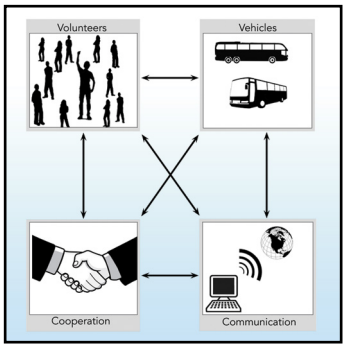
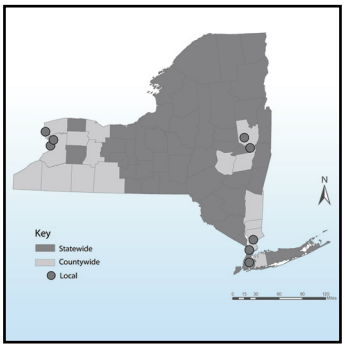
MCEER
EARTHQUAKE ENGINEERING TO EXTREME EVENTS

ISSN 1520-295X

Enhancing Resource Coordination for Multi-Modal Evacuation Planning

by
Daniel B. Hess
with Brian W. Conley and Christina M. Farrell





Technical Report MCEER-13-0002
February 8, 2013

This research was conducted at the University at Buffalo, State University of New York, and was supported by the University Transportation Research Center, The City College of New York, under subcontract no. 49111-30-21.

NOTICE

This report was prepared by the University at Buffalo, State University of New York, and was supported by the Research Foundation of CUNY on behalf of University Transportation Research Center – Region 2, The City College of New York, Subcontract No. 49111-30-21. Neither MCEER, associates of MCEER, its sponsors, the University at Buffalo, State University of New York, nor any person acting on their behalf:

a. makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe upon privately owned rights; or

b. assumes any liabilities of whatsoever kind with respect to the use of, or the damage resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of MCEER or its sponsors.

MCEER
EARTHQUAKE ENGINEERING TO EXTREME EVENTS

Enhancing Resource Coordination for Multi-Modal Evacuation Planning

by

Daniel B. Hess[1]
with Brian W. Conley[2] and Christina M. Farrell[2]

Publication Date: February 8, 2013
Submittal Date: December 1, 2012

Technical Report MCEER-13-0002

University Transportation Research Center
The City College of New York
New York, New York
Subcontract No. 49111-30-21

1 Associate Professor, Department of Urban and Regional Planning, University at Buffalo, State University of New York
2 Graduate Student, Department of Urban and Regional Planning, University at Buffalo, State University of New York

MCEER
University at Buffalo, State University of New York
133A Ketter Hall, Buffalo, NY 14260
Phone: (716) 645-3391; Fax (716) 645-3399
E-mail: *mceer@buffalo.edu*; WWW Site: *http://mceer.buffalo.edu*

Preface

MCEER is a national center of excellence dedicated to the discovery and development of new knowledge, tools and technologies that equip communities to become more disaster resilient in the face of earthquakes and other extreme events. MCEER accomplishes this through a system of multidisciplinary, multi-hazard research, in tandem with complimentary education and outreach initiatives.

Headquartered at the University at Buffalo, The State University of New York, MCEER was originally established by the National Science Foundation in 1986, as the first National Center for Earthquake Engineering Research (NCEER). In 1998, it became known as the Multidisciplinary Center for Earthquake Engineering Research (MCEER), from which the current name, MCEER, evolved.

Comprising a consortium of researchers and industry partners from numerous disciplines and institutions throughout the United States, MCEER's mission has expanded from its original focus on earthquake engineering to one which addresses the technical and socio-economic impacts of a variety of hazards, both natural and man-made, on critical infrastructure, facilities, and society.

The Center derives support from several Federal agencies, including the National Science Foundation, Federal Highway Administration, National Institute of Standards and Technology, Department of Homeland Security/Federal Emergency Management Agency, and the State of New York, other state governments, academic institutions, foreign governments and private industry.

The University Transportation Research Center - Region 2, through funding from the Research Foundation of the City University of New York, supported a study entitled "Barriers to Resource Coordination for Multi-Modal Evacuation Planning." Extreme events that require mass evacuation are a great concern for disaster planners and emergency managers; most state and local municipalities are ill-prepared to handle mass evacuations from urban areas. A lesson repeatedly learned from previous disasters (such as Hurricane Katrina) is that residents without access to automobiles and residents in need of special assistance are more likely to lack the means to evacuate independently. Developing integrated plans for jurisdictions and agencies to share resources (vehicles, equipment, communication networks, drivers and other personnel) for high-capacity evacuation methods and modes is difficult because of insurance, liability, and other legal and contractual matters. This research examines a unique combination of elements: disaster planning, large-scale urban evacuation, and coordination of volunteer transportation professionals to increase knowledge about coordinating effective multimodal evacuation for disasters.

This report presents the findings of the research project. It identifies strategies for evacuation of all residents, including carless residents during a disaster. It also addresses the challenges of effectively incorporating multi-modalism into local emergency plans by enhancing transportation

resource coordination through exploration of the feasibility of a new concept—a Transportation Reserve Corps (TRC). A TRC seeks to integrate planning for households without automobiles, multi-modal evacuation, and coordinated volunteerism with disaster preparedness, response and recovery. Specific action steps needed to conduct a pilot test of a TRC are provided.

.

Executive Summary

This research project seeks to increase knowledge about coordinating effective multi-modal evacuation for disasters. It does so by identifying, evaluating, and assessing current transportation management approaches for multi-modal evacuation planning. The research increases equity by identifying strategies for evacuation of all residents, including carless residents during a disaster. The research also seeks to address the challenges of effectively incorporating multi-modalism into local emergency plans by enhancing transportation resource coordination through exploration of the feasibility of a new concept—a **Transportation Reserve Corps (TRC)**. A **TRC** seeks to integrate planning for households without automobiles, multi-modal evacuation, and coordinated volunteerism with disaster preparedness, response and recovery.

Background

In an effort to understand the unique and complicated nature of disaster planning, we review published research about disaster preparedness, response, and recovery, especially as they relate to multi-modal evacuation. Although the federal government plays an integral role in disaster response, the primary authority during times of disaster still rests with state government. Most states place the decision to evacuate a locale with municipal leadership, specifically the chief executive officer of that municipality, if not the chief executive (*i.e.*, Governor) of the state. This structure can generally be viewed as bottom-up, placing the authority to respond to a disaster or mandate an evacuation principally on the affected jurisdiction in ascending order: village, town, city, county, state.

Many types of emergency events may or may not necessarily warrant an emergency evacuation depending on numerous interwoven and unpredictable variables. Several factors determine whether or not an evacuation should, or will, occur in the event of an emergency. While some of these factors are based on types of emergency incidents—natural, technological, or malevolent acts—others are largely based on the preparedness of the community to handle a large-scale evacuation. These preparedness efforts include understanding the demographic composition of the community and the level of preparedness and training possessed by both community members and local government. In practice, the decision to undertake an evacuation, either by a municipality or by an individual, may not be entirely reliant upon a concrete set of factors. Whether or not to mandate an evacuation therefore arises as a "wicked problem" in that it most often cannot be determined by a replicable, systematic formula. Ultimately, during a crisis, people will pursue the action that they judge to be the best for their safety and well-being.

The Challenge of Multi-modal Evacuation

Planners, engineers, and government officials face the challenge of establishing integrated systems that not only promote equitable and sustainable urban futures but serve as efficient systems for mass evacuation when there is a mandated evacuation. The first, and arguably the most important reason, is that there are approximately 10.4 million "carless" households in the U.S. (or about 9.1 percent of all households). In addition to families without access to automobiles, carless people also include (1) those who live at home but are sick, disabled and/or elderly and (2) people who live in institutions such as hospitals, nursing homes, and prisons. While evacuating the carless is the most pressing reason for planners to consider in multi-modal transportation evacuation, reliance on single-occupancy vehicles in an evacuation can jeopardize an entire populations' safety; when private automobiles are the primary source of transportation during an evacuation, traffic congestion in urban areas is likely to limit evacuation capability. Furthermore, multi-modalism is particularly important for emergency response and evacuation planning because it provides travel options that can accommodate diverse and uncertain needs that are the linked to a disaster. High-capacity vehicles can be a resource for people with various mobility limitations, long-distance evacuations, and resource limitations such as road space, vehicles and fuel.

Despite the importance of integrating multi-modal transportation into evacuation planning, many state and local governments do not have the appropriate plans, training, and exercises to evacuate households without automobiles. Strategies for effectively evacuating households without automobiles include pre-identifying the carless; providing vehicle inventories and instructions in advance to emergency responders; communicating with vulnerable populations about available assistance and transit and how to access it; and convincing evacuees to use that assistance to leave early. Transportation plans for disasters must include the quick and efficient deployment of high-occupancy vehicles. Such deployment requires an inventory of vehicles and their drivers, clear instructions for vehicle use, oversight of fuel, emergency repair and other support services, and proper coordination of these elements. Inventorying available transportation resources and matching carless individuals with appropriate and available modes of transportation, however, are challenges that planners face.

A number of legal and practical constraints make it difficult and expensive to incorporate multi-modal transportation into local emergency planning. Mutual aid agreements with neighboring jurisdictions and collaborative contracts and funding agreements with private providers can help ensure that transit vehicles, equipment, and trained drivers are available to meet surge requirements in an evacuation, but there are barriers to mutual aid agreements and legal obstacles that continue to discourage private-sector involvement. These issues include obtaining client medical information; the private-sector's vulnerability to lawsuits; the private sector's uncertainty about adequate reimbursement for services provided during a disaster; unified coordination between visiting units and hometown dispatchers; a lack of driver training; and

employees not reporting to work during an emergency for fear of their own and especially their family's safety.

Another problem is that jurisdictional and inter-organizational complexity may render transportation management in the event of disaster exceptionally difficult. This was illustrated during Hurricane Katrina, where one of the biggest problems was how quickly civilian, local, state, and federal government organizations were overwhelmed. Improving inter-jurisdictional collaboration through disaster preparedness efforts—such as established protocols, training and communication—may be an effective way to increase the effectiveness of multi-modal transportation during large-scale urban evacuations.

Funding for evacuation-related operations and capital expenses for multi-modal transport is another frequently cited concern related to emergency planning. It is widely understood that there is a lack of sufficient transportation resources and the unlikelihood of an adequate number of vehicles being effectively deployed during a disaster. Recognizing the severity of consequences likely caused by this lack of adequate emergency transportation, various scholars have recommended the establishment of a new organization to fill this void.

Volunteerism in Emergency Planning

The limitations in local evacuation plans, a lack of coordination among various levels of government, and considerable disparities which obstruct communications between authorities and vulnerable populations during emergency situations can be addressed with a community-based volunteer organization. Some such volunteer groups already exist, generally falling under the national Citizen Corps umbrella, to address issues related to disasters and emergency response. The Citizen Corps is a forum where all individuals and organizations are invited to educate themselves on disaster preparedness and logistics in efforts to safeguard communities from harm. The Citizen Corps was established in the aftermath of the terrorist attacks of September 11, 2001 to embrace the irrepressible community spirit that invariably arises when a disaster strikes. In the period since, this organization has grown to a national network of 1,175 locally-based Citizen Corps Councils. By all accounts, its membership has proven to uphold the organization's mission of coordinating community volunteers in order to build more resilient and secure communities. The Citizen Corps lists five partner programs—the most relevant to our research being the Medical Reserve Corps (MRC). Through this structured organization, willing medical and public health professionals are deployed more effectively during emergency response. The MRC exemplifies the administrative and procedural framework required for the effective management of any volunteer emergency response organization.

Transportation Reserve Corps

A **Transportation Reserve Corps** (**TRC**) is envisioned to be a volunteer-driven, community-supported organization for assisting primarily with the movement of people, but also supplies and goods during an extreme event or disaster—large or small. The main objective of a **TRC** is to assemble trained and licensed transportation coordinators and drivers (especially in situations where there are not sufficient drivers and vehicles to evacuate a population at risk) to conduct evacuations of buildings, neighborhoods, districts, cities or even entire metropolitan regions.

