabilities, recommends that private centers for independent living (CILs) communicate and coordinate with local/regional Emergency Management Agencies (EMAs), other CILS, other disability agencies, and community input to create evacuation plans for persons with mobility needs. Statewide Independent Living Councils (SILCs) should play a leadership role in bringing together various organizations throughout the state (White, et al. 2007). There may be a role for state regulations or oversight of these entities to encourage this. CILs and SILCs should also campaign for state and regional EMAs to separate people with disabilities from other people with so-called "special needs" (usually defined in terms of major medical support needs) in their emergency evacuation plans. In addition, this distinction should be clearly outlined in training to front-line emergency personnel. They should also have systematic training by staff and clients of CILs so that persons with disabilities have personal disaster plans. Personal disaster plans are a theme in other reports as well. White also encourages community-wide efforts to identify people with disabilities in the community and to link them with services they will need in a disaster to either evacuate or shelter in place (White, et al. 2007). Investing in local non-governmental organizations at the community level can also help post-disaster since people whose ability to function independently are dependent on access to medical and social supports (White, et al. 2007).

Other researchers also provide evidence of the effectiveness of government working with local trusted groups to collect and disseminate information and provide training and support. Prior to a disaster, planners can contact individuals and community groups to learn the kind and type of information each group wants to receive during emergencies and which modes work best, or are preferred, for delivering the information (Liu and Schachter 2007). Wallrich provides examples of information sharing after the disaster through his Chain of Information concept from Los Angeles, Miami-Dade County, and Malibu. For instance, information passed from the Los Angeles County Office of Emergency Services (LACO OEM) to the Central American Resource Center (CARECEN), via Emergency Network Los Angeles (ENLA), "will get on the street quickly, it will reach the people, and it will be trusted" (ENLA is a county level coalition of NGOs for emergencies, see: www.enla.org). Switchboard of Miami played the same role after Hurricane Andrew; it was able to provide FEMA and the County EMA with staff that had valuable language and telephone communications skills, and unmatched knowledge of local resources. Switchboard has since been incorporated in the Dade County emergency operations plans. These groups have also helped to staff FEMA Disaster Application Centers.

Government agencies should also find ways to tap or encourage citizens that are not part of organizations working with government agencies to help in disasters. This is necessary due to the volume of the carless population in large metro areas. Wolshon estimates that even the public sector transportation resources combined with private sector resources, such as school districts and tour operators, would not be enough. Also, there has been uneven success in prior contracting with these groups. He recommends the strategy that New Orleans and Louisiana emergency management officials included in their plans—to work with local churches to encourage "good neighbor" strategies in which people with means of transportation would help neighbors without means to evacuate (Wolshon 2002, p. 7). This idea emerged from a coalition of faith organizations, the Red Cross, City of New Orleans and the University of New Orleans applied disaster researchers. The Louisiana plan also planned on National Guard vehicles, air evacuations, and local shelters and refuges of last resort for those not able to evacuate.

While promoting the use of nonprofit organizations by government agencies, Wallrich (2005) also noted that government agencies need to recognize the difference between non-profit and

government cultures and allow nonprofits to act in their normal relationships with government outside of their disaster and emergency relationship, i.e. if a nonprofit is typically a citizen advocate or government watchdog, they should be supported in continuing to do so. Unless the nonprofit is solely a disaster relief agency, funding and actual mission-based programs are more important to non-profits than are preparations for a disaster. Therefore, EMA's can help the nonprofits to participate in disaster planning by staffing coalition meetings, providing technical expertise such as staff to serve as web-master for the coalition's website, copying the coalition newsletters, running tabletop exercises for coalition members, and training them in exercise design. In sum, government can provide them with in-kind or financial contributions that will afford them the staff time to service the governments need for evacuation planning.

The Easter Seals Project ACTION, is an example of training provided for government by a non-profit. ACTION developed a training program to help transit agencies meet their ADA obligations. It provides training for bus operators on serving passengers with cognitive disabilities (Iannuzziello 2001). Metra Commuter Rail serving metro Chicago worked with ACTION to create a film designed to teach "travel trainers" how to recognize, use, and guide disabled passengers on the equipment that Metra has installed to make its system more accessible to disabled passengers. The stated goals of training programs for regular transit passengers with impairments is to "achieve speed, maximum agility, and smoothness" when using transit (Iannuzziello 2001). This goal would aptly serve emergency evacuation procedures as well.

The American Red Cross (ARC) is a large agency that deals with disaster response. They have the federal mandate to operate shelters across the United States. However, the Red Cross does not engage much in planning for evacuation. This literature review has identified a gap within existing literature that debates how much the ARC should be involved within the planning for evacuations. Since Katrina, the Red Cross has refused to provide shelters south of I-12 (on the north side of Lake Ponchartrain). This has caused New Orleans City Officials to develop evacuation-only plans without considering sheltering options. The debate about sheltering in-place versus mandatory evacuations is a topic that needs more research.

Understanding Carless Populations

Scanlon (2003) and Fothergill et al. (1999) note the lack of understanding of how to assist, reach, and educate various populations for emergency preparedness and evacuation procedures. There are several case studies that describe how certain groups are more vulnerable, less likely to take protective measures, and less likely to evacuate, but the research is not clear on the reasons.

In a survey of transit agencies, for a 2001 Transit Cooperative Research Program (TCRP) (Iannuzziello) study of communication needs of transit passengers with disabilities, agencies reported four ways they determine the communication needs of passengers:

1. Consultation with organizations representing persons with disabilities;
2. Customer surveys and focus groups;
3. Field observations and unsolicited input from passengers; and
4. The formation of ADA advisory committees to recommend appropriate methods.

The Iannuzziello study on communications with persons with disabilities in an intermodal environment found that research lacked in two sub areas of this topic; what communications were preferred by travelers with disabilities; and the total operational and capital costs of implementing different transit communication technologies (2001). Research should focus on identifying cost-effective solutions that service passengers with disabilities, as well as improve the service for all transit passengers, perhaps even attracting more riders.

Disaster Preparedness Education and Outreach

Materials on how emergency planning and response systems operate around the country need to be in a user-friendly format for nonprofit organizations. The Federal government could fund the creation of these materials that should not only be user-friendly but also in multiple languages. Fothergill's 1999 literature review cited several studies that found "racial and ethnic communities were less likely to have had disaster educational opportunities in the earthquake-preparedness stage" (p.158).

Work by Wallrich (2005) and others on reaching and communicating with "hard to reach" populations is important for communicating with the carless population regarding evacuation, since there is cross-over between the two groups. Wallrich in his 2005 presentation outlines four essential issues for communicating with hard to reach populations:

1. Identification – the populations must be defined, geographically located, and, at least roughly, enumerated;
2. Media – it must be transmitted via media that reaches the people;
3. Form – the information must come to the individual in language that she or he can use; and
4. Legitimacy – it must come from a trusted source. All four issues are addressed simultaneously when emergency managers locate, mobilize, and train a coalition of local faith-based and secular non-profit organizations that work with these people on a day-to-day basis (p. 2).

In Iannuzziello's 2001 TCRP Synthesis on communicating with persons with disabilities in a multimodal environment, their review of the research suggested that training was a key method for assisting individuals with cognitive impairments on how to use transit and that local human service organizations [which could include local and county government departments of human services] could provide information or assistance. This comprehensive study documents the range of low-tech to high-tech communications methods for transit agencies to communicate with passengers with cognitive or sensory impairments, including route cards, digital signage, accessible websites, phone and fax systems, GIS systems, and other computerized systems that locate vehicles and routes and connects the information to a database. The report specified that several of these technologies could also help impaired travelers during an emergency, specifically Automated Vehicle Location (AVL) technologies, which locate vehicles that are equipped with the right technology (i.e. a wheelchair lift, etc., and visual signage).

In addition to real-time direct communications between transit providers and travelers, signing up transit patrons, especially carless patrons, for Smart Cards could provide planning information

for emergency management agencies. Information on smart card holders could provide information on the scope and scale of passenger travel needs.

Transit agencies in Iannuzziello's 2001 TCRP synthesis stated the following most and least effective methods for communicating with persons with disabilities:

Most effective marketing channels:

5. Transit promotional material
6. Radio
7. Television
8. Electronic signs
9. Internet

Least effective marketing channels:

10. Newspapers
11. Magazines

The above study was targeted at communications with persons with disabilities, but people with limited English proficiency also need to be considered in special communications strategies. Liu and Schachter found in their 2007 study that departments of human services, education, and transit agencies had increased their capabilities for serving people with LEP in their normal course of operations, but that there was still little assessment of the mobility needs of LEP travelers in the literature on emergency evacuation plans.

Liu's and Schachter's (2004) survey of LEP residents in New Jersey identified written materials (i.e. time tables, schedules, etc.) in their own language were most helpful and pictographs were also preferred by survey respondents. However, they note that providing written materials in every language is cumbersome and that each community of LEP persons may have a different need or preference. Some groups are better with computer technologies, while others prefer hard copy written materials, and all LEP populations in certain situations would benefit from one-on-one verbal communications.

Their survey also identified route deficiencies as a transit service need for LEP communities. In evacuations, planners need to consider where LEP persons and other carless households want to be sent during an emergency (Liu 2006).

Technology in Disaster and Emergency Planning and Operations

In 2000, the FHWA hired a disaster management expert, Janet Benini, to head the Office of Emergency Transportation. When the FHWA made a 10-year commitment of $200M/year to Intelligent Transportation Systems (ITS) in 2000, they set a priority to ensure any system developed contributed to the jurisdiction's disaster capabilities (Benini 2000). ITS systems can indirectly support the carless population by ensuring buses, private and public, have information on what streets are open and safe for travel. ITS can also ensure traffic moves freely, which includes buses and neighbors evacuating households without their own personal vehicle. The integration of transportation management systems within emergency management systems is crucial so that emergency management teams are able to route all first responders appropriately. Transportation system information will aid this. Integration is occurring through joint investment in technology by FHWA, U.S. Army Corps, and FEMA, in the Evacuation Traffic Information System (ETIS) (Wolshon 2002).

Scanlon (2003) illustrates through his review of a number of evacuation case studies, that transportation agencies regularly respond during emergencies by providing information and services. State and regional transportation agencies generally collect traffic information. Transit agencies provide information on the availability of rail and bus operators and drivers, and the number of available trains or other vehicles.

The University of Southern California responded to the attacks on September 11, 2001 by establishing a new research center, Center for Research on Unexpected Events (CRUE) that leverages several existing centers at USC; Digital Government Research Center, Center for Computer Systems Security, Center for Grid Technologies, and Center for Advanced Research in Teaching for Education. Two professors affiliated with CRUE, Yigal Arens and Paul Rosenbloom, outlined their recommendations for IT development for emergency response in a viewpoint article in the journal, *Communications of the Association for Computing Machinery*

(ACM). They find that it is infeasible financially or otherwise to create specific plans for every type of possible event or threat. Instead, society should use information technology to create a general purpose infrastructure that could also successfully adapt to any type of threat. This requires a major interdisciplinary research effort which the National Science Foundation estimated would cost $3 billion over 10 years consisting of individual projects as well as local, regional, and national centers with the capacity to develop and support "large-scale systems and testbeds" (Arens and Rosenbloom 2003). Their article lays out the following areas for the IT portion of such a research agenda:

- *Encyclopedic digital collections* on geography, environments, resources, buildings, computational facilities, and potential response personnel and organizations, together with software systems that can locate answers to pertinent questions. This requires research on storage of such a large set of information, computer languages to translate the different sources into a common source, and a method to allow distributed access and data management.
- *Assembling a nationwide grid of unlimited computation* using grid technology and the internet to create a network of computation, data, and services that would support the use of any resource available during a response.
- *Rapidly deployable sensors and effectors*, which include microsensors, Earth-observing satellites, simple actuators, autonomous robots, and other technologies can be instantly deployed and self-configuring. Today, such devices are able to detect motion, heat, light/images, sound, pressure, metal, and much more. The sensors and effectors need to network autonomously among themselves and communicate with controllers outside the crisis zone in order to "gather data and, functioning autonomously, convey firsthand information to emergency managers who could issue additional commands remotely, facilitate search-and-rescue missions, and work in teams with and support human responders." (p.34)
- *A pervasive, secure communications infrastructure* that operates free from sabotage and intrusion, and covers wireless and wired networks for speech and data.
- *Integrated analysis, fusion, and learning.* Computer-aided learning and training that is embedded within systems and made available to users as needed would allow for simulation

testing and assessment of training needs across personnel who may be expected to respond to an emergency. They could also be paired with software to "create comprehensive regional models, real-time sensor-updated models of significant geographic regions, even entire cities, including subsurface properties, utilities, transportation, structures, population, weather, and more" (pg. 34) and could also contribute to non-emergency planning and research needs.

- *Virtual organizations* that unite geographically dispersed people, software and hardware systems, into "flexible, resilient, dynamic, and coordinated teams" (pg. 35) aided and sustained by agents and robots that assist with discovery, task management, and coordination.
- *Legal framework*. Develop laws and technologies that enable the use of these technologies during an emergency without unduly infringing on personal privacy and civil liberties yet not being hampered by these constraints when critical information would aid in an emergency.

As noted in the last recommendation, each of these technologies have privacy issues that need to be resolved either on a case-by-case basis, or as they recommend, through a legal framework of laws and technologies. Research is also required to make each of these technologies secure while at the same time transparent to their users (2003). CRUE organized a workshop in New York in February/March 2002, at the request of the NSF to study this matter, "Responding to the Unexpected". Attendees included government agencies, universities, and businesses.

General Purpose Transit Technologies that Adapt to Emergencies

Since the passage of the Americans with Disabilities Act in 1990, transit agencies have undertaken significant initiatives to comply with the legislation and to better service passengers with disabilities (Iannuzziello 2001). Through new technologies, sensitivity training, new equipment, personalized training for passengers, and procedural changes, transit agencies have improved their ability to communicate and service persons with auditory, visual, cognitive and mobility impairments.

In a survey of 19 transit agencies, planned communication improvements for daily transit operations for persons with disabilities fell into five categories (Iannuzziello 2001):

12. Staff Training
13. Information
14. Signage
15. Stop Announcement
16. Computerization

Accessible passenger websites and calling out stop announcements were the top ranked in terms of most effective methods for communicating with persons with disabilities (Iannuzziello 2001).

Communication technologies include advanced technologies, such as smart cards; visual technologies, such as LED/LCD or computer screens; auditory technologies; tactile technologies; and cellular (wireless) and mobile technologies, including global positioning system signals, radios, short message system (SMS) in GSM cellular phones and pagers that can broadcast short messages and communicate with personal computers via the Internet. Low-tech technologies include "couriers, runners, loud hailers, sirens, written notices, whiteboards, and others" (Liu and Schachter 2007, p. 7). With all technologies, Liu points out the importance of robust systems with back-up systems that can handle the volume of a major disaster. For instance, telephone systems should allow direct dialing that can bypass potential switchboard blockages (Liu and Schachter 2007).

Institutional, Operational, and Technological Aspects of Emergency Planning

Researchers at the Louisiana State University (LSU) Hurricane Center have been researching transportation in hurricane evacuation plans. Based on an exhaustive review of state hurricane plans through LSU (Wolshon et al. 2001), Wolshon et al. noted in a 2003 article in *Transportation Research News* that State DOTs often include "special needs" groups in their state emergency operations plans, but do not specifically address the evacuation of low-mobility and special needs populations (p. 8). The American Highway Users Alliance recommended

governments address this failure by setting standards for state and regional emergency management plans to ensure they have detailed, realistic, and complete plans for evacuation of carless populations (American Highway Users Alliance 2006).

Federally mandated State emergency operations plans through FEMA should require that each area or facility responsible for evacuation take into account the number of LEP persons in their service area, where they live, and their special needs. This should be in addition to doing the same for persons with mobility or sensory impairments (Liu 2007). Several studies have recommended the use of numerous technological tools such as information technology systems (ITS) and geographic information systems (GIS) to pinpoint the location of various populations (Liu and Schachter 2007; Morrow 2002; and Pal, Graettinger, and Triche 2003). Pre-planning to service these groups should involve communication with group representatives, surveys, interviews, and focus groups. The goal is to identify each groups travel patterns, locations, and information needs and preferences.