A **TRC** is not a transportation provider in the traditional sense. A **TRC** will not own, nor can it acquire high-capacity vehicles during an evacuation. Its primary role is coordinator of high-capacity vehicles, drivers, equipment and fuel that already exist in a community. A **TRC** will use a highly sophisticated system of training, credentialing, and mutual aid that co-mingles public transit agencies and private transportation providers, private citizens, and any related and supplemental organizations to accomplish its objectives.

The goals of a **TRC** in no way interfere with existing local evacuation plans. On the contrary, a **TRC** can provide outstanding support for communities that possess emergency plans and can serve as an important component of existing emergency infrastructure such as the emergency management communications plan and the Incident Command System (ICS). Likewise, **TRC** functions would not supersede or replace emergency procedures at facilities that already have thorough evacuation plans such as hospitals or nursing homes. Instead, it could aid in this type of an evacuation through resource coordination or could act as a "back-up" when drivers and vehicles have been exhausted. Furthermore, **TRC** volunteers are not designed to take the place of on-duty, professional emergency responders or vehicle drivers expected to act during an emergency, but rather a **TRC**'s volunteers' roles are to supplement and/or relieve these first responders. This is an important function of a **TRC** because a large-scale disaster may demand the evacuation or movement of people and goods exceeding the capacity of existing emergency response networks. A **TRC**'s most valuable resources are its drivers; however, a **TRC** is not designed to train and certify drivers and assumes that drivers already possess the proper licensure. A **TRC** may, however, offer training for various emergency preparedness topics.

A **TRC,** positioned to focus much of its effort on preparedness while also functioning as a response and recovery organization, is an effective model for achieving its objectives. Preparedness efforts include (1) volunteer (both driver and non-drivers) recruitment, enrollment via online registration, volunteer licensure and credential checks, and volunteer emergency training, (2) resource management: inventorying volunteers, high-capacity vehicles, equipment and fuel, (3) procedures and protocols: establishing communication systems with public transit agencies, private transport providers, and volunteers; establishing mutual aid agreements; and achieving integration in a

meaningful way with existing emergency plans, emergency management organizations, and a community's Incident Command System.

Transportation Reserve Corps Key Facts

Profile	A volunteer-driven, community-supported organization for assisting primarily with the movement of people, but also supplies and goods during an extreme event or disaster.
Objective	To better integrate planning for households without automobiles, multi-modal evacuation, and coordinated volunteerism with disaster preparedness, response and recovery.
Motivation	People who are unable to self-evacuate during a disaster—carless, young, old, people in institutions, people with disabilities—are the most vulnerable to injury or death; reliance on single-occupancy vehicles in an evacuation can have detrimental effects on an entire populations' safety; multi-modalism provides travel options that can accommodate diverse and uncertain needs and unpredictable resource limitations common in emergency situations.
Emergency Planning	**TRC** does not create new emergency plans. It assists a jurisdiction in implementing its plan during the event of a disaster, with a focus on equity.
Resources	Volunteers (including vehicle drivers and non-drivers), high-capacity vehicles, maintenance equipment, fuel.
Coordination	With a community's carless population, the jurisdiction's Incident Command System, **TRC** volunteers, public transit agencies and private transport organizations, and other emergency management organizations.
Mutual Aid	Local, regional, state, interstate, federal, international.
Comparable Organizations	CERT and MRC share some characteristics.

Transportation Reserve Corps Operations

When a disaster is declared, an Incident Command System (ICS) provides coordinated and collaborative incident management in a community, especially where additional resources are required or are provided from various organizations within a single jurisdiction or outside a jurisdiction. It is imperative that a **TRC** be absorbed into an already established ICS because it is this call for additional resources that is the main function of a **TRC;** and because a **TRC** is reliant upon effective cross-jurisdictional and departmental coordination. When a request for resources from a **TRC** is made, a **TRC**, consistent with the procedures and protocols already established within the ICS, would communicate with appropriate transportation agencies and companies or volunteers to mobilize. The nature of an incident, more than anything else, decides the type and quantity of resources to be mobilized. A **TRC** would only respond with drivers, equipment or vehicles when requested by an appropriate authority, as previously established in preparation for activation.

TRC recovery actions would involve demobilization—the systematic and safe return of vehicles and volunteers to their places of origin or another secure location. A **TRC** would need to prepare for a demobilization process as soon as resources are mobilized in order to facilitate accountability, provide for the safety and well-being of volunteers, and provide efficient service. While the major role of a **TRC** is to better serve the carless population and those who cannot self-evacuate during an urban evacuation, a **TRC** could act in other important disaster recovery roles as long as liability insurance and mutual aid agreements are still in place. These recovery efforts could include traffic management, debris removal (employing volunteers trained to operate heavy machinery), pandemic relief (when citizens are confined to homes to slow spread of disease, but food and supplies must be distributed), and assistance in returning people to their homes after an evacuation.

Establishing a Transportation Reserve Corps

Other volunteer disaster response organizations, such as an MRC, operate through a nationally-based top-down structure, but there may be more interest in developing a **TRC** at the state level than at the federal level. This being said, as **TRC** response will require swift deployment of volunteer drivers, **TRC** units would be most effective if appropriate administrative models were developed at the local or county level. The first model might be to establish a new, independent home for a **TRC**. The second may be to house a **TRC** within an existing regional governmental agency such as city or county's emergency service organization, regional transportation organization or metropolitan planning organization (MPO). The third might be to house and share administrative functions with a community's existing formal volunteer organization associated with extreme events and disasters, and health and medicine. When deciding upon an appropriate administrative model for a **TRC**, a number of factors such as existing communication systems, technology, infrastructure, staffing and financial capacity would need to be taken into consideration. Dependent upon these factors, emergency managers should determine if a **TRC** could be absorbed into the operations of an existing organization or if a **TRC** would benefit from becoming an independent start-up organization that shares resources or partners with other emergency response and planning organizations.

Federal, state, and local funding sources will be needed to pilot and permanently establish a **TRC**. Funding for a **TRC** in the form of emergency preparedness grants could be sought from the U.S. Department of Homeland Security, U.S. Department of Transportation, U.S. Center for Disease Control, U.S. Department of Health and Human Services Health Resources and Services Administration. On a more local level, state offices of emergency management and transportation, local Metropolitan Planning Organizations (MPOs) for coordinated transportation planning, community foundations, local fundraising efforts, and mutually-beneficial partnerships (*i.e.*, partnering with local nuclear power plants were also suggested). Funds could be collected privately to support local TRC efforts, through an organization like the American Automobile Association, which could collect $1 (voluntarily) from new

members and renewal members to support local evacuation planning for manmade and natural disasters.

The geographic setting of a **TRC** is the dominant factor in determining the types of disaster to which its membership must be prepared to respond. The size of an area, in terms of both geographical coverage as well as population, has a tremendous impact on the practicality and functionality of a **TRC**. Other spatial dynamics, such as the likely types of natural disasters for any geographic region, should also play a large role in determining the feasibility and operating considerations of any application of a **TRC** model. Research gathered through the interview process suggests that a **TRC** is best suited to mid-sized metropolitan areas, where some or all of the supporting structure (organizations, leadership, written plans, vehicles, expertise) for a **TRC** is in place. These elements may not be in place in small cities and rural areas.

Research Findings

A majority of emergency management professionals consulted in the development of this report identified potential challenges in establishing a **TRC**. These discussions, supplemented by a review of relevant laws and literature, generally fall under four categories; (1) providing liability coverage and insurance for a **TRC**, its volunteers, and its vehicles, (2) ensuring that **TRC** volunteers possess the training and credentials necessary to respond to emergency events, (3) securing resources through legal agreements, inter-organizational reciprocity and reimbursement and (4) ensuring that a **TRC** is sustainable and functional. This report addresses these challenges and expands upon the scope of existing evacuation organizations that utilize volunteers, such as Evacuteer in New Orleans.

Having refined and detailed a **TRC**'s approach to transportation resource coordination for multi-modal evacuation, and identified its challenges, there are several actions steps we recommend for further research and to begin implementation of a **TRC**. These steps include (1) advocating for the inclusion of multi-modalism in emergency planning, (2) developing a plan for broad volunteer recruitment, and (3) further research about four key topics: (a) defining an organizational structure and business plan, (b) identifying permanent funding sources, (c) identifying best practices in the use of mutual aid agreements, taking into consideration identified challenges such as liability, reciprocity and reimbursement, and legality—especially in instances where adjacent states have conflicting laws—that could require modifications to state and federal legislation, and (d) vehicle modification and technological additions that could assist multi-modal evacuation of the carless population during large-scale disasters. In addition, a smartphone app could be developed to link evacuees with volunteer **TRC** members during a disaster.

The final action step is to launch a pilot test of a **TRC**. Using the outcomes of our research, we present recommendations on a suggested process to establish a pilot

program including location choice, community outreach, conducting an initial tabletop exercise, a work plan for preparedness activities, completing a pilot emergency response exercise, and assessing the results.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge individuals who served as an ad-hoc advisory committee for this project: Todd Litman, Deborah Matherly, Adel Sadek, Tom Sanchez, and Rae Zimmerman. Others who shared their insights include John Adolf, Nadia Aslam, Rich Barone, Connie Beroza, Edward Blakely, Tracy Chalmers, Leo Chiang, Shoshana Cooper, Bill Correa, Ray Davis, Dario Diaz, Kelly Dixon, Penny Eickemeyer, Theodore Fisch, J.T. Glass, Eric Goldwyn, Donald Goralski, James Griglio, David Heitner, Athena Hutchins, David King, Katharine Logan, Andrew Mark, Alex Marshall, Dean Messing, David Musick, Michael Perillo, Rob Pirani, Amy Post, Megan Pribram, Jim Reger, Nicholas Ronderon, Carl Sadowski, Herman Schaffer, Dan Schned, Greg Skibitsky, Harry Smith, Michael Smith, Eric Snyder, Ken Turner, Tom Vaughan, Ed Welch, and Jason Wind. Ernest Sternberg helped develop the idea for a Transportation Reserve Corps and Matthew Wattles assisted in preparation of the manuscript.

Contents

Contents (Cont'd)

Contents (Cont'd)

Contents (Cont'd)

List of Illustrations

List of Tables

1. Introduction

In 2004, the federal interagency Homeland Security Council (2004) identified fifteen planning scenarios for domestic catastrophic emergencies (Lipton, 2005). They include the detonation of a 10-kiloton nuclear device, large-scale delivery of aerosolized anthrax, release of pneumonic plague; chlorine tank explosion; major earthquake, major hurricane; and detonation of a radiological dispersal device. An enormous ensuing challenge in each of these scenarios, when warranted by a disaster, is urban evacuation, as the majority of the U.S. population (about 80 percent) lives in urban settings and metropolitan areas (RAND Health, 2009).

Though there are roles for airlift and sealift and for pedestrian movement, urban evacuation is predominantly a terrestrial vehicular logistical challenge. As the Hurricane Katrina disaster revealed, the greatest difficulty is the evacuation of the "carless" population—people who cannot drive, do not possess a vehicle, or cannot independently evacuate themselves and their families—including those who are sick and disabled. Though state and municipal organizations have evacuation plans, they—we argue—do not have the organized vehicles and drivers, or the logistical capacities, for collecting large numbers of people with buses and other vehicles under time constraint and distributing them to safe receiving destinations, perhaps, in a multi-state region.

According to a 2007 Rand Institute study of the governmental response to Hurricane Katrina, one of the greatest obstacles to the provision of relief was the insufficiency of transportation assets and personnel (Rand Corporation, 2007). Disasters that generate large-scale evacuation are a great concern for disaster planners and emergency managers. New York State is especially vulnerable to disasters. New York City is the largest urban area in the U.S. and one of the largest international trade centers, and it has historically been a target for international terrorism as evidenced by the World Trade Center attacks in 1993 and 2001.