A 1997 TCRP sponsored review of transit agency plans for terrorism response found most of the surveyed agencies use the Incident Command System or similar incident management structure for responding to emergencies, disasters, and accidents (Boyd and Sullivan 1997). In the late 1990s, an FTA rule for State Safety and Security Oversight required transit systems to prepare and implement plans by January 1, 1998 following guidelines in the FTA publications, *Transit System Security Program Planning Guide, Transit Security Procedures Guide.* The Incident Command Systems and Incident Response Plans should be reviewed to identify whether they incorporate specific procedures for evacuating special needs populations, including those with mobility, sensory, or cognitive impairments or limited English proficiency. For instance, the "scene support activities" should incorporate the use of multi-lingual responders and personnel trained in assisting low mobility patrons, or those who are blind or deaf.

Training, from table-top exercises to functional drills and full-scale exercises, should also include discussions and exercises on handling the groups within the carless population. The study recommended an interdisciplinary team for the training, including iron-workers, operating engineers, contractors, and firefighters. This literature review identified a gap in the training

recommendation and suggests that persons trained to work with persons with disabilities or impairments should also be involved in these training exercises. The emphasis on the terrorism planning is on combating the threat and maintaining the transit system and is less so on providing assistance to the public.

This 1997 TCRP study also mentioned several aspects of transit agency management that were essential for adequate emergency preparation and planning (Boyd and Sullivan). Top management needs to support the planning efforts. To begin, an agency-wide policy statement or directive from the general manager or executive director on the threat and necessary actions provides the necessary support to do the planning. Authority to act and plan should be granted to the right departments, and permissions for resource acquisitions, expenditures, and personnel should be given. Agencies should also seek regular updates, bulletins or other information sources from the FBI, FEMA, Federal Transit Agency, and other national sources on terrorism threats and other emergencies or disasters.

Facilitate Interaction between Emergency Management Agencies and Other Government Agencies

Emergency Management Agencies (EMAs) are the lead agencies for preparing federally mandated state emergency plans. FEMA is the federal agency overseeing these plans. EMAs are considered local, which is usually at the county, regional level, or state levels.

To identify the agencies that need to coordinate with EMAs, Scanlon (2003) outlines a typology to classify other government agencies. In this typology, transportation agencies are Type I organizations according to the Dynes 1970 typology which describes them as “an established organization carrying out a regular task” (p. 436 of the Scanlon article citing the 1970 Dynes book *Organized Behavior in Disaster*). For evacuation of carless households, government organizations should identify all Type I organizations within the field that regularly interact with or provide services to carless households. Some Type 1 organizations are those that service a subset of this population, such as the homeless, for non-transportation needs, such as law enforcement, physical and mental health care providers, and welfare departments (Wallrich

2005). Organizations that support persons with disabilities must also be designated at the city and county level as first responders/relief providers for inclusion in emergency operations centers when a disaster strikes (White, et al. 2007). Other Type 1 organizations should be from the transportation sectors that service the transportation needs of the carless population, including representatives from each department within transportation agencies; planning, management, operations, and direct service. These different types of Type 1 organizations should then be included in emergency management organizations to ensure they are central players in the planning and operations (Scanlon 2003, p. 437).

There are likely still many groups and agencies, even within FEMA, that need to be better coordinated with other agencies, particularly transportation agencies. For instance, another affiliation, Community & Family Preparedness (CFP) groups and the CFP program within FEMA have an annual conference on disaster and emergency preparation. The 2000 conference stressed the role of schools in educating children and families on disaster preparedness, including how children might evacuate or respond to an emergency, without their parents or guardians, however, our review of the conference symposium did not find mention of transportation issues. This is a good example of an emergency agency group that could benefit from coordination and joint planning with transportation agencies.

Much of the reviewed literature referenced the need for EMAs to include other agencies in their planning and offices. This can be done by EMAs extending the invitation or by transportation and other agencies requesting a seat. In a reverse situation, a 1997 TCRP report on emergency preparedness for transit terrorism, the synthesis reports that transit agencies are reaching out to EMAs, law enforcement, and offices of emergency medical services (OEMs) for guidance on their preparation (Boyd and Sullivan 1997). Transit agencies also provide "transit familiarization training" to local policy and special operations units. This report provides evidence that transit and other agencies seek assistance and support from EMAs for their emergency plans and training which are focused on protecting their employees, passengers/customers, and assets/facilities, but the reverse—EMAs seeking direct involvement from other agencies in their planning, based on this literature review, may be less common. This interagency coordination represents EMA cross-agency coordination, but most of the transit

agency terrorism preparation does not closely resemble large-scale evacuations for disasters or emergencies. Transit agency preparation, which usually results in incident response plans, is typically constrained to the transit agency's jurisdiction and facilities, and therefore, passengers already at a transit facility. Off-system incidents, such as the 1993 World Trade Center bombings, are a consideration in these plans, but are secondary. In the 1993 incident, most of the evacuation was unassisted (Boyd and Sullivan 1997).

Large-scale disaster planning necessitates that governments at all levels address a coordinated approach for evacuation planning. Research into this topic reveals that there is a clear gap in the literature with respect to defining the roles of various agencies across different levels of government. Hess and Gotham (2007) found that the New York State Emergency Management Office (NYSEMO) provides a template for counties to adopt, called the Empire County *Comprehensive Emergency Management Plan.* They also note that other states, including California provide similar documents and that NYSEMO encourages counties to tailor their plans to the specific needs of their communities. However, there seems to be few, if any, federal or state laws that require a holistic and coordinated approach to emergency preparedness and evacuation planning with respect to carless and special needs populations. This might be due to the complexity of managing agencies at the state, regional, county, and municipal levels. Furthermore, while emergency management agencies' primary focus is on emergencies, organizations like transit agencies are more concerned with day-to-day activities and often are not part of the discussions. For example, Michael Setzer, the General Manager and CEO of the Southwest Ohio Regional Transit Authority (SORTA) stated that emergency managers crafted plans which expected to utilize buses from SORTA without even contacting Setzer to manage the feasibility and logistics of how this would occur. Setzer noted that SORTA does not have much excess capacity during peak commuting hours and it's unrealistic to expect that all buses on routes are magically going to be available to serve the disaster without some sort of detailed planning which accounts for issues such as who will drive the buses (Setzer 2007).

The federal government requires all regions with a population of more than 50,000 people have a metropolitan planning organization (MPO). The MPO is mandated to coordinate transportation infrastructure planning across local government boundaries, but most do not deal with

emergency transportation planning, with a few exceptions including, for example, the Metropolitan Transportation Commission in San Francisco and the New Orleans Regional Planning Commission deal to varying levels evacuation planning. Chapter 5 of this report presents the findings of a recent study by one of the authors which looks into disaster planning at the MPO level.

Other regional planning efforts also exist, although not much research has been written on the topic. For example, the SE Louisiana Hurricane Task Force brings together the directors of the Offices of Emergency Preparedness for the 13 parishes in Southeast Louisiana. A similar task force exists for the parishes in the southwest part of the state. The task force meets regularly to reinforce the coordination that the state has provided for the last eight years or so. The chair of the task force speaks for the group when issues arise that require advocacy or recommendations for change. In some instances, the group cannot reach consensus because there are differences in the interests of the different parishes, especially depending on size and location (proximity to the coast and thus differential challenges to evacuate). Again, the regionalization of evacuation planning, particularly as it pertains to carless and special needs people, is an under-explored research area.

Summary

The literature indicates that the incorporation of transportation planning into evacuation and emergency planning is increasing. So is the recognition that populations with special needs, including mobility, sensory, and cognitive impairments, and LEP, need specific evacuation plans, and that the carless aspect of these groups as well as other populations that are carless need to be specifically addressed. However, most emergency plans do not yet incorporate specific enough procedures for each group, they are not at a sufficient scale given the size of the carless population, and institutions do not likely have the capabilities or necessary technologies in place to successfully respond to the needs of this population in the event of a large-scale operation.

Researchers who study both emergency plans and carless populations agree that non-profit organizations and other service providers should be reached out to by planners and EMAs for information on how best to communicate with these groups. It is also well documented that transit agencies are adept at handling large volumes of people, responding well in crises, and adequately planning for major events, such as sporting events, or events involving dignitaries. This expertise should be adapted to evacuation planning.

In terms of technology, there is agreement by many that technologies developed and implemented for emergency events could also provide benefits to daily operations for the target populations of this study as well as the general public. This fact makes these technologies more cost effective to implement and broadens the research capacity for studying and developing new technologies. It also makes the case for agency coordination. Transit agencies should not be preparing separately for terrorist attacks on transit, and emergency management agencies separately from transit agencies on disasters.

A key target to ensure government is creating successful plans for carless evacuation is an initiative between FEMA, Army Corp and FHWA to work on facilitating cross-agency and cross-jurisdictional planning exercises in a few pilot regions throughout the country. This program appears to understand the need for better evacuation planning and is working with the agencies directly responsible for either emergency planning or providing service to carless populations. Another appropriate target would be to include specific and detailed procedures and corresponding capacity for evacuating carless populations within the federal mandates that require state emergency planning.

In sum, many of the components, agencies, technologies, or capabilities exist for handling carless populations in evacuations, but they are not working together on this issue, or at an appropriate level of detail or scale. Terrorism planning is occurring somewhat separately from other emergency management planning and is being done by transit agencies, law enforcement, and EMAs, but it is not clear how integrated these planning processes are with one another. FEMA's Emergency Information Management System (EIMS) works to coordinate across agencies and jurisdictions but outcomes in practice are not clear. Most importantly for this

project, none of these planning efforts have enough involvement from organizations that service or represent citizens with impairments, disabilities, or who lack cars.

This last issue refers to the theme that more emphasis should be placed on institutional, operational, and technological aspects, as prior emphasis has been placed on law enforcement and infrastructure. For instance, as of 1997, transit agency police forces were prepared or preparing to respond to terrorism threats, but in 2003, LEP populations were still complaining that the transit system routes and the transit personnel were still not meeting their needs in terms of where they needed to go or in providing assistance in using the system. As Liu and Schachter (2006) pointed out, if these systems are not meeting the needs of patrons on a regular basis in a normal environment, they are even less likely to do so in an emergency response situation.

Different roles for each level of government have also been identified in the literature. Federal government is more likely to sponsor research, mandate standards, and facilitate cross-agency communications. They may also explore the development or modification of commerce laws that allow the private sector to be involved in disaster planning and response with reduced risk and liability. States can have a funding and coordination role in assisting local and regional governments and statewide nonprofit associations. States typically include "special needs" groups in their state emergency operations plans, but they need to specifically address the evacuation of low-mobility and special needs populations. State DOTs may use ITS technologies to monitor traffic flows and road conditions during disasters and evacuations and can help to direct mass transit and other vehicles that are evacuating the carless populations (Wolshon and Hicks Meehan, 2003, p.8). States also have access to the National Guard for vehicles and shelters. Regional and local governments need to be more focused on the actual plans and implementation, ensuring they have adequate vehicles for evacuation, and plans to reach out to those who need transportation. They should also coordinate with regional or state non-governmental agencies, public and nonprofit, that service carless populations, such as associations for Centers for Independent Living. Local governments can coordinate with neighborhoods, community groups and others who have connections to carless populations and LEP persons.

Chapter 4:
Multimodal Evacuation Planning

Transportation mode generally refers to the form of travel, such as walking, cycling, automobile, bus, rail, truck and aviation, and their variants. How modes are defined and grouped may vary depending on the planning application. For example, for some applications, nonmotorized modes are grouped together, but in others walking, cycling, wheelchair travel and other human and animal powered modes are considered separately. Similarly, for most planning applications, *automobile travel* includes cars, vans, sport utility vehicles, light trucks and even motorcycles, although in some situations these are considered individually.

Multimodal transportation refers to the use of multiple modes. *Intermodal* transportation refers to the use of more than one mode during a single trip, and therefore the connections between modes. Multimodal transportation planning strives to create a transport system that accommodates multiple modes and provide effective connections between modes.

Multimodal transportation is desirable for several reasons. A diverse and integrated transport system allows people to choose the combination of accessibility options that best meets their needs, and people rely on a variety of travel modes regardless of what is intended (for example, even roadways that lack sidewalks and paths often have pedestrian and cycling traffic). As a result, increased transport system diversity and integration tends to increase system equity and efficiency. For example, a multimodal transport system allows people to walk or bicycle for local errands, drive to dispersed destinations, and use public transit when they cannot drive or are traveling on congested corridors where it would be impractical to accommodate all trips by automobile. Multimodalism tends to be particularly beneficial to disadvantaged people, who rely significantly on modes such as walking, cycling, ridesharing and public transit. It reduces the degree to which non-drivers are disadvantaged relative to drivers, is progressive with respect to income, and tends to reduce the social stigma associated with use of alternative modes. Even people who do not currently use a particular mode may benefit from its existence. For example, motorists may benefit from the availability of alternative modes that reduce their chauffeuring responsibilities or traffic and parking congestion problems.

Increasing transportation system diversity tends to increase its *resilience*, that is, the system's ability to accommodate variable and unexpected conditions without catastrophic failure, or "the capacity to absorb shocks gracefully" (Foster 1993; Morlok and Chang 2004). Transportation system diversity includes providing multiple modes, routes and system components (such as redundant maintenance and repair resources, communications systems and fuel sources).

Each transport mode has a unique performance profile, that is, a combination of abilities and constraints that determine the role it can play in an efficient transportation system as summarized in Table 4. For example, walking is affordable and does not require special skill or a license, but it does require physical ability and is limited in speed, distance and carrying capacity. Automobile travel is more costly and requires a driver's license, but it can travel faster, farther and can carry a relatively heavy load.

In recognition of these benefits, transportation planning is increasingly multimodal, with increasing emphasis on alternative modes such as walking, cycling, ridesharing, public transit, car sharing and telework (Pedersen 1999). Many communities have policies and objectives to reduce automobile dependence and encourage use of alternative modes.

Multimodalism is particularly important for emergency response and evacuation planning because it provides options that can accommodate diverse and uncertain needs, including various:

- Types of people, including those with various disabilities and problems
- Mobility needs, including longer-distance evacuations
- Resource constraints, including limited road space, vehicles and fuel

Table 4. Travel Modes Performance Profiles

Mode	Typical Uses	Limitations
Walking	Shorter trips by physically able people. Access trips to motorized modes. Recreational trips.	Requires physical ability. Limited distance and carrying capacity. Difficult or unsafe in some areas.
Wheelchair and other mobility aids	Short trips by people with physical disabilities.	Requires sidewalk or path. Limited distance and carrying capacity.
Bicycle	Short to medium length trips by physically able people on suitable routes.	Requires bicycle and physical ability. Limited distance and carrying capacity.
Taxi	Infrequent trips, short and medium distance trips.	Relatively high cost per mile.
Demand response transit	Mobility for non-drivers in dispersed development.	Relatively high cost per mile.
Fixed route bus transit	Short- to medium-distance trips along busy corridors.	Destinations and times limited.
Rail transit	Short- to medium-distance trips along busy corridors.	Routes, destinations and times limited.
Charter bus	Medium- to long-distance trips with common origins and destinations	Requires planning and funding
Automobile driver	Travel by people who can drive and afford an automobile.	Requires driving ability and automobile. High fixed costs.
Motorcycle	Travel by people who can ride and afford a motorcycle.	Requires riding ability and motorcycle. High fixed costs. Relatively dangerous. Limited carrying capacity.
Ridesharing (using otherwise unoccupied seats in private vehicles, also called *carpooling*)	Trips that the driver would take anyway (ridesharing). Occasional special trips (chauffeuring).	Requires cooperative automobile driver. Consumes driver's time if a special trip (chauffeuring).
Carsharing (vehicle rentals)	Occasional use by drivers who don't own an automobile.	Requires convenient and affordable vehicle rentals services.
Telework (telecommunications substituting for physical travel)	Alternative to some types of trips.	Only suitable for certain activities. May stimulate additional travel (for example, people moving farther from worksites).

Note: Each mode has a unique performance profile making it suitable for certain users and uses.

The Role of Various Modes

The roles that various modes typically play in an evacuation are discussed below.

Walking and Cycling

Walking (including its variants, such as wheelchairs, handcarts and wheeled luggage) is important as a way for people to leave areas of damage or risk, either to their homes, local shelters or to access motorized modes. During major disasters, such as the 2001 World Trade Center attack, and the 2003 Northeast blackout, when transit systems failed and city streets were in gridlock, a large number of downtown workers simply walked home (Homer-Dixon 2007). Under such conditions, healthy people can reasonably walk as far as 10 miles (a three hour walk).

Cycling tends to play a smaller role, because it requires bicycles, the ability to ride, and adequate riding conditions, but can still be useful in some situations. For example, walking and cycling can be the primary mode for large numbers of people to evacuate away from a coastline during a hurricane or tsunami, and for evacuees to travel to transit and rideshare pickup stations.

Large magnitude events, such as evacuating sub-areas of large cities, may require coordination of walking and cycling routes with transfer points, services areas, collection areas, and reception centers. Special guidance and crowd control may be needed where large numbers of pedestrians walk or wait in a constrained area (RMC 1993). The box below summarizes recommendations by Pedestrian Council of Australia Secretary Ian Napier, learned from managing large pedestrian flows during the 2000 Sydney Olympics.

Planning for Large Pedestrian Crowds
Experience from the 2000 Olympics in Sydney, by Ian Napier, Secretary, Pedestrian Council of Australia

Up to half a million pedestrians were moved in, out or through the Homebush Bay site on the busier days of competition and from my observation and others reports it worked very well. The lessons from it were:

- Avoid, where possible, two-way pedestrian routes. (The main flows were organized in huge one-way converging and diverging loops and where necessary temporary overpasses had been put in so that the conflicting flows could cross.)
- Keep people moving where possible. This of course has its limits. People will start to resent being moved just for the sake of it especially if they know the territory and are aware that they are being sent the long way round. Generally there is the reassurance however that one is making progress.
- Keep people informed at all times. The information is in a number of forms - the fixed signs using internationally recognizable symbols wherever possible, -large programmable message screens (more familiar as warning signs for roadworks on highways), - people with loud hailers on raised positions able to direct and inform the crowds, easily identified staff (in this case usually volunteers) able to monitor progress and answer questions at ground level. - fixed and clearly identified information booths.
- Keep people amused/entertained- here we were blessed with an army (not THE army, although they were in the background if needed) of good natured, tolerant, and often very amusing, volunteers who have been hailed as the secret of Sydney. Street performers and musicians were located at critical points where queues were anticipated. There were even stories of railway staff breaking into song and announcing trains in rhyming couplets.
- Provide escape routes and eddy spaces so that people don't feel trapped in crowds
- Provide shady and sheltered places that people can rest and relax between events.
- Provide diversions for children of all ages.
- Build in sufficient flexibility to cope with varying numbers and unexpected eventualities. For example, queuing races (barriers used to shape lines) can be short circuited when the crowds are smaller.
- Raising (or lowering as the case may be) expectations in order to modify behavior. By the time the Olympics arrived no one in their right mind expected that they could drive all the way to events. They expected queues and long walks and in the end seemed to accept that with good humor.

Source: Litman, Blair, Demopoulos, Eddy, Fritzel, Laidlaw, Maddox, and Forster 2002

Of course, many people's ability to walk is constrained. People with disabilities, seniors, parents with young children, people carrying heavy loads, and even people with inadequate shoes (it would be unreasonable to walk more than a few blocks in high heals) all face constraints on their walking speed and distance.

Universal design refers to transportation facilities designed to accommodate a broad range of users, including people with special needs such as wheelchair users and people with wheeled

luggage and baby strollers. This provides many benefits, including improved disaster evacuation ability. Table 5 describes the roles that various modes typically play in emergency response.

Table 5. Emergency Response and Evacuation Roles of Various Modes

Mode	Typical Uses
Walking	Shorter trips by physically able people. Access trips to emergency shelters and motorized modes such as bus stops. Delivery of emergency services, particularly in urban areas.
Wheelchair and other mobility aids	Short trips for people with physical disabilities. Important for evacuating people with disabilities.
Bicycle	Short to medium length trips by physically able people on suitable routes.
Taxi	Can provide automobile transport for non-drivers. Capacity and reliability (number of taxis available) tends to be limited during major disasters.
Bus	Transport to emergency shelters. Evacuations. Delivery of emergency services, particularly in urban areas. Temporary shelters.
Rail transit	May be used for evacuations and temporary shelters.
Automobiles (cars, vans, SUVs, light trucks and motorcycles)	Emergency preparation activities. Evacuations. Delivery of emergency services.
Ridesharing	May help with evacuations, particularly if arrangements can be made previously.

Note: Some travel modes are particularly important for emergency response and evaluations.

Evacuees should be encouraged to choose comfortable shoes and clothing. When walking long distances, people need access to rest areas, refreshments, bathrooms, and medical care (including blister treatment). This can often be provided by coffee shops, restaurants and community facilities, but their availability should be confirmed and supported as part of the emergency evacuation program. For example, it may be appropriate to designate specific evacuation rest centers, or to encourage local shops to offer free water and bathroom access to pedestrian evacuees.

Public Transit

Public transit is important for evacuating carless people (including motorists who experience mechanical failures or other temporary problems) for moderate and long distances, and as a way to evacuate large numbers of people when resources (such as road space or fuel) are limited.

The Department of Homeland Security (DHS) *Nationwide Plan Review* in 2006 concluded that very few states and large urban areas have adequately planned for evacuating transportation-disadvantaged populations (DHS 2006; GAO 2007). The report also noted that, in the past, most evacuation planning efforts focus on evacuation by personal vehicle with little attention given to the role of public transportation systems. In the past, few U.S. public transportation operators had well-defined emergency and evacuation response plans.

Public transit can play a substantial role in emergency management planning (Schwartz and Litman 2008, FTA, 2007). Higgins, Hickman, and Weatherby (1999, p.9) identify various roles that transit agencies can play:

1. Help evacuate people, particularly carless populations
2. Transport of emergency workers and volunteers to and from an emergency staging site
3. Supplemental transportation for people and supplies within a city or county during recovery from a disaster
4. Use of air-conditioned/heated buses as shelter/respite facilities for emergency workers or victims
5. Communications support if vehicles are radio-equipped
6. Monitoring of road and weather conditions
7. Supplemental vehicles for police or other local agency

Automobile Transportation

Private automobile transportation (including cars, vans, SUVs, light trucks and motorcycles) often play an important role in disaster response and evacuation. Even many people who do not drive or lack access to a personal vehicle will rely on ride sharing with family and friends.

Wolshon (2002) describes the use of contraflow lanes and other traffic management techniques to maximize the number of vehicles that could evacuate New Orleans. Contraflow operation, lane reversals, or "one-way-out" as it is also commonly called, simply involves the use of one or more lanes of inbound travel for traffic movement in the outbound direction. It is a highly effective strategy because it can both immediately and significantly increase the directional capacity of a roadway without the time or cost required to plan, design, and construct additional lanes. Contraflow segments are most common and logical on freeways because they are the highest capacity roadways and are designed to facilitate high speed operation. Contraflow is also more practical on freeways because these routes do not incorporate at-grade intersections that interrupt flow or permit unrestricted access into the reversed segment. Freeway contraflow can also be implemented and controlled with fewer manpower resources than unrestricted roads.

Interestingly the concept of contraflow is not new. Various types of reverse lane operation have been used to accommodate routine non-emergency unbalanced flow for decades. It has been used on bridges where one or more outbound lanes are used for inbound commuters during the morning rush hour and one or more inbound lanes are used for outbound traffic during the evening peak period. In Washington, D.C., the center two lanes of Connecticut Avenue are used in contraflow fashion to add capacity during morning and evening peak periods. Contraflow operation is also common at special events where all lanes are converted to accommodate outbound traffic at the end of a concert or football game.

Contraflow operation for hurricane evacuation can take on several different forms. The most effective is an “all lanes out” configuration in which all inbound lanes are reversed into the outbound direction. In the past, states have also varied the number of inbound lanes used for outbound evacuees by using only a single inbound lane for outbound flow. In a single lane configuration, one lane of a 4-lane freeway has been maintained for incoming emergency and

service vehicles. Some states have also used shoulder lanes for evacuation and service traffic (Wolshon 2001; Wolshon 2007).

Officials can give motorists directions, coordinate vehicle rentals and fuel supplies, provide special services along evacuation routes, use counterflow and highway shoulders as traffic lanes, and apply other traffic management strategies.

Ridesharing

Ridesharing involves the use of otherwise unoccupied seats in private vehicles, which is often called *carpooling*. Ridesharing usually occurs informally, for example, when a relative, friend or neighbor offers a ride, and can be supported by formal ridematching systems which help arrange rides.

Ridesharing is often promoted as an evacuation strategy. For example, many evacuation guides advise non-drivers to find a friend or neighbor who has a car and can provide a ride. This may work in some situations, but in many communities, non-drivers are concentrated in certain neighborhoods where there is insufficient vehicle capacity, and there may be logistical problems, such as difficulty collecting non-drivers, vehicle failures and other unexpected constraints which prevent planned ridesharing to occur.

Prior to Katrina, a program called "Operation Brother's Keeper" was being developed by the faith community in conjunction with the American Red Cross, the City of New Orleans Office of Emergency Preparedness and the University of New Orleans Center for Hazard Assessment, Response and Technology (CHART) to enhance use of ridesharing during an evacuation.

Faith groups were encouraged to adopt "evacuation ministries" to organize their congregations and groups' resources (such as vans, 'sister' congregations outside of the disaster zone, and effort of congregation volunteers) to match members without means to evacuate with those who had cars. No specific example of this was found in the literature but elements of such efforts were found in two other smaller cities.

When Katrina struck, the program had been organized in too short a time to be effective. However, the mayor discussed the concept in one of his press conferences to reveal the important element: community members helping other community members to safety.

Ferries

Ferries can be considered a type of public transportation. They may be particularly important for evacuating people off islands or where a bridge has failed. Ferries played an important role in the evacuation of lower Manhattan on September 11th, 2001. If a community depends significantly on ferry service for general transportation, it will probably rely on it for evacuations.

They have specific legal and operational constraints (for example, each vessel is certified to carry a maximum number of passengers, and they may be limited as to where they can travel and dock, and the weather conditions in which they operate). Public and private ferry operators should be consulted during emergency evacuation planning and incorporated into emergency response networks.

Modeling

Evacuation modeling is a promising technology to assist transportation planners. While mock emergency exercises can be invaluable, such programs can be difficult to implement and are limited in availability (Sisiopiku 2007). Thus, computerized traffic simulation programs function as archetypes to replicating disaster scenarios. Evacuation modeling programs can provide emergency management agencies with a host of information regarding simulated traffic conditions in the event of a crisis. Detecting potential traffic queues, benefits of contraflow, lane optimization, and flow rate assessments are just a few examples of information that can be deducted from evacuation modeling.

Interest in evacuation simulation technology is growing, especially in the wake of Hurricanes Andrew, Floyd, Rita, and Katrina, as well as recent terrorist attacks in New York, Washington

D.C., Madrid and London. These events not only act as stimulants in developing evacuation simulation technology but also underscore the necessity of evacuation strategies that are catered to a particular type of disaster (Chien and Korikanthimath 2007). For example, an evacuation strategy for a hurricane differs from an evacuation strategy for a nuclear plant disaster; one emphasizing a preventative evacuation strategy whereas the other would insist upon rapid, urgent recourse to minimize fatalities (Chien and Korikanthimath 2007). These distinctions in disaster types are discussed in Chapter 2.

While evacuation simulation technology is still being tested and its applicability is still uncertain (Chang, Liu, and Lai 2006), it has yielded many important recommendations for evacuation planners. In one study, the Jefferson County Emergency Management Agency was forced to modify its hurricane evacuation strategy after the traffic modeling program, CORSIM, determined several delay causing access points in the county's evacuation plan (Sisiopiku 2007). Modeling the roads around the Fort Worth, Texas area concluded that utilizing a staggered evacuation method can cut overall network clearance time by 47% to 57% (Begley 2005).

Earlier modeling programs primarily consisted of simple mathematical relationships between flows, speeds, and densities (Chang, Liu, and Lai 2006), whereas newer modeling programs consider a wide range of variables and constraints with increasing the complexity and accuracy. New models are now taking into account human behavior and accidents into evacuation simulation scenarios. Human behavior and other stochastic events can have important effects on an evacuation plan's outcome (Church and Cova 2000), whether real or simulated. These events, though not limited to, can include psychological factors that would impair a person's cognition and ability to think as pragmatically as a computer simulator may expect them to, are being integrated into evacuation simulations (Pires 2005).

Some programs have the capacity to simulate an evacuation using real-time traffic conditions. This model, known as model reference adaptive control (MRAC) continuously updates simulation outcomes by providing the simulator with real-time traffic conditions taken from traffic detection devices (Ban, et al. 2007). Once updated, modelers can gain perspective on evacuation routes and act accordingly. The model holds an advantage over other models when

reality does not act in accordance with the predictions, the simulation updates the new traffic patterns into the adaptive control model, remodeling the simulation to incorporate current events.

While evacuation modeling is a tool that is becoming increasingly utilized by evacuation planners, simulation technology cannot yet plan for carless populations in evacuation scenarios. Cities comprised of significant carless populations stand to gain very little from evacuation strategies tailored to car-dependent populations. Also, as the baby boomer population ages and becomes increasingly reliant on mass on non-automobile modes (Weikel 2006), the overall number of carless individuals will increase, further underscoring the need for improved evacuation planning strategies.

In an effort to capture the carless population in evacuation modeling, Kim et al. (2007) have begun researching multi-modal evacuation scenarios to determine the most effective means of transporting evacuees. While Kim et al. are not yet modeling scenarios incorporating multiple evacuation modes; they are comparing pedestrian versus automobile evacuation techniques. Their research has produced stimulating conclusions. One of the findings is that evacuation on foot without contraflow can move the same amount of individuals in a significantly less amount of time than can evacuation utilizing automobiles with contraflow. This finding provides support for further research investigating carless evacuation modes (Kim et al. 2007).

Another modeling program called TRANSIMS is also creating opportunities for evacuation planners. While TRANSIMS cannot yet model evacuation simulations, it can model expansive areas as well as large populations. This unique ability makes it a prime candidate to model evacuation scenarios. Researchers at the LSU Hurricane Center and the University of New Orleans are attempting to adapt the TRANSIMS system to simulate emergency transportation scenarios; integrating multi-modal systems of transportation as well as special-needs individuals into the evacuation scenarios (Wolshon 2007). Given the temporal and spatial scales of mass evacuations, it was theorized that the scalability and level of detail afforded by the TRANSIMS program would make it an ideal system to model, test, and evaluate evacuation and other emergency transportation plans. Although the project remains in progress, preliminary indications are that the system can be readily adapted for such purposes (Wolshon et al. 2008).

A tool developed by the U.S. DOT called ETIS, a web-based GIS, is being used to outfit emergency management officials with real time data about an evacuation. ETIS relies on transportation officials to input evacuation data and then disseminates it where emergency management officials can monitor the evacuation process (U.S. DOT 2006). Neighboring states may find ETIS to be particularly useful to manage road usage as transportation networks are stressed by an influx of evacuees.

Geographic Information Systems (GIS) can also assist in evacuation planning. GIS has already provided evacuation planners with information that highlights problematic evacuation areas. Cova and Church (2000) used GIS along with census data to determine neighborhoods fostering evacuation demands that far exceeded their evacuation capacities. GIS can assist modelers with important demographic data about their target population. The combination of census data, GIS mapping technologies, and knowledge regarding the demographics of carless populations can illuminate areas where carless populations may be more centralized. This information can then be mapped and passed on to policy makers, government officials, and non-profit groups that can take the necessary steps to provide carless populations with evacuation information before a disaster.