This research project increases knowledge about the barriers to coordinate multi-modal evacuation for disasters. The research also increases equity by identifying strategies for evacuation of all residents, including carless residents, in high-capacity vehicles during a disaster. Recent studies of evacuation plans reveal that several U.S. large metropolitan regions fail to address the needs of special population groups without automobiles (American Highway Users Alliance 2006; Renne, 2006), especially the disabled, elderly, and lower-income transportation-disadvantaged groups. A growing concern is the vulnerability of the special needs population, especially as the baby-boom generations age (Renne, 2006). Another area given inadequate attention is evacuation planning from facilities such as employment centers, shopping centers, schools, universities, or places with clients or resident populations in institutions such as hospitals, nursing homes, prisons or detention centers.

1.1 The Context: Multi-Modal Evacuation Planning

Despite efforts made by the Department of Homeland Security (DHS) and Department of Transportation (DOT) to improve federal response to catastrophic disasters in the Hurricane Katrina aftermath, the role of federal agencies is not clarified in leading, coordinating, and supporting evacuation assistance for the transportation disadvantaged. DOT is the lead and coordinating agency for "provision of federal and civil transportation services, and the recovery, restoration, safety, and security of the transportation infrastructure" (Government Accountability Office [GAO] July 2006, p.12). But its role in evacuation is limited only to "providing technical assistance in evacuation planning to other federal agencies as well as state and local governments" (GAO July 2006, p. 12). In its nationwide plan review, the Department of Homeland Security found that a critical aspect of large-scale evacuation planning is regional coordination. Effective coordination requires enhanced communication among all three tiers of government (local, state and federal) as well as lateral coordination and communication within local governments.

Most state and local municipalities remain ill-prepared to handle large-scale evacuations from urban areas. One of the lessons repeatedly learned from disasters such as Hurricane Katrina is that residents without access to private automobiles and/or in need of special assistance have greater tendency to lack means to evacuate independently (Renne, 2006; Renne, *et al.*, 2009). Twenty-seven percent of all New Orleans households lacked access to an automobile in 2000. But during the evacuation for Hurricane Katrina, public transportation in high-capacity vehicles was not sufficiently available to evacuate poor, weak, disabled, institutionalized, or hospitalized residents.

In New York State, 28.5 percent of households lack access to an automobile (U.S. Census 2010). One quarter or more of all households in the larger metropolitan statistical areas in New York State do not have access to automobiles—55 percent in New York City, 30 percent in Buffalo, 24 percent in Albany, 26 percent in Syracuse and 25 percent in Rochester (U.S. Census 2010). At the time of Hurricane Katrina in 2005, most population centers in New York State (Albany, Buffalo, New York City, Syracuse) had a higher share than New Orleans of households without vehicle access (Hess & Gotham 2007). Yet, little attention is paid by the state's counties to multi-modal evacuation planning. In New York State, the Office of Emergency Management (NYSOEM) (formerly NYSEMO) provides a downloadable sample plan, titled Empire County Comprehensive Emergency Management Plan, but the majority of New York counties do not consider multiple modes of transportation for emergency evacuation such as buses, trains, ships, planes or even walking and bicycling (Hess & Gotham 2007; NYSEMO, 2004).

The potential for large-scale evacuations is high in New York. New York State ranks fourth among the 50 U.S. states for federally declared disasters in the past forty years (Federal Emergency Management Agency [FEMA] 2006; Hess & Gotham 2007). Flood-related events (77 percent) and other weather events (15 percent) have contributed to the largest share of federal disasters. The state is particularly vulnerable to international terrorist threats from its position as an international trade center and its location next to the U.S.-Canadian border. Other threats emanate from locations near major interstate highways or railroad lines from potential chemical spills or transportation-related disasters. Central New York and the Southern Tier are vulnerable to accidental nuclear power meltdowns or terrorists threats related to power plants.

The "carless" are particularly vulnerable if community lifelines are disrupted in a disaster (National Council on Disability, 2005).[1] Evacuation is more problematic when evacuees are unable to walk or they depend on life-support systems or specialized transport vehicles such as ambulances, accessible buses or vans. Making evacuation even more problematic are the challenges in identifying, locating, and communicating with special needs evacuees. Information is not always readily available nor is it shared with officials responsible for large-scale evacuation at the local level (GAO, May 2006). Compounding these issues is the variation of the needs of these population groups—some need no more assistance than vehicular transportation away from the disaster zone and safe shelter, others require transport vehicles with life support medical assistance, and others need transport vehicles accessible to those with mobility impairments (GAO, May 2006). Planners should also assume that carless evacuees will keep their pets with them, may need a caretaker to accompany them, and will have at least one carry-on bag containing essentials (Regional Plan Association interview, 2012).

Currently, large-scale evacuation plans devote little or no attention to carless populations. According to the Department of Homeland Security, only 10 percent of state planning documents address those who cannot evacuate because of a lack of automobiles (Hess & Gotham, 2007). More than half—56 percent—of the state documents are rated as "not sufficient" because state governments possessed neither a clear understanding of the timelines, expectations, and metrics for evacuations, nor the planning and exercise expertise to fully address large-scale evacuation requirements.

A key problem learned from past disasters is a lack of coordination for local and regional transportation for the responding medical assistance volunteers, patients, and special needs populations (Sternberg & Lee 2009; Tierney, *et al.*, 2001). Conflicts in

[1] This "carless" population includes: the frail and sick, disabled and elderly in their own homes; institutionalized persons in hospitals, nursing homes, and prisons; persons who do not own a car because they cannot afford one; those who as a matter of lifestyle choose not to own one; persons who have illegal or disputed immigration status; persons who own cars but do not currently have access (are cut off by the disaster, car is out of order); and temporary residents, such as tourists and other visitors. For evacuation of the disabled, problems include mobility impairment, need for special medical equipment (such as ventilators), cognitive impairments, sensory impairments (such as blindness, deafness), morbid obesity, transmissible disease, and the special difficulties of transporting infants and other pediatric patients.

missions and institutional differences between public and private providers may exacerbate inter-jurisdictional collaboration for large-scale evacuation. In other words, jurisdictional and inter-organizational complexity may render transportation management in the event of disaster exceptionally difficult, as illustrated by Hurricane Katrina (Sternberg & Lee, 2009).

Non-profit agencies provide special transportation services to the transportation-disadvantaged on a daily basis; these services include meal delivery or lifeline transportation to and from jobs, medical appointments, and other activities (GAO, May 2006). Yet, few inter-jurisdictional arrangements are in place to coordinate with these agencies for multi-modal evacuation, sharing of information about the needs of the transportation disadvantaged and making arrangements for the use of the appropriate equipment for evacuation of the special needs population.

Sternberg and Lee (2009) classify these challenges a "transportation assignment" problem. Agencies are traditionally prepared to manage day-to-day transportation logistics, but in the case of the turbulent conditions in a large-scale evacuation, various agencies may encounter problems in communication, information retrieval, and inter-organizational coordination. Recommendations for enhanced resource coordination that call simply for more investment or best practices are not sufficiently helpful. Based upon analyses of healthcare transportation during disasters, Sternberg and Lee (2009) stress the importance of identifying improvements that are possible within reasonable expectations for additional funding.

Disaster planners frequently give more focus to facility, location, and resource allocation than to integrated multi-modal planning for vehicular traffic, non-vehicular traffic, and life-saving assistance transport. Conventional emphasis on moving vehicles onto regional arterial networks is not always the most expedient or efficient evacuation strategy. Greater reliance on personal motor vehicles for evacuation actually contributes to traffic congestion, civic unrest, and shortages of gas, shelter, and necessities (including inadequate access to washrooms and emergency services). Better planning for transportation sustainability and finding more practical and functional resource coordination solutions can help municipalities avoid billions of dollars in property and productivity losses (Litman, 2006).

If highways are not substantially damaged in a disaster such as an earthquake, highway infrastructure in the U.S. is generally sufficient to allow residents with access to private automobiles to evacuate a large city within two days (Wolshon, 2002). Assuming that communication is sufficient (and not counting contingent disaster effects, such as pandemic, electromagnetic pulse damage, and infrastructure damage), the greatest obstacle is that large numbers of people who need to evacuate will lack access to private automobiles.

The limitations (not in priority order) of coordinated urban evacuation in high-capacity vehicles identified throughout this report include urban transit agencies in disarray; inability to manage the complex and unprecedented logistics; lack of fleet management capability outside the home city; problems of inter-agency and inter-jurisdictional coordination; failure of drivers and other staff to report for duty during an emergency; lack of driver training for emergencies; lack of experience in transporting disabled populations; lack of reciprocal insurance agreements; and lack of capacity to provide gasoline and repair services during emergency conditions.

Given varying expertise for preparing disaster plans—especially large-scale evacuation provisions—and the availability of resources, city, town, and county governments have various opportunities for working collaboratively to prepare appropriate disaster and evacuation plans (Hoard *et al.*, 2005). Getting buy-in from municipal disaster planners and transportation experts to establish coordinated multi-modal transportation plans will take significant time, considerable effort on the part of many stakeholders, and the focus of the country on the failures of several hospitals (subsequent to Hurricane Katrina) (Hess & Arendt, 2006). Yet we know that, in general, connectivity among organizations enables community resilience (Vale & Campanella, 2005).

Analyses conducted by the Department of Homeland Security show local emergency evacuation plans continue to devote little attention to the above challenges (Hess & Gotham, 2007). Most U.S. cities have received billions of dollars from the federal government for planning for emergencies such as fires, floods, toxic spills and terrorist attacks, but serious weaknesses continue to exist in coordination and communication for transportation of evacuees related to a large-scale event. We also know that various efforts have been made by the federal government to provide travel accommodations for the carless during disasters since Hurricane Katrina (FEMA, 2008; GAO, May 2006). However, these measures likely have not overcome a general perception of unpreparedness regarding evacuations among the transportation-disadvantaged community that were reinforced by events surrounding Hurricane Katrina (Cutter & Smith, 2009; Elder, *et al.*, 2007; Dombrowski, *et al.*, 2006).

With these experiences comes heightened awareness of the need for a multi-modal transportation system that is comprehensively planned to better coordinate large-scale evacuations of an entire population (Renne, *et al.*, 2008). Meanwhile, government leaders have recognized the involvement and cooperation of community members in disaster preparedness and recovery as a critical resource in safeguarding communities from disasters (CCC, 2012). Specifically, the use of community-based organizations to address the disconnection in critical communications between emergency officials and vulnerable populations has been advocated in several pieces of legislation (Matherly & Mobley, 2011). One potential facet of this more resilient transportation system could be a **Transportation Reserve Corps,** which would use volunteers, managed by a community-based organization, to supplement transportation during disasters.

1.2 A Potential Solution: A Transportation Reserve Corps

This project identifies, evaluates, and assesses transportation management approaches for enhancing resource coordination for multi-modal evacuation planning. We have assembled experts in transportation coordination and large-scale evacuation from across New York State as well as representatives from national and other state and local agencies to explore alternative management approaches for sustainable transportation resource coordination for multi-modal evacuation. We explore the feasibility of a **Transportation Reserve Corps**, modeled after The Medical Reserve Corps that can assemble thousands of trained and licensed medical volunteers in the case of a catastrophic disaster.[2] Disasters such as the 1993 and 2001 attacks on the World Trade Center, the August 2003 northeast power outages, and Upstate New York floods and snowstorms demonstrate the need for more flexible, reliable and sustainable transportation management of evacuees with special needs (NYSEMO, 2006). A **Transportation Reserve Corps** would help maximize use of resources during extreme events (Hick *et al.*, 2004).

Benefits of a **Transportation Reserve Corps** include fewer vehicles needed and more effective deployment of existing vehicle fleets in case of a disaster. If agencies establish a framework for better coordination during emergencies, a potential benefit may be greater coordination during non-emergency times, which can promote transportation sustainability. Without coordination, the transportation system is subject to stressors and extreme conditions during emergencies and evacuations. These extremes are not sustainable. More effective transportation management and the adoption of a **Transportation Reserve Corps** requires no new vehicles and may actually reduce vehicles, as well as energy costs of getting vehicles from other more distant locations. Raising awareness among transportation providers about a region's various vehicle fleets, equipment, and systems helps better coordination and sustainability of the state's transportation systems.

Extreme events that require large-scale evacuation are a great concern for disaster planners and emergency managers. Most state and local municipalities are ill-prepared to handle large-scale evacuations from urban areas. A lesson repeatedly learned from previous disasters (such as Hurricane Katrina) is that residents without access to automobiles and residents in need of special assistance are more likely to lack the means to evacuate independently. Developing integrated plans for jurisdictions and agencies to share resources (vehicles, equipment, communication networks, drivers and other personnel) for high-capacity evacuation methods and modes is difficult because of insurance, liability, and other legal and contractual matters. For example, during the evacuation of New Orleans for Hurricane Katrina, unused high-capacity vehicles were

[2] The Medical Reserve Corps Program was created as a national system of community-based units to promote the local identification, recruitment, training, and activation of volunteers, especially those with medical and public health backgrounds (Franco *et al.* 2007, Hoard & Tosatto, 2005) through advance registration (Peterson, 2006) and planning.

left behind in the city because inter-agency cooperative agreements were not in place and there reportedly was a lack of drivers to operate buses. Disaster planners should learn from these experiences and implement policy changes and other strategies to strengthen community resiliency against predicted and unpredicted events (Hess & Arendt, 2006; Quarantelli, 1985). This project offers insight into the nature of multi-modal evacuation; and seeks to address some of its challenges by exploring the feasibility of a **Transportation Reserve Corps**.

2. Research Methodology

The research for this project was conducted by gathering information using a multi-pronged approach with distinct phases; each phase of the research builds upon knowledge gained during the previous phases. The approach was intended to provide a rich, context-aware understanding of the policy, planning, and decision making around disaster planning, response, and recovery. The qualitative aspects of the research rely upon a theoretical sampling strategy (Glaser & Strauss, 1967) in which our participants were chosen because of their direct and indirect association with evacuation planning.

2.1 Project Advisory Committee

In the first task, we identified appropriate representatives from relevant organizations to serve on a project advisory committee. We relied on our regional, state, and national networks to seek potential representatives. The objective was to obtain a wide range of perspectives for the development of integrated management approaches for promoting transportation sustainability for resource coordination for multi-modal evacuation. In establishing the composition of the project advisory committee, the project team sought to include various organizations that have a stake in disaster planning and coordinated multi-modal evacuation. The project advisory committee was active for the duration of this project. Advisory Committee membership was voluntary. The five member advisory committee included:

- Todd Litman, Executive Director, Victoria Transport Policy Institute
- Deborah Matherly, AICP, Principal Planner, Louis Berger Group, Inc.
- Adel Sadek, Professor, Department of Civil Engineering, University at Buffalo
- Thomas W. Sanchez, Professor and Chair, Urban Affairs and Planning, Virginia Tech
- Rae Zimmerman, Professor of Planning and Public Administration, New York University

As a first step, we provided advisory committee members with the project proposal and asked for their comments and suggestions. The project advisory committee made recommendations for interviewees. In addition, committee members reviewed the findings of the project.

2.2 Background Research and Literature Review

The second task was the completion of a literature review (contained in Chapters 3, 4, 5 and 6) about best practices in coordinating multi-modal transportation management for large-scale evacuation. Using primarily academic literature published in scholarly journals and federal, state, and municipal plans and reports, we created a typology of

the nature of disaster planning, and existing transportation methods and management strategies for evacuation planning.

2.3 Data Collection and Analysis

In the following task, we chose two metropolitan regions—a medium-sized city (Buffalo, New York) and a large city (New York, New York)—for detailed study. This project is thus supportive of the UTRC mission to better plan and manage regional transportation systems in a changing world; and at the same time strengthen economies and improve quality of life. New York City receives special attention because it has been the most targeted in terrorist plots and attacks, and remains a likely target; is susceptible to hurricane and coastal surge; is the nation's largest city and is densely populated; has a high carless rate; and has many bridge and tunnel crossings that are bottlenecks in emergencies. We chose Buffalo because it is a medium-sized city; also, it is located on an international border and experiences extreme weather conditions.

It is important to note throughout the report we speak in general and hypothetical terms about the establishment of a **TRC** in any geographical location, but we also give many concrete examples of the potential and possibility of establishing a **TRC** in New York State and the Buffalo area in Western New York State because that is where our research was primarily conducted.

The primary means of data collection was through in-depth interviews with key informants[3] in the fields of emergency management, transportation, and healthcare to understand the complexities of inter-agency cooperation and identify barriers to collaborating on multi-modal evacuation. We also discussed the concept of volunteer corps with more than 35 interviewees (summarized in Table 2-1) in order to identify strengths, weaknesses, opportunities, and threats to such a scheme. Interviews were conducted in Albany, Buffalo, and New York City.

A roundtable discussion was held at the Regional Plan Association in New York City on November 15, 2012. Participants at the roundtable included representatives from the Regional Plan Association, Columbia University, New York University, and City College of New York. (Invited representatives (many of whom were interviewed for this project) from FEMA, New York State Office of Emergency Management (NYSOEM), New York City Office of Emergency Management (NYCOEM) were unable to attend due to involvement in recovery from Hurricane Sandy.) The roundtable helped to illuminate local, state, and federal perspectives on this project. In addition to collecting data about multi-modal transportation coordination for evacuation planning and exploring the notion of a **TRC**, the roundtable discussion served other purposes: (1) to disseminate the study's results to date; (2) to create opportunities for study participants to network and collaborate on future disaster planning; and (3) to develop

[3] The research protocol for this project was approved by the University at Buffalo Social and Behavioral Sciences Institutional Review Board (approval for study #4709).

avenues for future research to improve the use of coordinated transportation planning for disaster planning, response, and recovery. A summary of the roundtable discussion is included in Appendix A.

In addition, the research team attended the Stormwest Exercise in April 2012 sponsored by the Erie County Department of Emergency Services and other organizations. Combined, these efforts helped the research team better refine the description of a **TRC** and form a series of methods meant to assess value, practical feasibility, and potential organizational structure.

2.4 Documentation and Dissemination

In the final phase of the research, we analyzed the results of the literature review, interviews, roundtable discussion, and recommendations from policy experts for resource coordination for multi-modal evacuations in New York State. The analysis identifies points of convergence and divergences of various participants. This technical report documents all aspects of the project.

This project examines a unique combination of elements—disaster planning, large-scale urban evacuation, transportation planning for carless households, and coordinated volunteerism—to help identify, evaluate, and assess transportation management approaches for promoting enhanced resource coordination for multi-modal evacuation planning. The research relies on both previous studies and new information gathered from key informants that participated in interviews with the research team to shed light on these important issues related to multi-modal evacuation planning and resource coordination. This research is both interdisciplinary and transformative in that it examines, integrates, and extends knowledge about these distinct and emerging fields of inquiry as they relate to disaster preparedness, response, and recovery.

2.5 Limitations

This research project has some obvious limitations. By their nature, disasters are unpredictable, and any research project about emergency planning must face the challenge of the unpredictable nature of disasters and the various factors that contribute to a community's ability to prepare to respond to disasters.

In this research, we straddle a divide between conceptual and practical research—that is, we provide a conceptual framework for a new volunteer evacuation corps, but we attempt to present it in a practical manner in a real-world context. Although the key sites of our research project are located in New York State, we intend our research to be both generalizable and transferable to other settings; this is a challenge, since emergency planning is largely a local activity (with oversight from higher levels of government).

Table 2-1. Interviews Conducted January 2012-November 2012

Agency [number of interviewees]	Agency Activity	Organization Type
Interviews conducted in Buffalo, New York		
American Red Cross (Buffalo) [1]	Humanitarian	Non-profit
Center for Transportation Excellence [1]	Transportation planning	Business
County of Erie Emergency Medical Services [2]	Public Health	Government (county)
Erie County Department of Emergency Services [3]	Emergency management	Government (county)
Greater Buffalo-Niagara Regional Transportation Council [1]	Transportation planning	Government (regional)
Niagara International Transportation Technology Coalition [2]	Transportation planning	Government (regional/international)
New York State Office of Emergency Management [2]	Emergency management	Government (state)
Volpe National Transportation Systems Center [1]	Emergency management	Government (federal)
University at Buffalo Emergency Management [1]	Educational institution	Government (state)
Interviews conducted in Albany, New York		
New York State Office of Health Emergency Preparedness [2]	Emergency management	Government (state)
New York State Department of Transportation [1]	Transportation planning	Government (state)
Rensselaer County Public Safety [1]	Emergency management	Government (county)
Interviews conducted in New York, New York		
American Red Cross (Greater New York Region) [2]	Humanitarian	Non-profit
Federal Emergency Management Authority [5]	Emergency management	Government (federal)
Metropolitan Transportation Authority [1]	Transportation planning	Government (regional)
New York City Office of Emergency Management [5]	Emergency management	Government (city)
Port Authority of New York and New Jersey Office of Emergency Management [4]	Emergency management	Government (regional)
Regional Plan Association	Urban/regional planning	Government (regional)

Our primary method was to interview key informants who are experts in disaster preparedness, response, and recovery as they relate to transportation planning, evacuation, and healthcare. The experience and expertise of each interviewee helped shape our analysis of existing practice and proposal for a **Transportation Reserve Corps**. Since the **Transportation Reserve Corps** does not exist, interviewees' reactions to the idea were relevant only to the extent that they understood it as it was explained to them by the research team. Certain experts, who we envisioned to be potentially important contributors to the project, were not available for interviews.

3. Background

In an effort to understand the unique and complicated nature of disaster planning, this chapter presents a literature review of disaster preparedness, response, and recovery paying particular attention to the area of disaster planning most relevant to our project—multi-modal evacuation. Our research seeks to expose gaps between an evacuation call, and access to appropriate transportation away from danger for all members of a community.

3.1 Disaster Typology for Emergency Evacuation

In broadest terms, disasters fall under two categories based on their causality; natural disasters and human-induced disasters (either unintentional or malevolent act) (Hoetmer, 1991). A human-induced disaster may be an accidental occurrence (*e.g.*, nuclear meltdown, chemical spill, power outage, dam failure) or a premeditated act (*e.g.*, violence or terrorist attack). Though this simple typology does present a clear and functional classification of disasters, for this research project, the categorization of disaster occurrences should also consider which disasters may result in a large-scale evacuation.

Many types of emergency events may or may not necessarily warrant an emergency evacuation depending on various interwoven and unpredictable variables. Appendix B: Disaster Typology considers three types of emergency incidents, based on their causality: (1) natural, (2) technological, or (3) malevolent acts (Dotson & Jones, 2005). Building upon the material in Appendix B, this chapter provides a thorough inquiry into factors that influence the decision to evacuate at two scales: (1) government action and (2) individual decision-making. Several factors are then given closer scrutiny in order to discern which disasters among these classes may warrant an emergency evacuation, thereby forming a more meaningful classification of emergency incidents based on this qualification.

3.2 The Decision to Evacuate

Choosing whether or not to order a mandatory evacuation is a complex and critical decision that emergency managers and government leaders must face. Forming this judgment becomes ever more intricate when considering the sacrifice individuals, families and communities must endure to carry out an evacuation (Fairchild, *et al.*, 2006). Therefore, in making this decision, the imminence and potential harm of an emergency incident must be judged to be at a level which exceeds the costs of evacuating—that is to say that, with a high degree of certainty, the consequences of undertaking an evacuation are surpassed by the costs (in terms of property damage, injury, and loss of life) of forgoing an evacuation (Fairchild *et al.*, 2006). This maxim, permeating all the variables which play a role in making this judgment, is the

foundation which frames the decision to evacuate, a decision that occurs at two levels: (1) government decision-makers and (2) the individual. Here the determining factors at each of these levels are elucidated through an analysis of relevant literature citing both prior experience with emergency evacuations and perceived best practices. This knowledge will then frame an understanding of emergency incidents that define the milieu of events for which a new approach to multi-modal evacuation should be established.