Already, mapping techniques are being utilized by planners. According to the GAO, half of the 63 Gulf Coast jurisdictions were mapping their carless citizens by geographic location (GAO 2006). While this may sound promising, the GAO also reports that many metropolitan planning organizations have the capacity and the data to provide emergency planners with information regarding carless citizens but that no medium exists offering an exchange of information between the entities (GAO 2006). While no system can locate carless populations perfectly, there is hope that technology will provide emergency planners with much needed information regarding its populations.

Chapter 5:

City and Metropolitan Evacuation Planning

Introduction

This chapter discusses another dimension of the transportation planning literature – carless evacuation plans. We review the evacuation plans of the 50 largest cities to examine the provisions for those without automobiles. We also review regional plans for 50 of the largest metropolitan planning organizations (MPOs) in the United States to assess the level of emergency preparedness for both natural disasters and terrorist attacks. Analyzing evacuation plans from a local and regional perspective is necessary due to the nature of evacuations, which can be localized or regional depending upon the type and extent of the disaster.

America's 50 Largest Cities

Shortly after Hurricane Katrina, the University of New Orleans Transportation Center launched the Transportation Equity and Evacuation Planning Project. The goal of this initiative is to provide research into how low-mobility, carless, and special needs residents can evacuate from cities in any type of emergency. As part of this study, data was collected to analyze evacuation plans for the 50 largest municipalities across the Untied States. Content analysis was used to determine if there were any provisions for the carless or those with special needs.

It should be noted that these results represent a snapshot in time conducted during a period of about four months from October 2005 to January 2006. During that time, because of the national focus, cities began to turn attention to this topic, although most, if not all of the evacuation plans assessed for this project were written pre-Katrina.

Characteristics of each region were collected, including: population; percentage of households without automobiles; poverty rate; number of transit buses; number of rail cars; and the number of other transit vehicles, such as demand responsive vehicles (see Tables 6, 7 and 8). Population, poverty, and vehicle ownership were collected from the 2000 U.S. Census. The other variables

were collected from the FTA's *2003 National Transit Database*. We also collected the number of school buses for each city from cities and school districts.

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Table 6. America's 50 Largest Cities and Percentage of Carless Households

City	Population	Percentage of Carless Households and Ranking	Poverty Rate	City	Population	Percentage of Carless Households and Ranking	Poverty Rate
New York City, NY	7,735,264	56% (1)	21%	**Charlotte, NC**	542,131	8% (43)	11%
Los Angeles, CA	3,694,834	14% (21)	22%	**Fort Worth, TX**	535,420	9% (40)	16%
Chicago, IL	2,895,964	29% (6)	20%	**Portland, OR**	529,025	14% (23)	13%
Houston, TX	1,954,848	12% (27)	19%	**Oklahoma City, OK**	505,963	8% (44)	16%
Philadelphia, PA	1,517,550	36% (3)	23%	**Tucson, AR**	486,591	12% (28)	18%
Phoenix, AR	1,320,994	9% (37)	16%	**New Orleans, LA**	484,674	27% (8)	28%
San Diego, CA	1,223,341	10% (33)	15%	**Las Vegas, NV**	478,868	11% (32)	12%
Dallas, TX	1,188,204	11% (29)	18%	**Cleveland, OH**	478,393	25% (10)	26%
San Antonio, TX	1,144,554	11% (30)	17%	**Long Beach, CA**	461,381	16% (19)	23%
Detroit, MI	951,270	22% (12)	26%	**Albuquerque, NM**	448,627	7% (45)	14%
San Jose, CA	893,889	6% (46)	9%	**Kansas City, MO**	441,269	13% (25)	14%
Indianapolis, IN	782,414	10% (34)	12%	**Fresno, CA**	427,224	14% (24)	26%
San Francisco, CA	776,733	29% (7)	11%	**Virginia Beach, VA**	425,257	5% (49)	7%
Jacksonville, FL	735,503	9% (38)	12%	**Atlanta, GA**	416,629	24% (11)	24%
Columbus, OH	711,644	10% (35)	15%	**Sacramento, CA**	407,075	13% (26)	20%
Austin, TX	656,302	8% (42)	14%	**Oakland, CA**	399,477	20% (14)	19%
Baltimore, MD	651,154	36% (4)	23%	**Mesa, AR**	397,215	6% (47)	9%
Memphis, TN	649,845	14% (21)	21%	**Tulsa, OK**	393,051	9% (41)	14%
Milwaukee, WI	596,956	21% (13)	21%	**Omaha, NE**	390,112	10% (36)	11%
Boston, MA	589,141	35% (5)	20%	**Minneapolis, MN**	382,452	20% (15)	17%
Washington, DC	572,059	37% (2)	20%	**Honolulu, HI**	371,619	19% (17)	12%
El Paso, TX	564,280	11% (31)	22%	**Miami, FL**	362,563	27% (9)	29%
Seattle, WA	563,375	16% (18)	12%	**Colorado Springs, CO**	360,798	6% (48)	9%
Denver, CO	554,636	14% (22)	14%	**Arlington, TX**	332,695	4% (50)	10%
Nashville, TN	545,549	9% (39)	13%	**Louisville, KY**	256,420	20% (16)	22%

Source: 2000 U.S. Census

Table 7. Supply of Buses and Rail Cars

City	Number of Transit Buses	Number of Rail Cars[1]	City	Number of Transit Buses	Number of Rail Cars[1]
New York City, NY	4,539	6,127	**Charlotte, NC**	309	0
Los Angeles, CA	2,743	207	**Fort Worth, TX**	144	21
Chicago, IL	2,026	1,190	**Portland, OR**	655	83
Houston, TX	1,223	0	**Oklahoma City, OK**	98	0
Philadelphia, PA	1,365	934	**Tucson, AR**	189	0
Phoenix, AR	470	0	**New Orleans, LA**	364	42
San Diego, CA	456	112	**Las Vegas, NV**	299	0
Dallas, TX	809	121	**Cleveland, OH**	701	39
San Antonio, TX	498	0	**Long Beach, CA**	221	0
Detroit, MI	508	4	**Albuquerque, NM**	135	0
San Jose, CA	553	415	**Kansas City, MO**	264	0
Indianapolis, IN	180	0	**Fresno, CA**	103	0
San Francisco, CA	544	845	**Virginia Beach, VA**	330	0
Jacksonville, FL	144	0	**Atlanta, GA**	691	292
Columbus, OH	297	0	**Sacramento, CA**	254	36
Austin, TX	406	0	**Oakland, CA**	786	668
Baltimore, MD	931	268	**Mesa, AR**	49	0
Memphis, TN	221	10	**Tulsa, OK**	82	0
Milwaukee, WI	485	0	**Omaha, NE**	130	0
Boston, MA	1,024	1063	**Minneapolis, MN**	987	0
Washington, DC	1,463	594	**Honolulu, HI**	525	0
El Paso, TX	174	0	**Miami, FL**	957	136
Seattle, WA	1,183	5	**Colorado Springs, CO**	64	0
Denver, CO	1,129	49	**Arlington, TX**	NA	NA
Nashville, TN	130	0	**Louisville, KY**	284	0

Source: APTA 2003 National Transit Database (www.apta.com)
Note: 1. Includes light rail, heavy rail, commuter rail cars.

Table 8. Other Transit Vehicles and School Buses

City	Number of Other Transit Vehicles[1]	Number of School Buses	City	Number of Other Transit Vehicles[1]	Number of School Buses
New York City, NY	512 (DR)	6,200	**Charlotte, NC**	94 (VP), 76 (DR)	1,015
Los Angeles, CA	0	2,454	**Fort Worth, TX**	78 (DR)	433
Chicago, IL	1,299 (DR)	2,530	**Portland, OR**	211 (DR)	1,459
Houston, TX	955 (DR)	1,000	**Oklahoma City, OK**	76 (DR)	~160
Philadelphia, PA	469 (DR)	1,459	**Tucson, AR**	72 (DR)	~300
Phoenix, AR	182 (DR)	unavailable	**New Orleans, LA**	83 (DR)	unavailable
San Diego, CA	279 (VP), 39 (DR)	unavailable	**Las Vegas, NV**	177 (DR)	950
Dallas, TX	71 (VP), 4 (DR)	~1400	**Cleveland, OH**	102 (DR)	1100
San Antonio, TX	218 (DR)	551	**Long Beach, CA**	18 (DR)	unavailable
Detroit, MI	43 (DR)	951	**Albuquerque, NM**	54 (DR)	399
San Jose, CA	0	unavailable	**Kansas City, MO**	37 (VP), 106 (DR)	~440
Indianapolis, IN	70 (DR)	~500	**Fresno, CA**	25 (DR)	~86
San Francisco, CA	343 (TB), 40 (CC), 1,686 (DR)	unavailable	**Virginia Beach, VA**	46 (VP), 3 (FB), 145 (DR)	~560
Jacksonville, FL	8 (AG), 127 (DR)	~900	**Atlanta, GA**	94 (DR)	388
Columbus, OH	45 (DR)	508	**Sacramento, CA**	120 (DR)	~200
Austin, TX	152 (VP), 105 (DR)	466	**Oakland, CA**	0	unavailable
Baltimore, MD	112 (DR)	800	**Mesa, AR**	0	~340
Memphis, TN	47 (DR)	421	**Tulsa, OK**	133 (DR)	unavailable
Milwaukee, WI	17 (VP), 506 (DR)	1086	**Omaha, NE**	13 (DR)	435
Boston, MA	409 (DR), 14 (FB), 40 (TB)	687	**Minneapolis, MN**	47 (VP), 262 (DR)	unavailable
Washington, DC	234 (DR)	unavailable	**Honolulu, HI**	170 (DR)	unavailable
El Paso, TX	99 (DR)	unavailable	**Miami, FL**	29 (AG)	1,471
Seattle, WA	1,044 (VP), 167 (TB), 399 (DR)	420	**Colorado Springs, CO**	55 (DR)	unavailable
Denver, CO	263 (DR)	497	**Arlington, TX**	NA	unavailable
Nashville, TN	32 (VP), 36 (DR)	~600	**Louisville, KY**	88 (DR)	1080

Source: APTA 2003 National Transit Database (www.apta.com); Data gathered from public school district website, or from SBF 2001 Annual Top 100 School District Fleet Survey (www.http://www.schoolbusfleet.com/Stats/pdf/stats_1201_top100.pdf)

Note: 1. AG - Automated Guideway vehicle; CC - Cable Car; DR - Demand Responsive vehicle; TB - Trolleybus; VP – Vanpool

Status of Evacuation Plans and Provisions for the Carless

The status of evacuation plans are categorized into the following groups: 1. online, 2. plan obtained via email, 3. plan under construction/revision, and 4. plan not found. The status indicates the accessibility of the evacuation plan to the public. Even though Internet access is not universal, especially amongst lower-income populations, large municipal governments typically post most planning documents on city websites. Not being able to find an evacuation plan on the website of a large city is an indication that the public cannot readily access information or it does not exist.

Of the 50 selected cities, we found that 23 had readily accessible evacuation plans online. We called each of the remaining 27 cities to determine the status of plans and to ensure that we did not overlook any. Of these, three cities emailed us plans that were not available on city websites, making the total number of cities with evacuation plans just over half (a total of 26 cities). Twelve cities told us their plans were under construction or revision, but none of these cities could make a draft available. An additional twelve cities did not return phone calls or told us that no plan was available. We made multiple attempts over a four-month period to reach planners or emergency managers in each city, but in most cases, calls were never returned.

Cities with evacuation plans were categorized relative to the degree of preparation for the carless population. As shown in Table 9, categories of preparation include: 1. mentioning the availability of public transportation during an evacuation, 2. mentioning the designation of pick-up points (often ad-hoc decisions made based on extent and location of disaster), 3. specifically describing the location of pick-up points (whether along main routes, at pre-existing transit stops, or otherwise pre-determined collection points), or 4. the availability of a map locating these pick-up points.

Table 9. Status of Evacuation Plans and Provisions for the Carless

City	Status of Evacuation Plan	Provisions for the Carless	City	Status of Evacuation Plan	Provisions for the Carless
New York City, NY	Online	Pick-up points described (map)	**Charlotte, NC**	Online	Pick-up points described (map)
Los Angeles, CA	Plan under construction/revision	NA	**Fort Worth, TX**	Plan under construction/revision	NA
Chicago, IL	Plan not found	NA	**Portland, OR**	Plan under construction/revision	NA
Houston, TX	Online	Pick-up points described (bus routes)	**Oklahoma City, OK**	Plan not found	NA
Philadelphia, PA	Online	Pick-up points described (main roads)	**Tucson, AR**	Plan not found	NA
Phoenix, AR	Online	pick-up points mentioned	**New Orleans, LA**	Online	Pick-up points mentioned
San Diego, CA	Plan not found	NA	**Las Vegas, NV**	Plan under construction/revision	NA
Dallas, TX	Plan under construction/revision	NA	**Cleveland, OH**	Online	Pick-up points described (map)
San Antonio, TX	Online	Not addressed	**Long Beach, CA**	Plan under construction/revision	NA
Detroit, MI	Plan not found	NA	**Albuquerque, NM**	Plan obtained via email	Pick-up points mentioned
San Jose, CA	Plan under construction/revision	NA	**Kansas City, MO**	Plan under construction/revision	NA
Indianapolis, IN	Online	Pick-up points mentioned	**Fresno, CA**	Plan not found	NA
San Francisco, CA	Plan under construction/revision	NA	**Virginia Beach, VA**	Online	pick-up points mentioned
Jacksonville, FL	Online	Pick-up points described (bus routes)	**Atlanta, GA**	Plan not found	NA
Columbus, OH	Online	Pick-up points mentioned	**Sacramento, CA**	Plan not found	NA
Austin, TX	Plan obtained via email	Pick-up points mentioned	**Oakland, CA**	Plan under construction/revision	NA
Baltimore, MD	Online	Pick-up points mentioned	**Mesa, AR**	Online	Not addressed
Memphis, TN	Plan not found	NA	**Tulsa, OK**	Plan not found	NA
Milwaukee, WI	Plan obtained via email	Pick-up points mentioned	**Omaha, NE**	Online	Not addressed
Boston, MA	Online	Pick-up points described (map)	**Minneapolis, MN**	Plan not found	NA
Washington, DC	Online	Pick-up points described (bus routes)	**Honolulu, HI**	Online	Pick-up points described (main roads)
El Paso, TX	Plan under construction/revision	NA	**Miami, FL**	Online	Pick-up points described (bus routes)
Seattle, WA	Online	Not addressed	**Colorado Springs, CO**	Plan under construction/revision	NA
Denver, CO	Online	Not addressed	**Arlington, TX**	Online	Not addressed
Nashville, TN	Plan not found	NA	**Louisville, KY**	Online	Pick-up points mentioned

Note: NA – not available

Of the 26 cities that had published evacuation plans, 20 included provisions for carless residents. Ten cities' plans mentioned pick-up points during an evacuation but did not specify any locations. Two plans advise carless residents to wait on main roads, four advise people to wait along bus routes, and four show maps of exact pick-up locations. We also looked at the website for each transit agency corresponding with each city in this study to determine if the transit agency had any information regarding evacuation. In some cases, such as San Francisco, multiple transit agencies serve the city such as MUNI and BART. We chose the transit agency with the most coverage, which in this case would be MUNI. Only transit agencies in Washington, D.C., San Francisco, and Jacksonville provided information about evacuation.

City Evacuation Planning Examples

New York, Boston, Cleveland, and Charlotte are the only four cities that provide maps showing pick-up points for the carless. New Orleans, Baltimore, Miami, Houston, and Jacksonville advise people without cars to wait along bus routes. Philadelphia and Honolulu suggest that people wait along main roads to be picked up by public transit. This section summarizes each of the provisions for these cities, which has a varying degree of risk for large-scale disasters necessitating a large-scale evacuation. While risk or disaster potential is not the subject of this paper, all of the cities in this section are vulnerable to large-scale natural, industrial, and terrorist disasters.