3.2.1 Government Decision to Mandate Evacuation

3.2.1.1 Evacuation Protocol/Hierarchy

Before investigating the complexities of an evacuation decision by government leaders, it is essential to provide an overview of the hierarchical roles of governmental organizations that define disaster response and evacuation protocol. This structure can generally be viewed as bottom-up, placing the authority to respond to a disaster or mandate an evacuation principally on the affected jurisdiction in ascending order: village, town, city, county, state (Fairchild *et al.*, 2006). Therefore, local governments which possess primary responsibility for emergency management operations (in the United States as well as in most nations) play a critical role during evacuations and in emergency management in general (Henstra, 2010). State governments, especially governors, are typically afforded comparable authority to issue an evacuation order (Fairchild *et al.*, 2006). The federal government acts as coordinator and partner, assisting local and state governments when capacity to respond is exceeded by the effects of the incident (McGuire & Schenk, 2010).[4] State and local governments will thus be the focus of this discussion. First, however, federal laws and regulations which identify roles and standard emergency response procedures will be clarified.

In addition to assisting local and state governments during disasters, the U.S. federal government has historically established guidelines for individuals and organizations handling emergency response via the National Response Framework (NRF) along with the National Incident Management System (NIMS). [5]An annex provided in the NRF

[4] This structure was initially put into place by the Disaster Relief Act Amendments of 1974, frequently referred to as the Stafford Act (McCarthy, 2011). This act bestowed national government with power to aid in disaster relief on the conditions that (1) a governor requests such assistance, (2) the degree of necessary response does indeed surpass state capacity and (3) a governor must put into effect the State's emergency plan (Fairchild et al, 2006). Additionally, federal courts also maintain the authority to order evacuations during severe emergencies (*Thames Shipyard and Repair Co. v. United States*, 2003).

[5] The National Response Plan (NRP) and NIMS replaced the Federal Response Plan of FEMA following September 11, 2001 as the procedural document outlining the duties of federal first responders (McGuire & Schenk, 2010). The NRP was pivotal in that it assumed an all-hazards approach to disaster management and extended its national-based standards to local and state bodies (McQuire & Schenk, 2010). However, after failing the test presented in 2005 by Hurricane Katrina, the NRP was revised by the Department of Homeland Security (DHS) and re-released in 2008 as the National Response Framework (NRF) to provide a more well-defined and flexible framework for disaster response policy (McQuire & Schenk, 2010). NIMS was also revised at this time to provide a more apt and adaptable framework to

specifies when federal evacuation measures are to be taken (FEMA, 2008). As is the case regarding disaster response in general, FEMA (2008) states that the federal government will provide assistance when local or state resources are overwhelmed or incapacitated. The document also establishes the role of the federal government as an integral coordinator of emergency evacuations, especially those which necessitate the mobilization of population between state lines (FEMA, 2008).

Although the federal government plays an integral role in disaster response, the primary authority during times of disaster still rests with the state government (Fairchild et al, 2006). Most states, including New York (New York State Executive Law Article 2-B), place the decision to evacuate a locale with the municipality, specifically, the chief executive officer of that municipality, if not the chief executive (*i.e.*, Governor) of the state (Fairchild, 2006).

In New York State Executive Law Article 2-B, a directive is set for municipalities to develop disaster response plans, which should include procedures for a coordinated evacuation (New York State Executive Law Article 2-B). This mandate reinforces the significance of local government officials regarding the decision to evacuate. The New York State Office of Emergency Management (NYSOEM) has the responsibility to direct and control an emergency evacuation and is assisted by the National Guard (when activated by the governor) to maintain order during such operations (Durham & Suiter, 1991). An evacuation is implemented through the Emergency Operations Center (EOC) of the state, which acts as a command center for coordination during disasters (Durham & Suiter, 1991). An example of an EOC is depicted in Figure 3-1.

3.2.1.2 Governmental Decision to Evacuate

Ultimately, local government leaders are best poised to prevent localities from being overwhelmed by the effects of a disaster (Somers & Svara, 2009). Thus, they are most crucial in deciding if evacuation is necessary and what resources, if any, are to be requested of higher levels of government to conduct an evacuation. While guiding principles regarding the decision to issue an evacuation order are likely stated under emergency plans, the clarity and effectiveness of these principles surely vary from one municipality to the next and from one emergency situation to the next. Furthermore, municipal officials will undoubtedly base their judgment on certain factors to varying degrees based on the content and reliability of the information they receive, personal perception of the incident, and even intuition.

The catastrophic consequences of disaster incidents in recent years (most notably the outcomes of Hurricane Katrina) have underscored the need for local governments to better prepare themselves to confront all types of disasters (Somers & Svara, 2009). Local governments are acknowledged as the best prepared level of government to cope

guide individuals and institutions to more effectively cope with and manage disasters (McQuire & Schenk, 2010).

with emergency situations and the most effective in response (Torry, 1978); consequently, the readiness and coordination of local government regarding emergency situations will be critical in the decision to mandate an evacuation order. Additionally, city managers often misperceive the vulnerabilities in their communities to certain types of disasters (Rahm & Reddick, 2011), which affects a local government's level of preparedness and its ability to effectively mandate an evacuation. Since there is generally limited incentive for politicians within local governments to seek funding for emergency preparedness programs (Wolensky & Wolensky, 1990), the preparedness of these institutions is often inadequate. It has been recommended that the use of decision support systems, such as checklists or decision trees, should be incorporated into an executive's framework for choosing whether or not to evacuate under certain scenarios (Sorensen, Shumpert & Vogt, 2004; Walle & Turoff, 2008).

Figure 3-1. Emergency Operations Center, New Jersey Office of Emergency Management

Though the decision to initiate an evacuation rests with government leaders, it is important to recall that government does not act in isolation; that is, information provided by other institutions supplies critical intelligence for decision-making. Public health personnel, due to a risk of immediate casualties and disease after a disaster,

represent a convincing and trustworthy voice in gauging the need for an evacuation (Fairchild *et al.*, 2006). These officials should certainly be included in a broader governmental response to disasters (Fairchild *et al.*, 2006). For many natural disasters, which cause evacuations more commonly than any other type of disaster (Dotson & Jones, 2005), weather media play a pivotal role in government officials' decision to evacuate (FEMA, 2008; Stein *et al.*, 2010). Likewise, information provided by the National Weather Service and other weather media during a natural disaster will influence all individuals within disaster-affected communities as they decide whether or not to evacuate, regardless whether or not a mandatory evacuation is ordered (Sims & Baumann, 1983; Baker, 1991; Lindell, *et al.*, 2005; Stein, *et al.*, 2010).

In the Evacuation Incident Annex to the National Response Framework (2008), FEMA lists key considerations for personnel conducting large-scale evacuations which also are pertinent to evacuation decisions, foremost of which is the duration necessary to complete an emergency evacuation. FEMA (2008) recommends that evacuation plans be activated as far in advance as 72 hours before an actual evacuation should be started. This applies to a disaster for which prior notice is available (also called a "notice event"). Strictly employing this standard would severely narrow the categories of disaster that would warrant evacuation, as few incidents are approached so cautiously. Whether or not emergency incidents are preceded by a warning period is listed as an important consideration. Further complicating the timing considerations are challenges in predicting extreme weather events, which result in misjudgments of the severity or precise location of the damage associated with these events (FEMA, 2008). The condition of critical infrastructure systems and the effect of a large-scale evacuation on these resources is a key consideration in deciding to initiate a large-scale evacuation. The presence of environmental contamination is another key concern. The special needs of certain populations (*e.g.*, children, elderly, handicapped) and certain requirements for household pets are also identified by FEMA (2008) as key considerations.

Appendices C and D present summaries of Erie and Niagara counties' (New York State) evacuation plans. They help to illustrate the emergency management hierarchy, factors that determine the decision to evacuate, and government and non-government roles in an evacuation.

3.2.2 Individual Decisions to Evacuate

In an evacuation ordered by government leaders, all individuals are required by law to evacuate. A U.S. House of Representatives' Committee (2006) found that failing to comply with a mandatory evacuation order is illegal, applying the reasoning that this behavior would inevitably put responders' lives at risk. A person's willingness or ability to vacate an area with necessary urgency can be limited, as proven by the events of Hurricane Katrina, where some individuals chose not to evacuate and later found evacuation impossible (due to floodwaters) and required rescue by emergency personnel (Lindell et al, 2005; Elder *et al.*, 2007). Even when people are properly informed, it cannot be assumed that (1) the provision of a warning will provide

individuals with a sound appreciation of the implications of that warning, and (2) that this awareness, if realized, would lead to the recommended precautionary measures (Sims & Baumann, 1983). It can therefore be reasoned that, in general, during these incidents, individuals will pursue the action which they deem to be most sensible based on the information they are provided and their own perspective (Sorensen, Shumpert & Vogt, 2004). Those factors which most affect an individual's will or ability to evacuate are elaborated upon here.

The most fundamental predictor of evacuation participation is an individual's knowledge about an evacuation order (Baker, 1991; Hasan, *et al.*, 2011). Moreover, the reliability of the order, its source and any information corroborating that order as a formative condition of an individual's evacuation choice cannot be understated (Sorensen, 1991; Elder, *et al.*, 2007; Hasan, 2011). Even when an official order is placed, it is estimated that one-third of the public will not necessarily follow evacuation orders (Carter, 1979). With increased clarity of the evacuation procedure and credibility of an information source (*e.g.*, known government official) comes increased compliance with evacuation orders (Sims & Baumann, 1983). Also, the risk level of a specific location, along with residents' perception of this risk, both play a part in the likelihood of evacuating (Baker, 1991). Television and the saturation of news and weather media indeed prompt increasing levels of evacuation participation through footage, which can be sensational (Sims & Baumann, 1983; Elder, *et al.*, 2007). However, during many emergency incidents, an evacuation order may become muddled, if not wholly disregarded, by misinterpretation of this information, the proliferation of misinformation or limitations in communication resulting in individuals ignoring the evacuation order (Sims & Baumann, 1983; Baker, 1991; Sorensen, Shumpert & Vogt, 2004). For example, a lack of clarity in 2005 surely contributed to Mayor Ray Nagin's indecisiveness in activating an evacuation order in the days preceding Hurricane Katrina, a delay which ultimately cost the lives of hundreds (Heller, 2010).

The most effective deterrent to complying with an evacuation order may be when evacuation orders given by the authorities themselves conflict (Elder, *et al.*, 2007). When an individual first learns of an evacuation order from a friend or family member (as opposed to finding out through media sources), he or she is more likely to evacuate (Lindell, *et al.*, 2005; Hasan, *et al.*, 2011).

An individual's life experiences, especially those attached to previous emergency incidents, may be regarded as the most well-accepted factor influencing a decision to evacuate (Sims & Baumann, 1983; Cutter & Smith, 2009; Riad *et al.*, 1999). Numerous studies have demonstrated the relationship between prior disaster experience to an individual's evacuation decision as highly provisional and contradictory (Sims & Baumann, 1983; Baker, 1991; Lindell *et al.*, 2005; Elder, *et al.*, 2007). Survival of a previous hurricane, for instance, may decrease one's compliance with evacuation orders (Baker, 1991).

The demographic composition and social characteristics of affected households also play an instrumental role in the willingness, as well as the ability, to evacuate. For example, the age of an individual is related to compliance (Rasid, Haider & Hunt, 2000; Elder, *et al.*, 2007). A post-flood survey of residents in four affected communities in Manitoba, Canada suggests that people of at least 70 years of age or more were somewhat less likely to obey evacuation orders (Rasid, Haider & Hunt, 2000). If a household includes children, especially younger children, a family is more likely to follow evacuation orders (Hasan, *et al.*, 2011). Evidence also suggests that residing in mobile housing, having a high-level of educational attainment or a high-income also increases household members' willingness to evacuate (Hasan, *et al.*, 2011). Research by Elder, *et al.* (2007) suggests that racial composition may also play a role in evacuation behavior; specifically, a majority of African American individuals in New Orleans did not evacuate prior to Hurricane Katrina (although this may be related to socioeconomic conditions connected with inner-city residents).

The type of evacuation also shapes individuals decision to evacuate (Rasid, Haider & Hunt, 2000). Interviews of urban residents within the flood zone of the Red River in Manitoba, Canada, suggest that individuals are more receptive to voluntary rather than mandatory evacuations when faced with the likelihood of a flood. This evidence suggests that mandatory evacuations are only suitable when the public perceives an impending disaster through the conveyance of reliable information (Rasid, Haider & Hunt, 2000). Skepticism of top-down directives and mistrust of government information regarding disasters were seen as the most prominent reasons for the unfavorable perception of mandated evacuations among those interviewed (Rasid, Haider & Hunt, 2000). However, subsequent studies have suggested that mandated evacuations do indeed trigger greater evacuation participation rates than voluntary orders (Hasan, *et al.*, 2011).

One of the most influential yet overlooked factors affecting an individual's decision to evacuate seems to be the perspective assumed by an individual—attitudes, values and beliefs (Sims & Baumann, 1983). The pivotal dynamic rests upon a person's beliefs, specifically, what can be called the *locus of control*, which can be either *internal* (the belief that one controls their own fate), or *external*, destiny (the belief that an outside or supernatural force controls the outcome of events). While people who believe in an internal locus of control are prone to buy flood insurance or take proactive measures against tornado threats, for example, those believing in an external locus of control are far less likely to do so (Sims & Bauman, 1983). This finding was reinforced by a study which found that hopefulness incurred through religious faith was a primary reason for residents of New Orleans to *not* evacuate when threatened by Hurricane Katrina (Elder, *et al.*, 2007).

3.2.3 Shelter-in-Place versus Evacuate

Other than evacuation, emergency managers also reserve the option to keep and provide for affected populations in the disaster zone, a strategy known as "shelter-in-

place," which is thought to be more reasonable and safer than evacuating under certain conditions (Cutter & Smith, 2009). In a review of shelter-in-place decisions related to wildfires, several factors were determined to play a role in individuals' decisions to evacuate or remain in-place, including (1) hazard level, (2) community context, (3) warning time and (4) policy context (Cova *et al.* 2009). In a review of the shelter-in-place decisions regarding an environmental contamination incident, Sorensen, Shumpert & Vogt (2004) identify several situations where one option is clearly favored over the other. Sheltering-in-place may be the best option when the duration of an event is extremely short or when an evacuation would unnecessarily expose populations to danger (*e.g.*, contamination along emergency evacuation routes). Evacuation may be a more favorable for incidents in which people have ample time to evacuate before a disaster occurs (for example, before a toxic plume arrives). Sheltering-in-place has indeed proven to be a wiser option than large-scale evacuation, but only under certain circumstances (Mannan & Kirkpatrick, 2000).

3.2.4 Critical Factors in the Decision to Evacuate

Ultimately, during a crisis, people will choose the action which they judge to be the best for their safety and well-being (Sorensen, Shumpert & Vogt, 2004). It is important to note that for optimal implementation of an emergency evacuation, institutional partnerships between government, residents and other actors are essential, as is a high degree of disaster preparedness and education at the community and government level (Glotzer, *et al.*, 2007). Several factors found to influence whether or not an evacuation should, or will, occur in the event of an emergency are listed below (first four items in the list are determined by the type of emergency event impacting an area):

1. Presence and timing of disaster warning period (i.e., a "notice" event or "no notice" event");
2. Severity, nature and duration of disaster effects (including weather and climate conditions);
3. Resources available for sheltering;
4. Condition of critical infrastructure;
5. Community context (preparedness/training of individuals, demographic composition of community); and
6. Policy context (preparedness/training of local government).

It must be emphasized that this summary of factors is largely conceptual; that is, it allows for a more apt interpretation of which disasters would warrant an evacuation. In practice, the decision to actually undertake an evacuation, either by a municipality or by an individual, may not be entirely reliant on a concrete set of identifiable factors especially when considering the possibility of a "double event," i.e., a nuclear spill in the aftermath of an earthquake (Regional Plan Association interview, 2012). Whether or not to mandate an evacuation therefore arises as a "wicked problem" in that it most often cannot be determined by a replicable, systematic formula (Rittel & Webber, 1973).

3.3 Defining Multi-modal Transportation

Multi-modal transportation systems include various modes of travel—walk, bicycle, public transit, private vehicle—and effective connections between modes. Past research suggests that, facing potential evacuation of an urbanized area, emergency managers should not completely depend on decentralized private evacuation strategies (Berube & Raphael, 2005), but should in fact utilize multimodal transportation systems (Renne, *et al.* 2008). In evacuation planning, multi-modal transport should include walking, wheelchair use, bicycling, taxi, bus (both public transit and tour/charter charter bus), public transit/light rail transit, automobiles (cars, vans, SUVs, light trucks and motorcycles), ridesharing, demand response transit, carsharing, ferries, water-borne ships, airplanes, and helicopters (Renne, *et al.*, 2008).

For the purposes of this study, there will be less focus on those who can independently evacuate via walking, bicycling, private automobiles, and ridesharing during a large-scale evacuation that is pre-planned, organized and directed by emergency officials. This is because during a large-scale evacuation, use of small-capacity vehicles (e.g., automobiles) meets the demand only for those households with access to them. Because large-scale evacuations involve the coordination of *all* people, regardless of automobile access, *all* dwelling types, and *all* modes of travel (Hess & Gotham 2007) the primary focus of this study will be on terrestrial evacuation by means of high capacity public and private modes of transportation and emergency vehicles requiring hired drivers as depicted in Table 3-1.

Table 3-1. Travel Modes to Consider for Evacuation Planning

Public Transit	**Private Transport**	**Emergency Vehicles**
- Bus - Rail (light, heavy, commuter) - Ferry - Paratransit - Long-distance train (Amtrak)	- School Buses - Private Bus/Coach - Charter/Tour Bus - Taxis - Church vans - Vehicles owned by non-profit organizations	- Ambulance - Other medical transport vehicles - Fire trucks - Other emergency vehicles

3.4 Importance of Multi-modal Transportation in Evacuation

Planners, designers, developers, engineers, and government officials face the challenge of establishing integrated systems that not only promote equitable and sustainable urban futures but serve as efficient systems for large-scale evacuation. The devastating aftermath of Hurricane Katrina accentuates the urgent need for reliable evacuation plans. During Hurricane Katrina, evacuation for people with access to automobiles was relatively effective, but the evacuation system failed for transit dependent people,

causing arguably avoidable fatalities, suffering, and indignity. Thanks to lessons learned from Hurricane Katrina, especially plans for deploying buses to evacuate non-drivers, households without automobiles were better served during Hurricane Rita. However, excessive automobile traffic due to the failure to implement contra-flow lanes, manage fuel distribution, provide basic services along the evacuation route, and prioritize the evacuation of high-occupancy vehicles (Litman, 2006) once again underscored the value of comprehensive multi-modal transportation planning for large-scale evacuation.

3.4.1 The Carless

Determining the extent to which various available modes of transportation could be applied in disaster scenarios is important for a number of reasons. The first, and arguably the most important reason, is that there are approximately 10.7 million carless households in the U.S., about 9.3 percent of households (U.S. Census, 2011). In a 2011 Brookings Institute study of the 100 largest metropolitan areas in the U.S., households without access to a personal vehicle, referred to as zero-vehicle households, constitute 10 percent of all households in those large metropolitan areas, about 7.5 million households. Overall, seven metropolitan areas host over half of all 100 metro areas' zero-vehicle households: New York 2,093,861 (28 percent), Chicago 399,927 (5 percent), Los Angeles 358,705 (5 percent), Philadelphia 310,583 (4 percent), Boston 223,207 (3 percent), San Francisco 195,997 (3 percent), and Washington DC 193,558 (3 percent) (Tomer, 2011).

The study also found that a majority of zero-vehicle households are located in cities—62 percent of all zero-vehicle households live in the 132 primary cities of the 100 largest metropolitan areas. Furthermore, a majority of zero-vehicle households are low income; 60 percent of zero-vehicle households in the 100 largest metropolitan areas have incomes below 80 percent of the median income for their metro area. By comparison, 24 percent of households with a personal vehicle are low income. While large shares of zero-vehicle households live in cities and earn low incomes, race is more consistent across the three largest racial groups: Whites (36.4 percent), Hispanic/Latino (27.7 percent) and Black/African American (25.3 percent) (Tomer, 2011).

To put this demographic information in the context of a large-scale urban evacuation, in 2000, New York, Washington, D.C., Baltimore, Philadelphia, Boston, Chicago, and San Francisco had higher shares of households without vehicles than New Orleans (Renne, *et al.*, 2008). While some carless households may be able to rely on friends, neighbors, or extended families to evacuate in emergencies, we should assume that a large share of this population is likely to depend on government assistance to evacuate (Bailey, *et al.*, 2007).

Despite the challenges that carless households face, over 90 percent of carless households in the 100 largest metropolitan areas in the U.S. are located in neighborhoods with access to public transit service of some kind. This suggests that

transit service coverage aligns with households who rely on it (Tomer, 2011) and that alternatives to the private automobile are feasible for evacuation if adequately planned and coordinated.

3.4.1.1 Special Needs Population

The carless population is a diversified group that represents a variety of characteristics and situations. The carless population includes: the frail and sick, disabled and elderly in their own homes; residents of institutions such as hospitals, nursing homes, and prisons; families who do not own a car because they cannot afford one, or who as a matter of lifestyle choose not to own a car; persons who have illegal or disputed immigration status; persons who own cars but lack access at a critical time (cut off by the disaster, car is out of order); and temporary residents, such as tourists and other visitors. Members of these carless households are disproportionately poor, minority, have limited English proficiency, live in areas that are racially segregated, possess disabilities and are age 60 years or more (Berube & Raphael 2005; Renne, 2006; Bailey, 2007).

Determining how to define this "special needs" population, especially in the field of emergency planning, is complicated. Kailes & Enders (2007) argue that the placement of all disabilities under one umbrella does a grand disservice to every included group, limiting the likelihood that specific needs are planned for in disaster response. Depending on the definition of the term, the special needs population could range from between 50 percent and 70 percent of the total U.S. population (Kailes & Enders, 2007). Furthermore, an oversimplified, dichotomous classification is misleading, since 80 percent of the population will likely experience some type of disability (temporary or permanent) during their lifetime, it is more appropriate to identify individuals along a continuum of functionality, rather than merely disabled or non-disabled (Kailes & Enders, 2007).

While respecting this disclaimer, a working definition of special needs can still be gained and employed here. Formally, FEMA (2010) upholds the definition of special needs populations stated in the National Response Framework as those individuals who,

> "...may have additional needs before, during, and after an incident in functional areas, including but not limited to: maintaining independence, communication, transportation, supervision, and medical care. Individuals in need of additional response assistance may include those who have disabilities, live in institutionalized settings, are elderly, are children, are from diverse cultures, have limited English proficiency or are non-English speaking, or are transportation disadvantaged."

For this study specifically, *the definition of special needs is focused on all those who do not possess the capacity to evacuate themselves*; this could include a sizeable share of the

population. In fact, in a 2005 survey by the National Center for Disaster Preparedness (NCDP) of the American public's attitudes and views on terrorism, preparedness, and associated issues, over a quarter of respondents (29 percent) reported that they would not be able to self-evacuate, while another 30 percent would not be able to evacuate as they do not possess personal transportation (Redlener, *et al.*, 2005).