New Orleans

New Orleans fell into the category of mentioning pick-up points, but did not specify particular locations. During the evacuation of Katrina, Mayor Nagin advised that residents without cars to wait along bus routes for pick-up, and that they would be taken to the Superdome. It should be noted here that the evacuation plan in New Orleans was carried out. The problems the New Orleans evacuation experienced were two-fold. First, the shelter (Superdome) was inadequate to handle all of the evacuees and the safety of its location is questionable. Second, most of those that died were disabled and elderly living independently. Many of these people did not want to evacuate for a variety of reasons, including a false perception that they would be safe in their home, not wanting to leave behind pets, or possibly because they were unaware of the danger or

could not physically get to the bus routes. To mitigate this problem, some cities have developed special needs registries to assist the homebound during an emergency. We found six cities have special needs registries (Honolulu, Houston, Jacksonville, Miami, San Francisco, and Oakland). San Francisco and Oakland were the only two cities on this list whose evacuation plans were under construction. The other four had detailed pick-up points for the carless.

Despite the New Orleans Regional Transit Authority (RTA) losing nearly half of its bus fleet in the flood, Katrina revealed that public transport could be used to evacuate the carless from harm's way. Lives could have been saved and economic loss to the RTA could have been avoided if a plan had been implemented that brought both people and buses to a safe location.

In 2006 and 2007, the City of New Orleans released a City of New Orleans Assisted Evacuation Plan (City of New Orleans 2006 and 2007). The plan utilized buses, trains, and planes to evacuate tourists and anyone that cannot leave with a car. One of the issues was that each year the plan must be updated because the memoranda of understanding between the City and various transportation providers (i.e. Amtrak) could only be issued for one year at a time.

New York

In New York, the Office of Emergency Management posted an online preparedness guide. Residents seeking public shelter are instructed to go to one of 23 reception centers located throughout the city. All reception centers are accessible via public transportation. Each reception center is associated with a number of emergency shelters. From the reception center, residents are transported to a designated shelter via van or bus. If a resident is unable to get to reception center due to disability, they are advised to contact the Red Cross to make an arrangement. All residents, regardless of car ownership, are advised to evacuate via mass transit to avoid and prevent congestion.

Boston

The Ready Boston website has an online emergency preparedness and evacuation guide for residents. The guide provides a link to a list of neighborhood emergency centers. It states that residents without cars should go to one of these centers where transportation out of the hazard

area will be provided. It encourages all residents, regardless of car ownership, to use this service in order to keep traffic to a minimum and avoid long waits. There are 75 of these centers throughout the city, most of them churches or schools. A map of their location is provided.

Cleveland

The Cleveland downtown emergency evacuation plan is available online. The plan says that people should go to a pre-designated transit hub. From there, they will be transported to a temporary shelter where the resident will arrange for personal transportation. The locations of the four transit hubs are shown on a map.

Charlotte

The Charlotte police provide a city-center evacuation plan. One aspect of the plan is a pedestrian evacuation, if a vehicular evacuation is not an option. In this case, people are instructed to walk along designated routes to a pedestrian hub, the locations of which are located on a posted map. From the hub, people would be transported out of the hazard area. If they need assistance for either a vehicular or pedestrian evacuation, they are advised to make their own personal plan ahead of time.

Baltimore

The Office of Emergency Preparedness has posted its plan online. Annex C (Protective Actions) of the plan states that depending on the type of emergency and response time available, railroad lines may be used for evacuation of residents lacking transportation. It also says that the City will designate centrally located pickup points or bus routes for people without private automobiles.

Miami

The City's Emergency Operations Center has posted evacuation guidelines online. The City has designated several bus pick-up points throughout hazard zones that will be activated during an emergency. Buses serving this purpose will indicate this on their display. The buses will transfer residents to Red Cross evacuation centers. Residents with disabilities can pre-register via the Emergency Evacuation Assistance Program. If eligible, special transportation to appropriate facilities will be provided.

Houston

The City's Office of Emergency Management (OEM) has posted an Emergency Operations plan online. Residents without private transportation are encouraged to make arrangements with friends or family. If this is not possible, the Houston Metropolitan Transit Authority, METRO, will provide public transportation to evacuees at designated pickup points located along regular bus routes. These individuals will be transported to reception centers outside of the hazard zone. The OEM has also posted a registration form on their website for individuals who anticipate difficulty evacuating, whether due to lack of private transportation or disability. The OEM will contact those who pre-register to make specific evacuation arrangements.

Jacksonville

Jacksonville has an online registration form for people who need bus transportation to a general shelter during an emergency. The bottom of the form says general shelter evacuation pickup points will be at all bus stops in the city. Special needs residents can also register through a different form for transportation to a shelter with appropriate facilities. These registrants will be contacted via phone during an emergency to coordinate transportation. Registration can also be completed by phone.

Philadelphia

For residents without a car, the website advises they should ask a neighbor for a ride. If that option is not available, they are told to go to one of the pickup points along a main road. There was no further description of where the points are. Those with special medical needs that prevent mobility are told to call 911 for assistance.

Honolulu

The Oahu Civil Defense Agency has evacuation guidelines on their website. If evacuees have no car, they are told to leave by foot, ask a neighbor for assistance, or take a bus to a shelter. Evacuees can flag down the buses along major routes. Residents are warned that this system should not be solely relied upon.

50 Large Regions in the United States

There are a variety of arguments for regional emergency response and evacuation planning. Metropolitan Planning Organizations (MPOs) are logical places for this planning and coordination to occur given that they are recognized entities dealing with multi-jurisdictional, regional planning activities in areas with significant urban development and populations. Litman (2006) acknowledges the importance of "resilience" which has more meaning at a regional scale, especially relative to transportation and communication networks. Evacuation problems are commonly associated with the transportation network and resulting congestion levels. Obviously, the scale of impact on a transportation network is a function of the type and magnitude of an event.

In most cases, emergency evacuations rely on auto related modes that depend on an extensive and interconnected highway system. Highway systems provide very good regional accessibility (for those who own cars) which can be used by other high occupancy modes (such as buses) with proper coordination (American Highway Users Alliance 2006). Evacuation by private autos remains a priority due to the fact that auto ownership levels are very high in the U.S. and autos are often the largest physical asset owned by renters, and frequently the second most valuable asset for homeowners next to their houses (Lui 2006). This represents a very big challenge for households without cars, especially when public transportation agencies have not focused sufficient resources on evacuation and emergency management planning (see Schwartz and Litman 2008).

Meyer (2002) discusses the important role that MPOs can play in promoting coordinated planning for incident/disaster event response. He identifies five potential roles for MPOs in this regard. To oversee and coordinate emergency response planning, MPOs can act in traditional ways by being involved in management and operations activities for region-wide transportation systems. MPOs can also extend their current activities as conveners by providing a forum for regional emergency response plan making. In addition, MPOs can also serve as champions and take the lead in regional coordination efforts, where subregional entities such as cities and counties may be perceived as having only parochial interests. Finally, Meyer sees MPOs having

the potential to be both developers and operators of regional systems that involve evacuation and emergency response planning.

Review of MPO Evacuation Planning

A review of 50 large MPOs assessed the level of effort put into emergency response and evacuation planning. This included a content analysis of MPO's "Plan of work", 3-year plans (TIPs), Constrained Long Range Plans (CLRP), Public Involvement Plans, and web sites. We limited the search to electronic media, assuming that this information would be the most accessible to the public. The objective was to determine whether evacuation planning was integrated into transportation plans at the metropolitan scale and whether adequate consideration was given to communications and public information dissemination. The review specifically looked for language (i.e., keywords) related to: a) "evacuation", b) "disaster", c) "emergency", and d) "terror". In addition, web sites were assessed in terms of the prominence given to public information access and availability. A total of 50 web sites and over 320 documents were reviewed.

To collect information on 50 large MPOs, we began with a search and review of individual MPO web sites. All of the selected MPOs had web sites, most of which had links to planning documents, reports, and committee activities. Follow-up telephone contacts were made in cases where the location of particular plans or documents was not easily determined in navigating the web sites. Individual web sites were examined because there were no comprehensive sources of information about MPO plans or activities. The following are the elements collected, which took place between June and August 2006:

- **Response Information**

  Indicates whether any information related to emergencies is provided
- **Reports**

  Either a report or draft emergency report
- **Emergency Maps**

  Maps pertinent to emergencies (i.e. evacuation routes or storm surge maps). Maps simply depicting boundaries or transportation routes were not included.

- **Government Plans**

  Government emergency plans
- **Resident Plans**

  Normally brochures/websites describing what to do in case of emergency
- **Resident Training**

  Emergency training offered through the MPO
- **Call Centers**

  MPO emergency call center
- **Contact Information**

  Non-emergency contact information regarding emergency programs.
- **Low-income, carless, or special needs**

  Programs related to providing services to low-income/carless/special needs. Research only found services targeted to persons with special needs. Specifically, elderly or people with medical conditions.

Nearly 70 percent of these MPOs did not readily supply any of the forms of information considered useful for communicating with the public. The Palm Beach MPO, the Metropolitan Washington Council of Governments (COG), and the Houston-Galveston Area Council each provided six of the nine types of information. It is no surprise that these are leaders among regional planning agencies given their experiences with natural disasters (coastal areas of Florida and Texas) and terrorist threats (Washington, DC). It is very interesting to note that MPOs in very large metropolitan areas like New York, Chicago, New Jersey, San Francisco, Philadelphia, Detroit, Atlanta, and Boston had little or no evacuation planning information on their web sites.

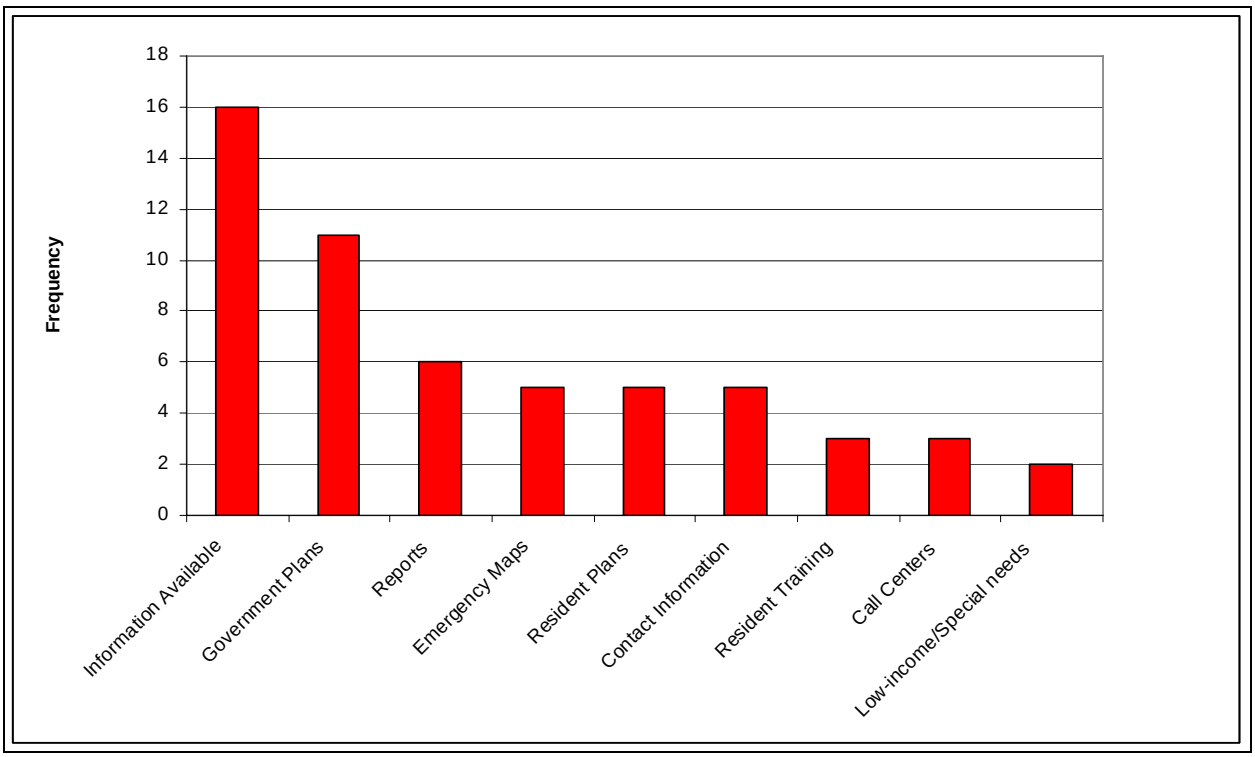
Figure 5 shows the frequency of selected evacuation planning activities undertaken by the 50 MPOs included in this analysis. The first category "Information Available" means that the MPO made some type of evacuation related information available from their web site, whether it was just a link to another web site or information from a full evacuation plan and outreach effort. In just over 20 percent of the cases MPOs had "Government Plans." Metro Washington DC's *National Capital Region Homeland Security Strategic Plan* and Palm Beach County's

Comprehensive Emergency Management Plan is available for visitors to their web site. All other types of reports, maps, plans, and documentation were relatively scarce among the selected MPOs as shown in Figure 5. Only the Palm Beach MPO and the Hillsborough County MPO (both in Florida) had evacuation information specifically for low-income, carless, or special needs persons. For example, Palm Beach County's Special Needs Programs assist people who meet the following criteria:

1. People who cannot be without electricity because they depend upon their own electrically energized life support equipment within the home
2. People that are too immobile and/or have a chronic stable illness, but are not suitable for regular shelter placement
3. Insulin diabetics who depend on refrigeration for their insulin
4. People who are bedridden and require custodial care[3]

[3] Source: http://www.pbcgov.com/pubsafety/EOC/scu2.htm accessed on April 24, 2007.

Figure 5. Summary of Evacuation Planning Activities by Frequency



Beyond the review of MPO web sites, a content analysis of plans and documents from these large MPOs revealed that several organizations included at least some mention of "evacuation", "disaster", "emergency", or "terror".[4] Planning for terrorist related events was much less frequent than was planning for natural disasters or emergencies. However, while less than one in three MPOs had included these issues in their plans or documents, closer inspection showed that little actual planning had been dedicated to these activities. Instead, in a majority of the cases the mention of "evacuation", "disaster", "emergency", or "terror" was related to future planning activities or as those identified by an MPO committee or the public as being needed.

The review of MPO plans and documents based on the four categories mentioned above identified specific directions in which the MPO had given them consideration. For "evacuation"

[4] The web site review looked for information specifically mentioned for evacuation and emergency response purposes. While several MPOs mentioned these issues in plans or reports, the plans and reports were not specifically for emergency response purposes.

related sections in MPO plans, most were in relation to "Goals and Future Projects" as well as "Current Projects." Examples include the Houston-Galveston Area Council's Long Range Transportation Plan (LRTP) where they state that one future goal is to, "Identify and improve roads for evacuation during emergencies and natural disasters and support emergency management programs." Examples of current projects related to evacuation planning were development of performance measures (Broward County MPO, LRTP) and an evacuation plan and route map for downtown Cleveland (Northeast Ohio Areawide Coordinating Agency, State of the Region Report).

For "disaster" related sections of MPO plans, examples include public concerns received (and documented) by the First Coast MPO (Public Involvement Plan) and under "Coordination Efforts" by the New Orleans Regional Planning Commission where they state their intent to:

> Work with local law enforcement and other public safety agencies to coordinate ITS planning, deployment, and operations with the security efforts to protect high profile events and significant infrastructure. In this regard, conduct a critical facilities assessment and develop a GIS database of vulnerable transportation infrastructure and other public and private critical facilities including spatial reference data and other pertinent information that can be used in developing evacuation, mobilization and other plans to deal with security emergencies and natural disasters (New Orleans Regional Planning Commission, 2005).

Two illustrations of "emergency" themes in MPO transportation plans include two excerpts from the Jacksonville MPO and the San Francisco Metropolitan Transportation Commission (MTC) that focus on modeling activities and multimodal planning:

> Goal D—To recognize the interrelationship of land use and transportation and consider the long and short-range impact of transportation policy decisions to enhance the regional transportation system's ability to provide for adequate evacuation times in the event of an emergency. (First Coast (Jacksonville, FL) MPO, LRTP Update)

> A related activity involving earthquake preparedness is the need for coordination of transit service immediately following the event and continuing into the recovery of the transportation system. The region has adopted a plan for emergency communications and coordination of regional transit services. MTC and the region's transportation providers annually conduct a training exercise to test this cooperative process. (SFMTC, RTP)

Finally, examples of where potential terrorism and terrorist activities had been mentioned in MPO plans were primarily in relation to weaknesses identified and/or future MPO planning activities. In some cases the future planning activities included implementation of new technologies that could potentially have broader transportation planning application. Examples include:

<u>Weaknesses</u>

"Safety Concerns regarding terrorists crossing international border." (Greater Buffalo-Niagara, Long Range Transportation Plan)

<u>Studies</u>

"Continuing a comprehensive study to examine areas within the Northern New Jersey and New York transportation network that are critical in the aftermath of the September 11th terrorist attacks. (Task 04/401)" (North Jersey Transportation Planning Authority, Unified Planning Work Program)

<u>Technology</u>

"…developing/enhancing regional emergency preparedness capacity as it relates to utilization of Intelligent Transportation Systems or transportation management tools." (North Central Texas Council of Governments, Unified Work Program)

Overall, the selected MPO plans reviewed for this analysis represented relatively weak efforts at articulating the need to consider evacuation planning and emergency response at a regional scale. The case of New Orleans and Hurricane Katrina represents the chronic neglect of warnings about inevitable disaster and, in this case, the lack of attention devoted to clearly foreseen risks and the

planning to deal with them. Particular examples include the lack of foresight in evacuation planning for people in New Orleans who did not own or have access to reliable cars. One could argue that this was a completely unique set of circumstances; however, some South Florida cities that have extensive experience with disasters ranging from fire to hurricanes actually monitor car ownership statistics and have emergency plans that feature sending public transportation to neighborhoods with low car ownership rates (Raphael and Berube, 2006). The information from public transportation route planning (which often takes into account mobility levels) could be easily used to identify the locations of residents likely to need assistance during evacuations. Related to these planning efforts should be the coordination and use of existing infrastructure, such as fleets of school buses. This would result in the consequent need for legal liability safe harbors that are common barriers to interagency sharing of resources.

Conclusions

Despite a focus on homeland security following September 11th, the fact that nearly half of the 50 largest cities lack an evacuation plan indicates that there is a crisis in evacuation planning in the United States. This is true at the municipal and regional levels. This is likely to change in a post-Katrina environment where evacuation planning has become a major issue.

Evacuation planning needs to be coordinated across the transportation, emergency management, and health service professions, especially for residents with special mobility needs. This study found that most metropolitan planning organizations and transit agencies fail to address evacuation planning. Moreover, when it comes to evacuating the carless and people with special mobility needs, only a handful of cities have any sort of plan.

Evacuation plans need to address the evacuation of pets, the sick, incarcerated, and any person or group that might not be able to drive themselves out of a city. Moreover, the experience from Hurricane Rita in Houston showed that car-based evacuations, particularly in large cities, create massive congestion and gridlock. Alternative modes could create more efficient evacuations, due to higher capacities. For example, the Lincoln Tunnel bus lane carries more than 1,700 buses from New Jersey to Manhattan during the morning rush hour commute between 6:15 am and 10 am. This one lane of traffic carries more than 62,000 people in just over four hours (Rife

2006). This compares to a typical lane of traffic that can carry 2,000 – 3,000 people per hour in cars. Perhaps contraflow evacuation plans could include bus-only lanes to help ease traffic congestion. Staging areas could be located throughout cities to serve both the general-public and people with special mobility needs.

Chapter 6:

Policy Recommendations

Government agencies and non-profit organizations face many challenges when planning emergency response services for special needs populations. Recent disasters have not only illuminated the limitations of outmoded evacuation plans that have traditionally accounted for auto-dependent populations but have also highlighted evacuation planning techniques that have safely and effectively evacuated carless populations. Notwithstanding, advancements in information technology can augment existing evacuation plans with the assistance of GIS and evacuation simulating software.

Disaster response analysis should be considered a normal part of transportation planning. For example, local and regional transportation plans, and transit agency plans, should include analysis of disaster vulnerabilities (the types of disasters that could occur in the service area), risks to the transportation system, emergency response transportation requirements, and how emergency transportation activities will be coordinated. This may reference a general emergency response plan or be a special section of the transportation plan.

Emergency response plans should be evaluated based on their effectiveness at serving the most disadvantaged and vulnerable populations. This requires emergency response planning to give special consideration to serving people with special needs, including physical and mental disabilities, low incomes, inability to speak the local language, and socially marginalized groups such as homeless populations.

Serving disadvantaged populations often requires new perspectives, relationships and tools. Conventional transport planning is based on census data and travel surveys, intended to measure vehicle travel demand and traffic conditions. Travel activity by disadvantaged populations, and nonmotorized travel, tends to be undercounted. Special data collection and planning activities may be needed to identify disadvantaged populations and evaluate their transport needs, including their special needs during emergency evacuations.

Conventional transportation planning may provide little information on the number of people with disabilities in an area, or the portion of households that lack a reliable automobile suitable for emergency evacuation. Many people cannot speak or read English, lack telephone and Internet access, lack a reliable mailing address, distrust public officials, and face other complications in their lives. As a result, serving these populations often requires innovative planning and communications programs that respond to their needs. This requires working with social service agencies, community organizations, medical and mental health professionals, and special service providers to understand the needs, obstacles and preferences of these groups.

The widest range of possible disasters and transport system risks should be considered, as well as options for responding to these emergencies. For example, New Orleans' emergency transportation plan should consider risks besides hurricanes, and San Francisco's emergency transportation plan should consider risks other than earthquakes.

Emergency action plans should specifically identify who will do what during disasters. There should be no ambiguity as to planning and decision-making responsibility, although plans should be flexible so they can respond to changing needs and conditions. Such plans should be critiqued by stakeholders and external experts to identify possible weaknesses and potential improvements. The plan should be updated regularly and reviewed after any exercise or actual emergency event.

Transportation facilities and equipment should be designed to withstand extreme conditions (earthquakes, storms, etc.). Critical transport system components should be designed to be fail-safe, self-correcting, repairable, redundant and autonomous. For example, designing intersections with roundabouts rather than traffic lights may be safer and more efficient considering that traffic can flow even without electricity. Staff should be cross-trained to perform a multitude of roles. Transportation systems should be designed with redundancy, with multiple routes and modes to each destination, including multiple rail lines, roads, paths and bridges. Emergency response planning should evaluate potential problems from, and responses to, the failure of critical links in the transportation networks during a disaster, such as the collapse of a bridge or closure of a highway due to a major crash.

Communications systems in particular should be designed to function despite multiple stresses on people and equipment. Public agencies should develop effective ways to maintain communication systems among transportation system managers, staff residents, businesses and travelers under normal and emergency conditions.

Job requirements for transportation agency staff should specify which positions are "critical" during emergencies, with specific instructions concerning employees' responsibilities to be available. This may require public agencies to help protect and evacuate critical staff's families while they work. For example, transit operators may be allowed to carry their families when evacuating buses and trains.

Future plans should provide systems to prioritize use of transport resources. For example, design systems to give emergency, service and freight vehicles priority over general traffic. Governments should maintain contingency plans for allocating fuel and other resources in emergencies.

Emergency transportation plans should include:

- Communication and support networks that serve the most vulnerable people: This involves a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation, and establish a chain of responsibility for caregivers. This requires effective community outreach before an emergency situation develops. Each service area (municipality or neighborhood) should have an inventory of people who may need assistance, ways to contact them, directions for their evacuation, and a list of their friends and family who can provide emergency support. If possible, social service agency staff or volunteer community leaders should travel with vulnerable evacuees to provide information and reassurance to people who may be frustrated and frightened. Implementing such a system requires that planning professionals work with a broad range of community groups, professionals and social service organizations.

- Guidelines for emergency deployment of public transportation resources, including buses, vans and trains: This requires an inventory of such vehicles and their drivers, and clearly established instructions for their use.

- A system to prioritize evacuations based on factors such as geographic location (evacuate the highest risk areas first), and individual need and ability

- Emergency evacuation information distributed to at-risk populations and all officials, including instructions on pickup locations and what evacuees should bring: This information should be distributed regularly, not just during major emergencies.

- Coordination of fuel, emergency repair and other support services

- Priority for buses and other high occupancy vehicles where critical resources (road space, ferry capacity, fuel, etc.) are limited

Large-Scale Transportation Difficulties

Emergency managers face a number of challenges with respect to large-scale evacuation. This includes finding adequate shelter, coordinating across agencies, and identifying and reaching out to the carless.

Developing a method for identifying carless populations is the first hurdle planners must address. No single solution exists to this problem; and methodologies are still experimental and ever-changing. Once carless populations are identified, planners must then decide which methods should be employed to communicate, transport, and shelter these individuals. Appropriating resources such as vans, buses, and other transportation is a start to a complex transportation conundrum. Once the appropriate transportation assistance can be acquired, authorities must then man the buses with trained drivers. Assuming drivers can be acquired, a series of legal concerns relating to liability and compensation must also be resolved. Accommodating the evacuees is the next step in the process. Providing shelter to accommodate evacuees with

medical needs can also be very difficult. Tracking evacuees is another challenge due to the nature of their situation. Many fail to bring important paperwork, which can delay necessary medical assistance and create liability issues.

Once a given populations' needs are appraised, planners and emergency managers must then work to secure arrangements with public or private transportation providers. While the USDOT has outlined and catalogued capabilities within a number of transportation organizations and agencies (US DOT 2006), gaps in the planning process remain. In Cameron County, TX, which faces a high probability of being struck by a hurricane, officials have made plans to use up to 1,000 school buses and motor coaches in the event of an evacuation (Steinebaker 2007). But according to a safety auditor with the USDOT, a majority of the bus drivers noted that they would only drive the buses providing that their families' safety was first guaranteed (Steinebaker 2007). Some cities have begun compensating for a possible lack of drivers by training emergency personnel not traditionally trained to operate multi-passenger vehicles to obtain commercial driver's licenses, expanding the pool of available drivers (GAO 2006).

Moreover, a number of legal barriers prevent planners from securing buses and other forms of transportation assistance to carless communities. Concerns regarding liability in the event of an accident or injury have driven up insurance costs to the point of rendering the service cost-prohibitive to some governments (GAO 2006). Also, due to a renewed focus on evacuation planning, demand for buses has increased. Overall, heightened demands for buses and escalating insurance costs have resulted in bus rental fees being three times higher in 2007 than the year before (Kunzelman 2007).

Recommended Practices for Carless and Special Needs Evacuation Planning

- Integrate disaster response as part of all non-emergency transportation planning efforts. Consider all types of disasters and stresses on the transport system, and consider all possible solutions.
- Develop an emergency action plan that identifies specifically who will do what during disasters. Update the plan regularly, particularly after a disaster event tests its effectiveness.
- Design transportation facilities to withstand extreme conditions and consider lifecycle costs in budget analyses.
- Create transportation system networks that provide multiple links to each destination, including multiple rail lines, roads, paths and bridges.
- Insure that transport planning takes into account people with special needs. Work with community organizations to identify their needs and maintain effective communications with vulnerable groups.
- Develop effective ways to maintain information and communication systems among transport system managers, staff and users under normal and extreme conditions. Develop ways to communicate with residents and travelers under emergency conditions.
- Develop ways to prioritize transport system resources when necessary. For example, design systems to allow emergency, service and freight vehicles priority over general traffic. Maintain contingency plans to allocate fuel and other resources in emergencies.
- Design critical components of the transportation system to be fail-safe, self-correcting, repairable, redundant and autonomous. For example, where possible, use roundabouts instead of traffic signals, since they function without electricity.
- Cross-train staff to perform critical management and repair services.
- Ensure that plans take into account communication and support networks that serve the most vulnerable people. This involves a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation, and establish a chain of responsibility for caregivers.
- Plan to allow quick deployment of buses, vans and trains. This requires an inventory of such vehicles and their drivers, and clearly established instructions for their use.
- Create a system to prioritize evacuations based on factors such as geographic location (evacuate the highest risk areas first), and individual need and ability.
- Distribute emergency evacuation information to at-risk populations and all officials, including instructions on pickup locations and what evacuees should bring. This information should be distributed regularly, not just during major emergencies. It should include clear descriptions of where evacuees will be taken and what provision is being made for their pets.
- Create a plan for the coordination of fuel, emergency repair and other support services.
- All priority for buses and other high occupancy vehicles where critical resources (road space, ferry capacity, fuel, etc.) are limited.

Institutional Issues and Recommendations

Coordinating disasters, both large and small-scale, necessitate effective communication across various agencies and levels of government. This section discusses the roles and responsibilities of various types of agencies to plan for and accommodate carless and special needs people before and during an emergency.

Federal Government

The federal government must create a national policy on carless and special needs evacuation planning. This should include funding to lower-levels of government to plan, implement, test, and continually refine such evacuation plans. Such an endeavor could be embraced by the DHS's Interagency Coordinating Council on Emergency Preparedness and Individuals with Disabilities. Targets should be set with incentives. These regional councils could encourage cooperation amongst local, county and state governments, the metropolitan planning organization, transit agencies, special needs transit providers, the American Red Cross, and other non-profits that provide services to special needs residents.

State Government

Similar to the federal government, state governments can facilitate carless and special needs evacuation planning through funding and facilitating intergovernmental coordination. Agencies, such as the state police, department of transportation, and departments of health and/or human services should meet on a regular basis. In larger states, with multiple urbanized areas such as California, the state should allow the metropolitan planning organizations or other regional entities to take the lead role in coordinating across jurisdictions and agencies for carless and special needs evacuation planning.

Metropolitan Planning Organizations

Metropolitan planning organizations (MPOs) are responsible for decisions on transportation capital improvements and for creating long-term regional transportation plans. Evacuation has

typically been planned and administered locally by departments of emergency management or regionally by the state police. It is currently unclear who has the responsibility for regional disaster planning to identify the "demand side" of the carless and those with special needs as well as the "supply side" of transportation resources. Since MPOs already deal with regional transportation issues, they are a logical place for regional disaster planning. Many MPOs already embrace areas such as land use, environmental, and economic development planning because such fields are integrally connected with transportation systems. Disaster planning is no different.

MPOs would make a logical home for regional coordinating councils on emergency preparedness for carless and special needs. MPOs already have the infrastructure in place to coordinate regional decisions across local jurisdictions. MPOs currently deal with transportation planners across regions, not emergency managers. However, some examples exist where MPOs are increasingly becoming involved with emergency preparedness and therefore are beginning to coordinate with emergency managers. Future reports of this study will discuss current efforts underway in Chicago, Miami, New Orleans, New York, and San Francisco. Another study by the Transportation Research Board, to be published in mid-2008, will also present similar research findings for five urbanized regions across the United States. These include Chicago, Houston, Los Angeles/Long Beach/Santa Ana, New York/Newark, and Tampa/St. Petersburg.

Regional coordinating councils on emergency preparedness for carless and special needs could serve a number of important functions. This includes:

- Providing assistance to local governments in planning for all types of hazards.
- Representing local governments to state and federal governments to ensure that regions have adequate funding and resources for all types of hazards.
- Coordination of local plans into a regional plan so multiple jurisdictions in a region can share limited resources during an emergency.
- Coordinating with other regional councils so that regions can borrow resources from nearby regions in the event of a massive catastrophic disaster. This will create a web of resource sharing that would extend across the United States.

- Cross-jurisdictional evacuation planning, which includes contraflow, high occupancy evacuation lane and/or corridors, and coordination of transportation resources across all modes, including: foot, bicycle, automobile, van and shuttle, bus, rail, air, and boat.
- Creating and streamlining regional memoranda of understanding agreements that all local jurisdictions can sign onto, ensuring liability concerns are addressed before a disaster.
- Providing technical expertise for community and local emergency preparedness.
- Backing-up important local data for local partners.