It is worthwhile further defining two subcategories of this special needs population: (1) people who live at home but are sick, disabled and/or elderly and (2) people who live in institutions such as hospitals, nursing homes, and prisons. In a 2010 study of the disabled living at home in seven states recently impacted by large-scale evacuations, such disabling conditions were defined as various types of impairments (medical, mobility, hearing, mental health, cognitive, visual, and other); a household that included a person with one or more of these impairments; and a household that included an elderly person who did not have an aforementioned impairment. One quarter of all survey respondents reported they were either not very well prepared or not at all prepared to evacuate in the event of a disaster. Respondents with disabilities predicted they were more likely than persons without disabilities to experience a difficult evacuation, and those with multiple disabilities reported a lower capacity for independent evacuation or sheltering (Gerber, Norwood, and Zakour 2010). Relating the shelter in place versus evacuation debate to the people who live at home but are sick, disabled and/or elderly, it must be remembered that, as some individuals or households do not have the means or ability to evacuate, many also lack the capacity to adequately care for themselves at home during an emergency (Redlener, *et al.*, 2005; Cutter & Smith, 2009).

Residents and patients of institutions such as hospitals, nursing homes and prisons must also rely on transportation service other than private automobiles to evacuate safely. These individuals often require special equipment, assistance, or other factors complicating their ability to evacuate. In a report from the Government Accountability Office (GOA, July 2006) in which the GAO studied healthcare institutions in areas affected by Hurricane Katrina in Mississippi and Hurricane Charley in Florida, findings suggest that facility administrators struggled to secure a sufficient number of vehicles to evacuate patients because although facilities had contracts with transportation providers, competition for the same pool of vehicles created supply shortages. In addition, communication systems were impaired by damage to local infrastructure.

The Government Accountability Office (July 2006) suggests that medical institutions consider evacuation to be an option of last resort when faced with an emergency, considering the significant burden of mobilizing patients along with necessary equipment while taking proper precautions. Hospital administrators consider many factors in making the decision to evacuate or shelter in place (Hess & Arendt, 2009). These include: the availability of resources on site to provide for the patient and staff population, the level of risk patients will be put into if evacuation is attempted, the

accessibility of suitable transportation, and the condition of facilities and community infrastructure (GAO, July 2006).

3.4.2 Dangers of Relying on Private Vehicles

While evacuating the carless is the most pressing reason for planners to consider multi-modal transportation evacuation, reliance on single-occupancy vehicles in an evacuation can place at risk an entire populations' safety. When private automobiles are the primary source of transportation during an evacuation, traffic congestion in urban areas is likely to limit evacuation capability (White, *et al.* 2008). Reliance on personal motor vehicles for evacuation may actually contribute to traffic congestion, as well as to civic unrest, and shortages of fuel, shelter, and necessities (including inadequate access to washrooms and emergency services). For example, during Hurricane Rita, an estimated 3 million people evacuated the Texas Gulf Coast, creating 100-mile-long traffic jams on interstate highways that left many stranded and out of fuel (Litman, 2006). A disabled or out-of-fuel vehicle may block travel, reducing the traffic-carrying capacity for evacuation and restricting access for emergency vehicles.

Hurricanes in coastal regions are well-known to cause large-scale evacuation, but other types of disasters in various urban settings can also require evacuation. In November 2000, a snowstorm in Buffalo, New York stalled all vehicular traffic—in the midst of an exodus due to closure—and immobilized the city, trapping school children in buses, commuters in cars, and emergency vehicles throughout the city (Becker & Pignataro, 2000).

Traffic congestion during an evacuation is a grave concern in densely populated areas. The city of Boston's evacuation plan encourages residents, regardless of car ownership, to report to neighborhood emergency centers where transportation out of the hazard area will be provided by means of high-capacity transportation, including buses, trains, vans to ensure that congestion is minimized (Menino, *et al.*, 2005). Likewise, in New York City, residents are advised to evacuate via public transit to reduce traffic congestion (Renne, *et al.*, 2008).

The reality that a supply of existing transport routes will not accommodate an enormous demand for private vehicle evacuation associated with an evacuation of many medium-to-large population centers has led some state departments of transportation to establish plans for the use of contraflow highway operations. Contraflow plans permit nonstandard operation (or reverse direction) of certain roadways to maximize the capacity of the available highway infrastructure. Contraflow operations pose many challenges to both supervising agencies and evacuating drivers. It requires close cooperation between numerous agencies across political boundaries and jurisdictions both within and between participating states. Such cooperation between agencies has not been effectively accomplished in the past, leading Wolshon *et al.* (2005a, p. 160) to conclude that contraflow is not a "magic solution" to an organized vehicular evacuation. While contraflow systems, if properly implemented, may help

maximize the efficiency of existing highway networks, other evacuation strategies should be explored, such as the coordination of traffic control systems on arterial routes and the use of public transit and other vehicles (Urbina & Wolshon, 2003).

In recent years, emergency evacuation modeling has been developed to investigate the effect of one or more strategies, such as coordinated or phased scheduling, to improve the performance of evacuation processes in cities. However, most of these studies are typically focused on automobile-based evacuation using a certain strategy without considering other modes of transportation or attempting to simultaneously synergize several possible strategies at once. In response to this, a large-scale evacuation model was developed for the evacuation of the city of Toronto using multiple modes of transportation including vehicular traffic, public transit, and shuttle buses combined with integrating evacuation scheduling and destination choice (Abdelgawad & Abdulhai, 2010). Estimates suggest that the multimodal strategy developed in the model would evacuate the city 4 times faster than without multi-modalism. The model showed that the average automobile evacuation time for the 1.21 million people with access to cars was nearly 2 hours and that optimizing the Toronto Transit Commission fleet (4 rapid transit lines and 1,320 transit buses used as shuttles) was found to evacuate the transit-dependent population (1.34 million) within 2 hours. The study found that incorporating multiple modes in emergency evacuation has the potential to expedite the evacuation process and is essential to assure evacuating transit-captive segments of the population (Abdelgawad & Abdulhai, 2010).

3.4.3 Multi-Modal Transportation as a Solution to the Unpredictable Nature of Disasters

Disasters vary tremendously in their extent, duration, and location. Depending on disaster type and severity, each transport mode available to assist has a unique performance profile (or combination of possibilities and constraints that determine the role that travel mode can play in an efficient transportation system). Multi-modalism is particularly important for emergency response and evacuation planning because it provides travel options that can accommodate diverse and uncertain needs, including (1) people with various mobility limitations, (2) long-distance evacuations, and (3) resource limitations such as road space, vehicles and fuel. Consequently, planners should assess the unique performance qualities of various travel modes and how they could be of benefit in a variety of emergency situations especially where one type of infrastructure is critically damaged and roads are impassable (Renne, *et al.*, 2008).

Public transit agencies have a history of playing pivotal roles during crisis situations, performing services such as evacuation of victims, transport of emergency personnel, and maintaining mobility for residents and recovery workers after a disaster. For example, after the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City, Metro Transit began running 24-hour service to accommodate travel demand. Metro Transit buses transported emergency workers, evacuated residents from a nearby

housing complex, and operated the Multi-Agency Command Center, which coordinated communications during relief efforts (Higgins, *et al.*, 1999).

Enhancing transportation system diversity also tends to increase resilience or the ability to accommodate variable and unexpected conditions without catastrophic failure (Renne, *et al.*, 2008). For example, the 1989 San Francisco earthquake destroyed some of the area's primary thoroughfares and damaged others to the point of impassability. Within nine hours of the earthquake, the undamaged BART subway system restored rail service, providing the region's most reliable transportation service until certain roadways were rebuilt (Higgins, *et al.*, 1999).

This discussion details which specific disaster events more readily necessitate a large-scale evacuation by recalling six factors found to determine whether or not an evacuation should, or will, occur in the event of an emergency. While several of these factors are based on the *type* of disaster, others are largely based on the *preparedness* of the community to handle a large-scale evacuation. These preparedness efforts include understanding the demographic composition of a community and the level of preparedness and training both community members and local government possess. The chapter also describes why incorporating multi-modalism into disaster planning is imperative not only for the safety of the carless, but also for the safety of an entire urban population. Chapter 4 will present a literature review of challenges communities face when preparing for a large-scale evacuation.

4. Barriers to Multi-Modal Evacuation

Despite the aforementioned research on multi-modal transportation and the importance of integrating it into evacuation planning, many state and local governments do not have the appropriate plans, training, and exercises to evacuate households without automobiles. The Department of Homeland Security (DHS)'s *Nationwide Plan Review* (2006) of emergency plans from 50 U.S. states and 75 of the largest urban areas reported that only 10 percent of states and only 12 percent of urban areas adequately addressed evacuating households without automobiles. The study also found that the majority of emergency operations plans were not "fully adequate, feasible, or acceptable to manage catastrophic events" (DHS, 2006, p. ix). The assessment further found that 18 percent of state plans and only 7 percent of urban plans had incorporated all available modes of transportation into emergency plans (DHS, 2006). The Department of Transportation's (DOT) (2006) evaluation reported that most state and local evacuation plans focus on highway evacuations using personal vehicles. Overall, the findings showed that a majority of emergency operations plans for large urbanized areas are only partially sufficient in describing in specific and measurable terms how a major evacuation could be conducted successfully. Few plans adequately consider the role of public transit. For example, in New York State, the State Office of Emergency Management (NYSOEM) (formerly NYSEMO) provides a downloadable sample plan, titled *Empire County Comprehensive Emergency Management Plan*, but the majority of New York counties do not consider multiple modes of transportation (such as buses, trains, ships, airplanes or even walking and bicycling) for emergency evacuation (NYSEMO, 2004; Hess & Gotham, 2007).

Following the DHS and DOT studies from 2006, much research has been conducted to better understand why multi-modal evacuation is not a priority for federal, state and local governments, and to understand the barriers for creating plans to evacuate the carless. These barriers, which we discuss in greater detail in the following passages, include (1) identifying and communicating with households without automobiles, (2) inventorying available resources and matching these resources with the unique needs of the carless population, (3) legal and practical constraints, (4) lack of coordination & deficiencies in command structure, and (5) inadequate funding.

4.1 Identifying and Communicating with Carless Populations

It is widely accepted that identifying and opening the lines of communication with households without automobiles are necessary disaster preparedness measures. Strategies for effectively evacuating households without automobiles include pre-identifying the carless and those who need special assistance through registries and mapping; providing these lists as well as instructions in advance to emergency responders; communicating with these vulnerable populations about available assistance and transit and how to access it; and convincing evacuees to use that

assistance to leave early (White, *et al.*, 2008; Renne, *et al.* 2009). There is, however, an intrinsic link between communication and transportation. People with barriers to accessing transportation in an emergency may also experience obstacles to receiving information about how to receive assistance prior to and during an emergency. Communication barriers are often caused by the same factors that affect the carless population—including disability status, limited English proficiency, isolation, age, and poverty (Matherly, *et al.* 2001; Matherly & Mobley 2011).

Not surprisingly, community leaders have faced profound challenges in identifying and communicating with these vulnerable populations. Some people cannot speak or read English, lack telephone and Internet access, lack a reliable mailing address, distrust public officials, and face other challenges that limit their access to traditional communication techniques (Renne, *et al.*, 2008; Litman, 2006). Increasing access to social networks can increase better preparedness, response and recovery for the disabled in disaster scenarios (Gerber, *et al.*, 2010). Creating a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation, and establishing a chain of responsibility for caregivers requires collaboration with various groups: social service agencies, community organizations, medical and mental health professionals, and special service providers (Renne, *et al.*, 2008; Litman, 2006).

Obtaining information such as the number of people with disabilities in an area, the portion of households that lack access to an automobile, and an evaluation of their transport needs during an evacuation are not data generally incorporated into conventional emergency planning. Because of these limitations, serving vulnerable populations relies more on new perspectives, relationships and tools. For example, DHS's (2006) *Nationwide Plan Review* found that some jurisdictions were developing voluntary special registries so that individuals could pre-identify themselves as needing evacuation assistance. Keeping these registries up to date, however, proved costly and difficult, particularly in large urban areas. Similarly, the Government Accountability Office (GAO, December, 2006) found that information on the location of households without automobiles was not readily available because such data had not been collected, could not be collected due to staff and other resource restrictions, was not housed in a central location (but instead in separate databases across numerous agencies), or could not be shared with emergency management officials due to privacy requirements. A lack of coordination was further underscored when GAO (December 2006) found that in one of the five major cities visited, the registration system had only registered 1,400—or 0.3 percent—of the 462,000 people estimated to require evacuation assistance.