Transportation Providers

Transit agencies, paratransit providers, school districts, and private transportation providers all play an important role in carless and special needs evacuation planning because they own the resources needed to conduct an evacuation. Transportation providers need a seat at the table to plan for both localized and large-scale evacuations. Logistical details, such as who will drive buses and how will the bus drivers' family be treated are important issues to overcome. Transportation providers should be mandated to work with the recommended regional councils to maintain an accurate database on the numbers and types of all transportation resources. This list should be detailed to include how many buses are wheelchair accessible and the location where the buses are stationed. The regional council should work with all transportation providers in a region to ensure effective communication to mobilize transportation resources at a moments notice. Furthermore, communications lines should be strong enough so emergency managers can make important last minute changes depending upon the nature and extent of any disaster.

Local Government

Local government (including municipal and county government) serves an important function in emergency preparedness and disaster response. Emergency response works best when disasters do not cross political boundaries and when people are able to evacuate by car. Of course, disasters are not sensitive to political boundaries and as this report has demonstrated, many

groups within society do not and cannot drive for a number of reasons. Professor Brian Wolshon, Chair of the Transportation Research Board's Subcommittee of Emergency Evacuation stated at the 2007 National Hurricane Conference in New Orleans that automobile-based evacuation planning is the "low-hanging fruit." He noted that a more difficult task is to plan for the more marginalized groups within society that are not able to evacuate by automobile.

Planning at the local government level is critical for carless and special needs evacuation planning. Important functions include:

- Creating all hazards emergency response plans that considers both sheltering in-place and evacuation depending upon the extent and type of disaster
- Planning, testing, implementing and evaluating emergency response plans
- Coordinating with transportation providers, nonprofits, metropolitan planning organizations, state and federal government
- Signing memoranda of understanding with various agencies to ensure all liability concerns are addressed before a disaster
- Tracking, mapping, and coordinating transportation resources such as buses, vans, and trains
- Tracking and mapping where carless and special needs residents live
- Establishing and maintaining a special needs registry
- Continual public education efforts to ensure that everyone is prepared at all times for any type of disaster

References

AARP. (2006a) AARP Offers Tips to Help Older Americans Prepare for Emergencies. New Release, Accessed 6 September 2006. http://www.aarp.org/research/presscenter/press currentnews/preparing_for_emergencies.html

AARP. (2006b) We Can Do Better: Lessons Learned for Protecting Older Persons in Disasters. American Association of Retired Persons. http://www.aarp.org

Access Board. (2005) Resources on Emergency Evacuation and Disaster Preparedness. Access Board. http://www.access-board.gov/evac.htm

Adler, M. D. (2006) Equity Analysis and Natural Hazards Policy. On Risk and Disaster: Lessons from Hurricane Katrina. R. J. Daniels, Kettl, D.F., and Kunreuther, H. Philadelphia, University of Philadelphia Press.

Altman, Drew, John M. Benson, Robert J. Blendon, Brodie Mollyann, and Erin Weltzien. (2006) Experiences of Hurricane Katrina Evacuees in Houston Shelters: Implications for Future Planning. American Journal of Public Health. 96.8: 1402-08.

American Highway Users Alliance AHUA. (2006) American Highway Users Alliance Emergency Evacuation Report Card 2006. Washington D.C.: American Highway Users Alliance, October. Accessed March 29 2007 from http://www.highways.org/pdfs/evacuation_report_card2006.pdf

American Public Transportation Association. (2001) Checklists For Emergency Response Planning and System Security, American Public Transit Association (www.apta.com/services/safety/checklist.htm).

Arens, Yigal and Paul S. Rosenbloom. (2003) Viewpoint - Responding to the Unexpected: How IT can help prepare for future attacks and disasters. Communications of the ACM. 46, no. 9: 33.

Balog, John N., Annabelle Boyd, Jim Caton, Peter N. Bromley, Jane Beth Strongin, David Chia and Kathleen Bagdonas. (2005). Public Transportation Security: Volume 7: Public Transportation Emergency Mobilization and Emergency Operations Guide. Transit Cooperative Research Project, Transportation Research Board (www.trb.org); at www.trb.org/publications/tcrp/tcrp_rpt_86v7.pdf.

Ban, Jeff X., Henry X. Liu, Wenteng Ma, and Pitu B. Mirchandani. (2007) Model Reference Adaptive Control Framework for Real-Time Traffic Management under Emergency Evacuation. Journal of Urban Planning and Development. 133.1: 43-50.

Barton, A. H. (1969) Communities in Disaster: A Sociological Analysis of Collective Stress Situations. Garden City, Doubleday.

Bateman, Julie M. and Bob Edwards. (2002) Gender and Evacuation: A Closer Look at Why Women Are More Likely to Evacuate for Hurricanes, Natural Hazards Review, August, pp. 107-117.

Bates, F., C. Fogelman, et al. (1963) The Social and Psychological Consequences of Natural Disaster. Washington, DC, National Academy of Sciences-National Research Council.

Begley, S. (2005) Man-Made Mistakes Increase Devastation Of 'Natural' Disasters, Wall Street Journal, September 2, 2005; Page B1.

Benini, Janet. (2000) Transportation Resources in Disasters: The Role of the Office of Emergency Transportation. Edited Version of May 17, 2000 Transcript EIIP Virtual Forum Presentation. Accessed 29 March 2007 from http://www.emforum.org/vlibrary/transport.htm

Berdica, Katja. (2002) An Introduction to Road Vulnerability, Transport Policy, Vol. 9. No. 2 (www.elsevier.com/locate/tranpol), April 2002, pp. 117-127.

Bernert, E. H. and F. Ikle (1952) Evacuation and Cohesion of Urban Groups. American Journal of Sociology. 58, 133-138.

Blaikie, P., T. Cannon, et al. (1994) At Risk: Natural Hazards, People's Vulnerability, and Disaster. London, Routledge.

Bojer, H. (2003) Distributional Justice: Theory and Measurement. London: Routledge.

Bolin, R. C. (1993) Household and Community Recovery after Earthquakes. Institute of Behavioral Science, University of Colorado, Boulder.

Bourne, Joel K. Jr. (2004) Gone With The Water, National Geographic (www.nationalgeographic.com) October 2004.

Boyd, Annabelle and John P. Sullivan. (1997) Synthesis of Transit Practice 27: Emergency Preparedness for Transit Terrorism. Washington D.C.: Transit Cooperative Research Program of the Transportation Research Board National Research Council, National Academy Press.

Bring New Orleans Back Commission. (2006) Infrastructure Final Report, Public Transit. Accessed 15 March 2008, http://www.bringneworleansback.org

Bryan, Marguerite, and Dahlia V. Kirkpatrick. (2007) Hurricane Emergency Planning by Home Health Providers Serving the Poor. Journal of Health Care for the Poor and Underserved 18: 299-314.

Burke, Jennifer M., Ken Lachlan, Mathew W. Seeger, and Patric R. Spence. (2007) Media Use and Information Needs of the Disabled During a Natural Disaster. Journal of Health Care for the Poor and Underserved 18: 394-404.

Business Executives for National Security. (2007). Getting Down to Business: An Action Plan for Public-Private Disaster Response Coordination. The Report of the Business Response Task Force. January. Accessed 29 March 2007 from http://www.bens.org/Getting-Down-To-Business.pdf

Cameron, Carl. (2007) T. Emergency Preparedness for People with Disabilities and Other Special Needs: Another Look After Katrina. Center for Disability and Special Needs Preparedness. Accessed 10 July 2007, http://www.disabilitypreparedness.org

Chakraborty, Jayakit, Graham Tobin, & Burrell Montz. (2005) Population Evacuation: Assessing Spatial Variability in Geophysical Risk and Social Vulnerability to Natural Hazards. Natural Hazards Review. Vol. 6, No. 1.

Chang, Gang-Len, Ying Liu, and Xiaorong Lai. (2006). Two-Level Integrated Optimization System for Planning of Emergency Evacuation . Journal of Transportation Engineering. 132.10: 800.

Chien, Steven I., and Vivek V. Korikanthimath. (2007) Analysis and Modeling of Simultaneous and Staged Emergency Evacuations. Journal of Transportation Engineering. 133.3: 190.

Church, Richard L., and Thomas J. Cova. (2000) Mapping Evacuation Risk on Transportation Networks Using a Spatial Optimization Model. Transportation Research Part C. 8: 322.

City of New Orleans. (2006). City Assisted Evacuation Plan. Office of Emergency Preparedness. Accessed 18 March 2008, http://www.cityofno.com/Portals/Portal46/portal.aspx?portal=46&tabid=38

City of New Orleans. (2007). City Assisted Evacuation Plan. Office of Emergency Preparedness.

Cochrane, H. (1975). Natural Disasters and Their Distributive Effects. Boulder, CO., Institute for Behavioral Sciences-University of Colorado.

Cova, T. J. and R. L. Church (1997). Modeling Community Evacuation Vulnerability using GIS. International Journal of Geographical Information Science. 11(8): 763-784.

Cutter, S. L. (2005). The Geography of Social Vulnerability: Race, Class, and Catastrophe. http://understandingkatrina.ssrc.org/cutter

Cutter, Susan L., Jerry T. Mitchell, and Michael S. Scott. (2000) Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. Annals of the Association of American Geographers. 90.4: 713-37.

Cutter, S. L., B. J. Boruff, et al. (2003) Social Vulnerability to Environmental Hazards. Social Science Quarterly. 84(1).

Daniels, R. J., Kettl, D.F., and Kunreuther, H., D. F. Kettl, et al. (2006). On Risk and Disaster: Lessons from Hurricane Katrina. Philadelphia, University of Pennsylvania Press.

Decker, S. (2000) Data Needs for Decision Makers. Transportation Operations During Major Evacuations: Hurricane Workshop. Atlanta, GA.

Dow, Kirsten & Susan Cutter. (2002) Emerging Hurricane Evacuation Issues: Hurricane Floyd and South Carolina." Natural Hazards Review Vol. 3, No. 1.

Dynes, Russell R. (1994) Situational Altruism: Toward an Explanation of Pathologies in Disaster Assistance, paper presented in Research Committee #39--Sociology of Disasters, XIII World Congress of Sociology, Bielefeld, Germany, 18-23 July.

Dynes, Russell R. (1970) "Organizational Involvement and Changes in Community Structure in Disaster" American Behavioral Scientist 13: 430-439.

Dynes, Russell R. (1970) "Organized Behavior in Disaster." Heath Lexington Books.

Federal Emergency Management Association. (1997) Multihazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy. Washington, DC.

Federal Transit Administration. (2005) National Transit Database, Data Tables for 2003 National Transit Database Report Year. Washington D.C.: FTA.

Federal Transit Administration. (2006). Disaster Response and Recovery Resource for Transit Agencies. Federal Transit Administration . http://www.transit-safety.volpe.dot.gov/publications/safety/DisasterResponse/PDF/DisasterResponse.pdf

Federal Transit Administration (2007). Transportation Equity in Emergencies: A Review of the Practices of State Departments of Transportation, Metropolitan Planning Organizations, and Transit Agencies in 20 Metropolitan Areas, Office of Civil Rights, Available at http://www.fta.dot.gov/civilrights/civil_rights_6343.html.

First Coast MPO (2004). *Long Range Transportation Plan Update*. Jacksonville, FL.

Fischett, Mark. (2001), Drowning New Orleans, Scientific American (www.sciam.com), Oct.

Flynn, J., P. Slovic, et al. (1994). Gender, Race, and Perception of Environmental Health Risks. Risk Analysis. 14.

Foster, H. (1993) Resilience theory and system evaluation. in J.A. Wise, V.D. Hopkin V D and P. Stager (editors), Verification and Validation of Complex Systems: Human Factor Issues, NATO Advanced Science Institutes, Series F: Computer and Systems Sciences, Vol. 110, Springer Verlag (New York), pp.35-60.

Foster, Harold. (1995), Disaster Mitigation: The Role of Resilience, in D. Etkin (editor) Proceedings of a Tri-lateral Workshop on Natural Hazards, Merrickville, ON, pp. 93-108.

Foster, Harold. (1997), The Ozymandias Principles, Southdowne Press, UBC (www.hdfoster.com).

Fothergill, A. (1996) Gender, Risk, and Disaster. International Journal of Mass Emergencies and Disasters 14(1): 33-55.

Fothergill, A. and L. A. Peek. (2004) Poverty and Disasters in the United States: A Review of Recent Sociological Findings. Natural Hazards. 32.

Fothergill, A., et al. (1999) Race, Ethnicity and Disasters in the United States: A Review of the Literature. *Disasters*. 23.

Geis, D. (1997) Disaster Resistant Communities: A Community-Based Approach to Hazard Mitigation. The Central United States Earthquake Consortium Journal. 4(1): 1-2.

Giuliano, Genevieve and Jacqueline Golog (1998), Impacts of Northridge Earthquake on Transit and Highway Use, Journal of Transport. Statistics, Vol. 1, No. 2 (www.bts.gov), May 1998, pp. 1-20.

Greater Buffalo-Niagara Regional Transportation Council (2007) 2030 Long-Range Transportation Plan for the Erie and Niagara Counties Region. Buffalo, New York.

Guillette, E. A. (1993) The Role of the Aged in Community Recovery following Hurricane Andrew, Natural Hazards Research and Applications Center, University of Colorado, Boulder.

Gundel, S. (2005) Towards a New Typology of Crises. Journal of Contingencies and Crisis Management. 13(3): 106-115.

Hartman, Chester and Gregory D. Squires (eds). (2006) There Is No Such Thing as a Natural Disaster: Race, Class, and Katrina. New York: Routledge.

Hess, Daniel Baldwin and Gotham, Julie C. (2007) Multi-Modal Mass Evacuation in Upstate New York: A Review of Disaster Plans. Journal of Homeland Security and Emergency Management. Vol. 4 : Iss. 3, Article 11. Available at: http://www.bepress.com/jhsem/vol4/iss3/11

Higgins, Laura L., Mark D. Hickman, and Cynthia A. Weatherby (1999). Role of Public Transportation Operations in Emergency Management: Research Report. Texas Transportation Institute, College Station, Texas.

Homer-Dixon, Thomas (2007) The Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization. Washington, D.C.: Island Press.

Hughes, Polly R. (2007) Registration lagging for evacuation help; Officials hope those in need won't wait until the next hurricane to seek assistance. The Houston Chronicle. 7 July: 1A.

Husdal, J. (2004). Why reliability and vulnerability should be an issue in road development projects. Samferdsel: Journal of the Norwegian Institute of Transport Economics http://www.toi.no/samferdsel and http://www.husdal.com

Iannuzziello, Angela. (2001). Communicating With Persons With Disabilities In A Multimodal Transit Environment, Transit Cooperative Research Program TCRP Synthesis 37, National Academy Press. Washington, D.C.

Interagency Coordinating Council on Emergency Preparedness and Individuals with Disabilities (ICCEPID) (2008). Accessed 11 April 2008, http://www.dhs.gov/xprepresp/committees/editorial_0591.shtm

Jenkins, Pamela, Shirley Laska, and Gretchen Williamson (2007) Connecting Future Evacuation to Current Recovery: Saving the Lives of Older People in the Next Catastrophe. *Generations*, Vol. 31, No. 4: pp 49-52.

Jenkins, R., B. Smith, et al. (2000) Lessons Learned About Transportation Operations During Major Evacuations. Transportation Operations During Major Evacuations: Hurricane Workshop. Atlanta, GA.

Kettl, Donald F. (2006), The Worst Is Yet to Come: Lessons from September 11 and Hurricane Katrina, Fels Institute of Government, University of Pennsylvania (www.fels.upenn.edu/fgrs_reports.htm#05-01).

Kim, Sangho, Shashi Shekhar, and Jeffrey Wolff. (2007) Software Tools to Compare Transportation Modes for Car-less Evacuation. National Conference on Disaster Planning for the Carless Society, New Orleans, LA.

Kunzelman, Michael. (2007) Costs of buses triples for state's hurricane evacuation plan. The Associate Press State and Local Wire. 1 June 2007, Accessed via LexisNexis Academic, 12 August 2007, http://web.lexis-nexis.com

Laska, Shirley**,** and Betty Morrow. (2006) Social Vulnerabilities and Hurricane Katrina: An Unnatural Disaster in New Orleans. Journal of the Marine Technology Society 16–26 (2007).

Levinson, Jay and Hayim Granot. (2002). Transportation disaster response handbook. New York and San Diego: Academic Press.

Lindell, Michael, Jing-Chein Lu, & Carla Prater. (2005). “Household Decision Making and Evacuation in Response to Hurricane Lili.” Natural Hazards Review Vol. 6, No. 4.

Litman, Todd. (2006) “Lessons From Katrina and Rita: What Major Disasters Can Teach Transportation Planners,” Journal of Transportation Engineering (http://scitation.aip.org/teo), Vol. 132, January 2006, pp. 11-18; also presented at the 85th Transportation Research Board Annual Meeting, January, 2006; at www.vtpi.org/katrina.pdf.

Litman, T., Blair, R., Demopoulos, B., Eddy, N., Fritzel, A., Laidlaw, D., Maddox, H., Forster, K., (2002), Pedestrian and bicycle planning: A guide to best practice**,** Victoria Transport Policy Institute, Victoria, Canada.

Liu, Rongfang (Rachel) and Hindy Lauer Schachter. (2007) Emergency Response Plans and Needs of Communities with Limited English Proficiency. Transportation Research Record: Journal of the Transportation Research Board, No. 2013, Washington, D.C., 2007, pp. 1–7.

Liu, R., and H. L. Schachter. (2004) Assessing Mobility Information Needs of Limited English Proficiency Travelers in New Jersey. Presented at 83rd Annual Meeting of the Transportation Research Board, Washington, D.C.

Lockwood, Stephen, John O’Laughlin, David Keever, and Karen Weiss. (2005). Surface Transportation Security, Volume 6: Guide for Emergency Transportation Operations. National Cooperative Highway Research Program (NCHRP) Report 525, Transportation Research Board (www.trb.org); at http://trb.org/publications/nchrp/nchrp_rpt_525v6.pdf.

Lui, Meizhu, Emma Dixon and Betsy Leondar-Wright (2006) Stalling the Dream: Cars, Race and Hurricane Evacuation, United for a Fair Economy, Boston, MA.

Martin, S.T. (2005) Can We Learn from Cuba’s Lesson. St. Petersburg Times, 9 September 2005, Accessed 8 August 2007 at
http://www.sptimes.com/2005/09/09/Worldandnation/Can_we_learn_from_Cub.shtml

McKerlie, D. (1989) Equality and Time. Ethics 99.

Meyer, Michael D. (2002) The Role of the Metropolitan Planning Organization (MPO) In Preparing for Security Incidents and Transportation System Response. AMPO Web site: http://www.planning.dot.gov/Documents/Securitypaper.htm.

Mileti, D., T. Drabek, et al. (1975). Human Behavior in Extreme Environments. Boulder, CO., Institute for Behavioral Sciences-University of Colorado.

Moore, Martha T. (2005) States Review Evacuation Plans for the Elderly, the Disabled." USA Today 30 Dec. 2005: 4a.

Moore, H. (1958). Tornadoes Over Texas. Austin, University of Texas Press.

Morduch, J. (1994). Poverty and Vulnerability. American Economic Review. 84.

Morlok, Edward K. and David J. Chang (2004), Measuring Capacity Flexibility of a Transportation System, Transportation Research A, Vol. 38, No. 6 (www.elsevier.com), July 2004, pp. 405-420.

Morrow, B.H. (2002) Community Rebuilding since Hurricane Andrew. National Hurricane Conference, Orlando, FL. April.

Morrow, B. H. (1999) Identifying and Mapping Community Vulnerability. Disasters. 23.1: 1-18.

Morrow, B. H. (1997) Stretching the Bonds: The Families of Andrew. Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters. W. G. Peacock, B. H. Morrow and H. Gladwin. London, Routledge.

Nagel, T. (1991) Equality and Partiality. Oxford, Oxford University Press.

National Council on Disability. (2005) Saving Lives: Including People with Disabilities in Emergency Planning. Available at http://www.ncd.gov/newsroom/publications/2005/saving_lives.htm

New Orleans Regional Planning Commission (2005) Unified Work Plan, New Orleans, LA.

New York City (2007) Ready New York: Preparing For Emergencies In New York City. Office of Emergency Management, City of New York. Available at http://www.nyc.gov/html/oem/downloads/pdf/household_guide.pdf

North Central Texas Council of Governments (2005) Unified Work Program, Arlington, TX.

North Jersey Transportation Planning Authority (2006) Unified Planning Work Program, Newark, NJ.

Okasaki, N.W. (2003) Improving transportation response and security following a disaster. ITE Journal. 71.7: 30-32.

Oliver-Smith, A. (1986) The Martyred City: Death and Rebirth in the Andes. Albuquerque, University of New Mexico Press.

Olsen, M. (1970) Social and Political Participation of Blacks. American Sociological Review 35: 682-697.

Pal, Akhilesh, Andrew J. Graettinger, and Michael H. Triche. (2003) Emergency Evacuation Modeling Based On Geographical Information System Data. Paper Presented at the Annual Transportation Research Board Meeting, Washington, DC.

Palm Beach County (2007) Special Care Unit and Special Needs Shelter, http://www.pbcgov.com/pubsafety/EOC/scu2.htm, accessed on April 24, 2007.

Peacock, W. G. and E. Enarson (1994) Assessing a Community Recovery Function for the ARC Disaster Response Plan. Alexandria, American Red Cross Hurricane Andrew Recovery Project.

Pedersen, Neil J. (1999), Multimodal Transportation Planning at the State Level State of the Practice and Future Issues, A1D01: Committee on Statewide Multimodal Transportation Planning (http://onlinepubs.trb.org/onlinepubs/millennium/00076.pdf).

Perry, Ronald W. and Marjorie R. Green (1982) The Role of Ethnicity in the Emergency Decision-Making Process. Sociological Inquiry, Vol.52, No.4: 307-334.

Phillips, B. D. (1993) Cultural Diversity in Disasters: Sheltering, Housing, and Long Term Recovery. International Journal of Mass Emergencies and Disasters. 11.

Pires, Thiago T. (2005) An Approach for Modeling Human Cognitive Behavior in Evacuation Models. Fire Safety Journal. 40: 177-89.

Pojman, L. P. and R. Westmoreland (1997). Equality: Selected Readings. Oxford, Oxford University Press.

Quarantelli, E. L. (1995). What is a Disaster? International Journal of Mass Emergencies and Disasters 13(3): 221-230.

Quarantelli, E. L. (1997). Ten Criteria for Evaluating the Management of Community Disasters. Disasters 21.

Raphael, Steven and Alan Berube. (2006). Socioeconomic Differences in Household Ownership Rates: Implications for Evacuation Policy.

Renne, John. (2006). Evacuation and Equity: A Post-Katrina New Orleans Diary, Planning, *May*.

Riccardi, Nicholas and James Rainey (2005). Save Yourself: New Orleans Had A Plan To Warn The Poor, But It Sat On A Shelf In L.A., Los Angeles Times (www.latimes.com), 13 Sept. 2005.

Rife, Judy. (2006). Improving the Lincoln Tunnel's Bus Lane in New York, Mass Transit <http://www.masstransitmag.com/article/article.jsp?siteSection=3&id=1729>Accessed 27 October 2006.

RMC (1993). Crowd Control & Event Management: Crowd control and event management requires careful planning. Health and Safety Executive IND(G)142L C1000 293 (www.equicross.us/crowdcontrol.htm).

San Francisco Metropolitan Transportation Commission. (2005). Regional Transportation Plan, San Francisco, CA.

Scanlon, Joseph. (2003). Transportation in emergencies: an often neglected story. Disaster Prevention and Management Volume 12, Number 5, pp. 428-437.

Schwartz, Michael and Todd Litman (2008), Evacuation Station: The Use of Public Transportation in Emergency Management Planning, ITE Journal on the Web, (www.ite.org), pp. 69-73; at www.vtpi.org/evacuation.pdf.

Schachter, Hindy Lauer and Rachel Liu. (2005). Policy Development and New Immigrant Communities: A Case Study of Citizen Input in Defining Transit Problems. Public Administration Review 65(5):614-623.

Setzer, Michael (2007). What to Expect from Your Public Transportation Provider in a Disaster Scenario, Proceedings of the National Conference on Disaster Planning for the Carless Society, 8 February 2007. [Accessed 9 April 2008 at: http://www.carlessevacuation.org]

Sharon, Begley. (2005) Modeling, Simulations Can Help a City Offer More Efficient Exodus. Wall Street Journal 30 Sept.: B1.

Sisiopiku, Virginia P. (2007) Application of Traffic Simulation Modeling for Improved Emergency Preparedness Planning. *Journal* of Urban Planning and Development 133.1: 51.

Stallings, R. A. and E. L. Quarantelli (1985). Emergent Citizen Groups and Emergency Management. Public Administration Review 45.

Steinebaker, Joe. (2007) Authorities plan hurricane evacuation of Rio Grande Valley. The Associate Press State and Local Wire 9 May 2007. LexisNexis Academic. University of New Orleans. 12 Aug. 2007 <http://web.lexis-nexis.com/>.

Stubblefield, H. (2000). Public Safety's Role in Contraflow Evacuations. Transportation Operations During Major Evacuations: Hurricane Workshop. Atlanta, GA.

Swisher, Ralph. (2000). Community & Family Preparedness Conference 2000 Overview. Edited Version of August 30, 2000 Transcript EIIP Virtual Forum Presentation. Retrieved March 30 2007 from http://www.emforum.org/vlibrary/aware.htm

Taylor, A.J.W. (1989) Disasters and Disaster Stress, AMS Press, New York.

U.S. Census Bureau (2007) Facts for Features: Americans with Disabilities Act: July 26. 29 May 2007. 8 July 2007 <http://www.census.gov/Press-Release/www/2007/cb07ff-10.pdf>.

US Census Bureau. (2007) Population pyramids and demographic summary indicators for U.S. Regions and Divisions. Washington, DC. <http://www.census.gov/population/www/projections/regdivpyramid.html>.

U.S. Department of Homeland Security. (2006) Nationwide Plan Review Phase 1 Report, Washington, DC.

U.S. Department of Transportation (2005). Effects Of Catastrophic Events On Transportation System Management And Operations: New York City- September 11. U.S. Department of Transportation; at www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_te/14129.htm.

U.S. Department of Transportation. (1994) Federal Transit Administration. Transit System Security Program Planning Guide, Transit Security Procedures Guide Research and Special Programs Administration Final Report.

U.S. Department of Transportation and the U.S. Department of Homeland Security. (2006). Congress on Catastrophic Hurricane Evacuation Plan Evaluation: A Report to Congress, June 1, 2006. at http://www.fhwa.dot.gov/reports/hurricanevacuation Accessed 5 September 2006

U. S. Government Accountability Office, (2006) Transportation-Disadvantaged Populations: Actions Needed to Clarify Responsibilities and Increase Preparedness for Evacuations (GAO-07-44), Report to Congressional Committees, December.

U.S. Government Accountability Office. (2007). Transportation-Disadvantaged Populations: Actions Needed to Clarify Responsibilities and Increase Preparedness for Evacuations (GAO-07-44), Washington, D.C.: Author.

Urbina, E. and B. Wolshon. (2003) National Review of Hurricane Evacuation Plans and Policies: A Comparison and Contrast of State Practices. Transportation Research, Part A: Policy and Practice, Vol. 37, No. 3, pp. 257-275.

Wallrich, Burt. (2005). Disaster Warnings: The Problem of the Last Step Reaching the Hardest-to-Reach With Critical Information. Conference Proceedings of Virtual Symposium, Early Warning Systems – Interdisciplinary Observations and Policies from a Local Government Perspective. Public Entity Risk Institute. Accessed April 2007 from https://www.riskinstitute.org/peri/images/file/PERI_Symposium_Wallrich.pdf

Walter Gillis Peacock, Betty Hearn Morrow, and Hugh Gladwin (Eds). (1997). Hurricane Andrew: Ethnicity, gender and the sociology of disasters. London and New York: Routledge.

Weikel, Dan. (2006) They've Got a Ticket to Ride. Los Angeles Times 8 Oct., home edition ed.: 1.

White, G. W., Fox, M. H., Rooney, C., & Cahill, A. (2007). Assessing the impact of Hurricane Katrina on persons with disabilities. Lawrence, KS: The University of Kansas, The Research and Training Center on Independent Living.

White, G. and G. Haas (1975). Assessments of Research on Natural Hazards. Cambridge, MA., MIT Press.

Willegen, Marieke, Bob Edwards, Stephanie Lormand, and Ken Wilson. (2005). Comparative Assessment of Impacts and Recovery from Hurricane Floyd among Student and Community Households. Natural Hazards Review Vol. 6, No. 4.

Wilmot, C. G. (2004). Data Collection Related to Emergency Events. The International Steering Committee for Travel Survey Conferences', 7th International Conference on Travel Survey Methods. Costa Rica.

Wilmot, Chester G. and Bing Mei. (2004). Comparison of Alternative Trip Generation Models for Hurricane Evacuation, Natural Hazards Review, November, pp. 170-178.

Wilson, Frank. (2005). Houston METRO's Hurricane Squared Response, Passenger Transport, 24 Oct. 2005.

Wolshon, Brian. (2007) Micro-level Simulation of Regional Multimodal Evacuations: A New Orleans Case Study. Delivered at National Conference on Disaster Planning for the Carless Society, Feb 9.

Wolshon, Brian. (2001). One-Way-Out: Contraflow Freeway Operation for Hurricane Evacuation. Natural Hazards Review Vol. 2, No. 3, pp. 105-112.

Wolshon, B. (2007) Contraflow for Evacuation Traffic Management, Encyclopedia of Geographical Information Science, New York: Springer Publishing Inc.

Wolshon, B. (2002) Planning for the Evacuation of New Orleans, ITE Journal, Institute of Transportation Engineers, February 2002, Vol. 72, No. 2, pp. 44-49.

Wolshon, Brian and Brandy Hicks Meehan. (2003). Emergency Evacuation: Ensuring Safe and Efficient Transportation out of Endangered Areas. TR News 224 January-February.

Wolshon, Brian. (2008a). Empirical Characterization of Mass Evacuation Traffic Flow, Transportation Research Record - The Journal of Transportation Research Board, (forthcoming).

Wolshon B. and B. McArdle, Temporospatial Analysis of Hurricane Katrina Regional Evacuation Traffic Patterns, ASCE Journal of Infrastructure Systems – Special Infrastructure Planning, Design, and Management for Big Events Issue, (forthcoming).

Wolshon, Brian and Brandy Hicks Meehan. (2003). Emergency Evacuation: Ensuring Safe and Efficient Transportation out of Endangered Areas. TR News 224 January-February.

Wolshon, Brian, Elba Urbina, and Marc Levitan. (2001). National Review of Hurricane Evacuation Plans and Policies. LSU Hurricane Center.

Wolshon, Brian, Elba Urbina, Chester Wilmot, & Marc Levitan. (2005). Review of Policies and Practices for Hurricane Evacuation. I: Transportation Planning, Preparedness, and Response. Natural Hazards Review Vol. 6, No. 1.

Wolshon, B., J. Lefante, H. Naghawi, J. Renne, P. Haughey, and W. Dufour. (2008) Application of TRANSIMS for the Multimodal Microscale Simulation of the New Orleans Emergency

Evacuation Plan, Draft Final Report, United States Department of Transportation, Federal Highway Administration, Washington, DC.

Zelinsky, Wilbur & Leszek Kosinsky. (1991). The Emergency Evacuation of Cities: A Cross-National Historical and Geographical Study. Savage, Maryland: Rowman & Littlefield Publishers.

Zimmerman, R., C. Restrepo, B. Nagorsky, and A. Culpen. (2007). Vulnerability of the Elderly during Natural Hazard Events, Proceeding of the Hazards and Disasters Researchers Meeting, Boulder, Colorado, July 11-12, 2007, pp. 38 – 40.