Even when vulnerable populations are identified, effectively communicating with these populations can prove challenging during an emergency. DHS's (2006) *Nationwide Plan Review* found that there were widespread challenges in providing messages to the public in multiple languages. During a series of stakeholder meetings, Renne, *et al.* (2009) found that communication was identified as a major obstacle due to social

isolation and language barriers by each of the five major U.S. cities that participated. There is also a tension between communicating with carless populations about evacuation routes and pick-up locations on an ongoing basis (Litman, 2006) and compromising public security by publicizing sensitive disaster planning information. For example, in Chicago, evacuation routes are not public information due to security concerns (Renne, *et al.* 2009). A little- or no-notice incident, one that occurs unexpectedly or with minimal warning, is often characteristic of an emergency situation in which people must be evacuated. A no-notice incident further introduces unique challenges for communicating with and evacuating at-risk populations (DOT, 2007).

4.2 Inventorying Available Resources and Matching Resources with Needs

Transportation plans for disasters must include the quick and efficient deployment of high-occupancy vehicles. Such deployment requires an inventory of vehicles and their drivers, clear instructions for vehicle use, oversight of fuel, emergency repair and other support services, and proper coordination of these elements (Litman, 2006). Inventorying available transportation resources and matching carless individuals with appropriate and available modes of transportation, however, are challenges that planners face, a feat that Renne *et al.* (2008 p. 81) refer to as the "start to a complex transportation conundrum."

The needs of the carless population vary greatly, both in terms of mode of transportation required and in the degree to which professional assistance is required in an evacuation. For example, carless individuals who are ambulatory can access fixed-route transit while those with disabilities may require door-to-door specialized providers with trained operators and equipment. In an emergency evacuation, these limited providers often face competing demands for their services and may be requested to assist simultaneously in an evacuation of assisted living facilities and nursing homes. Furthermore public entities and private companies have been driven to increase efficiency by reducing or eliminating underused inventory. This has resulted in fewer vehicles available and less flexibility in times of increased demand (White, *et al.* 2008).

New York City provides an interesting example of this dilemma. The city does have paratransit service but the number of these vehicles would be insufficient if the region was faced with a large-scale evacuation during which most or all paratransit users would require transport simultaneously. The New York City Metropolitan Transportation Authority (NYC MTA) is concerned that if buses were utilized to provide services to people with special needs it would reduce the fleet available for the general population. Additionally, buses are not designed to carry a large number of wheelchairs at the same time. Counting all available fleets, there is still an inadequate supply of transportation resources for everyone in NYC due to the fact that NYC has 1.3

million seniors and nearly 60 percent of NYC households do not have private vehicle access (Renne, *et al.* 2009).

Large metropolitan areas are not the only places that face challenges in the quantity of available transportation modes that could be deployed in an evacuation. In a study of rural coastal communities in the Gulf Coast, Chaudhari *et al.* (2009) found that evacuation services may make rural transit agencies, which may be experiencing financial crisis, even more financially unstable. Even school buses, often considered a viable mode of transportation for the carless in an emergency, have limitations such as lack of air conditioning and limited wheelchair and seating capacity for adults.

4.3 Legal and Practical Constraints

There are a number of legal and practical constraints facing communities that make incorporating effective multi-modal transportation into local emergency planning either too difficult or too expensive. In order for communities to effectively incorporate multi-modal transportation into emergency planning, they must first understand the spatial dimensions of the demand and supply of transit, incorporate private transportation providers into plans, and assess the availability and allocation of modes of transportation, equipment and drivers. To do this, studies suggests entering into mutual aid agreements with neighboring jurisdictions and developing contracts and funding agreements with private providers in order to ensure that transit vehicles, equipment, and trained drivers are available to meet surge requirements in an evacuation (White *et al.* 2008). Failure to enter into mutual aid agreements was illustrated during Hurricane Katrina when, in response to the evacuation of New Orleans, unused high-capacity vehicles were left behind in the city because inter-agency cooperative agreements were not in place and there was a lack of drivers to operate buses (Hess & Arendt, 2006). Since then, the Government Accountability Office (GAO, December 2006) found that several cities had begun to develop memoranda of understanding and mutual aid agreements for the use of vehicles and drivers in an emergency and that some cities, in order to expand the pool of drivers, had begun compensating for a possible lack of drivers by training emergency personnel not traditionally trained to operate multi-passenger vehicles to obtain a commercial driver's license.

While this is a good start, there are still barriers to mutual aid agreements and legal obstacles that continue to discourage private-sector involvement. Government officials concerned about privacy are hesitant to obtain client medical information from transportation providers in preparedness efforts. The private sector is often discouraged from participating in evacuation planning due to its vulnerability to lawsuits. For example, those who transport persons with disabilities may be dissuaded from providing services in an evacuation due to the possibility of being sued for damages if an evacuee becomes injured while, for example, boarding a bus. Another major problem is the private sector's uncertainty about being adequately reimbursed for services

provided during a disaster. Entering into legal agreements (such as memoranda of understanding) that ensure reimbursement and that reduce liability requires legal representation as well as additional liability insurance entailing monetary costs that are prohibitive for state, local governments and transportation providers (GAO, December 2006; Renne, *et al.* 2009). Mutual aid agreements among EMS transportation services in neighboring municipalities impose a special set of problems. Some visiting units must be dispatched by hometown dispatchers, preventing unified coordination. In addition, in a large metropolitan area, drivers may have difficulty navigating if they are unfamiliar with new surroundings (Sternberg & Lee, 2009).

Public transit employees themselves have been identified as the most valuable human resource for agencies during an evacuation operation (Chaudhari, *et al.*, 2009) but like public and private transportation companies, they too face limitations. One issue is a lack of driver training. In San Francisco, informal agreements pair every available driver with the nearest city vehicle in case of a disaster. However, disaster driver training is lacking because transit agencies with limited resources have resisted this type of training because transit agencies cannot justify the cost of staffing training sessions (Renne, *et al.,* 2009).

In past emergency evacuations, there are reports of employees not reporting to work for fear of their own and especially their family's safety. In a recent survey of Gulf Coast transit agencies, respondents reported that more than 50 percent of employees did not report to work during their most recent evacuation calls (Chaudhari *et al.* 2009). Transit agencies have tried to address this issue by offering special compensation to employees for complying, sheltering families at secured facilities, and giving ample notice to prepare. This is difficult for agencies when there is often the even more fundamental problem of establishing communication with employees post-disaster. Employee roles and responsibilities in emergency situations should be well defined in job descriptions and should be reinforced with job training. Employers should require employees to sign a commitment form clarifying expectations in an emergency and defining emergency assistance benefits (Chaudhari *et al.*, 2009). In San Francisco, where there is concern about employee absenteeism from work during an emergency because of fears for personal safety, the mayor and the governor appear in a video that reminds government employees of their duty to serve during a disaster (Renne, *et al.* 2009). Clarifying transit staff expectations and responsibility, providing for the evacuation needs of staff families, establishing stronger means of staff communication, and performing mock training drills are repeatedly identified as needs for strengthening the role of multi-modal transportation in emergency evacuation (White, *et al.*, 2008; Goodwill & Reep, 2005).

4.4 Lack of Coordination and Deficiencies in Command Structure

Conflicts in missions and institutional differences between public and private providers may exacerbate inter-jurisdictional collaboration for large-scale evacuation. In other

words, jurisdictional and inter-organizational complexity may complicate transportation management in the event of disaster. This was illustrated during Hurricane Katrina, where one of the biggest problems was how quickly civilian, local, state, and federal government organizations were overwhelmed. Blame was placed on a lack of plans, deficiencies in certain types of response capabilities, and organizational inadequacies (Rand, 2007; Sternberg & Lee 2009). The challenges of inter-jurisdictional collaboration are two-fold. First is the need for improved coordination among first responder agencies (Renne *et al.*, 2009). A key problem learned from past disasters is a lack of coordination for local and regional transportation for the responding medical assistance volunteers, patients, and special needs populations (Sternberg & Lee 2009; Tierney *et al.*, 2001). It is suggested that there be established protocols with a clear chain of command and checklists for transit personnel and emergency responders (White *et al.*, 2008). The second challenge is a need for more clearly defined intergovernmental relationships and processes. The distribution of responsibilities and resources for evacuation planning can become hindered when the local structure of coordination and command are disrupted by state and federal response (Renne, *et al.*, 2009).

Some major U.S. cities are carefully considering the importance of collaboration and coordination to better manage the complex and unprecedented logistics of large-scale evacuations: advanced emergency preparations were the backbone of New York City's response on September 11. Representatives of several transportation agencies noted that documented and practiced emergency response procedures could have never accommodated for a catastrophic event with such widespread impacts. But it is clear that practicing and preparing for less-significant emergencies did, in fact, help transportation agencies manage and adapt to September 11. Multi-institutional coordination was key. Reliable communication mechanisms were crucial and advanced technologies aided decision makers and travelers in many ways (DeBlasio, *et al.*, 2002, p. 51).

Likewise, others have found that ongoing command and operations training among region-wide emergency management partners has strengthened the effectiveness of emergency planning: Chicago Transit Authority participates in unified command training and operations with governmental agencies, and coordinates with the City of Chicago, Cook County, Chicago Fire and Police departments, and the 40 suburban municipalities served by the authority (Bailey, *et al.* 2007 p. 40).

Improving inter-jurisdictional collaboration through disaster preparedness efforts—by establishing improved protocols, training and communication—may be the most effective way to increase the effectiveness of multi-modal transportation during large-scale urban evacuations.

4.5 Funding for Evacuation Planning

Funding for evacuation-related operations and capital expenses for multi-modal transport is a frequently cited concern related to emergency planning. White, *et al.* (2008) recommend that federal funding should be provided for the development of regional evacuation plans that include public transit and other transportation providers and that grant recipients should be required to evaluate their progress. In the Gulf Coast, transit agencies indicated they lacked a budget for emergency preparedness efforts and compensation and overtime for employees. Operating budget restrictions and billing and payment obstacles were other areas of concern (Chaudhari, *et al.* 2009).

Department of Homeland Security (DHS) grants may be used by state and local governments to plan, train, and conduct exercises for the evacuation of households without automobiles, but the Government Accountability Office (GAO, December, 2006) found that only two of the five major cities and only one state in the study had requested a DHS grant for these purposes. The officials who requested funds for multi-modal evacuation planning reported that DHS placed a greater emphasis on purchasing equipment (rather than on planning) and on terrorism preparedness (as opposed to preparedness for natural or other disasters). In addition, DHS could not confirm how much of its funding had been disbursed to state and local governments to prepare for the evacuation of households without automobiles. Three years after the GAO report, Renne *et al.* (2009) suggested that post-Hurricane Katrina, funding for and attention to natural disaster planning had increased.

It is widely understood that there is a lack of sufficient transportation resources and the unlikelihood of adequate vehicles being effectively deployed during a disaster (Wolshon, *et al.*, 2005b; Sternberg & Lee, 2009; NYSOEM interview, 2012, Stormwest Exercise, 2012). Recognizing the severity of consequences likely caused by a lack of adequate emergency transportation, the establishment of an organization to fill this void has been recommended by various scholars (Hess & Gotham, 2007, Matherly, *et al.* 2001; Matherly & Mobley 2011, Sternberg & Lee, 2009).

4.6 Addressing Barriers to Multi-modal Evacuation Planning

Local government emergency evacuation plans often place the responsibility of providing transportation for carless individuals on one or several emergency officials. However, the treatment of this issue in evacuation plans can appear cursory or incomplete and is often untested (Hess & Gotham, 2007; FEMA, 2008; Ecology and Environment, Inc., 2007; Erie County Department of Emergency Services, 2010). This sentiment has been echoed by researchers: in interviews with more than 50 transportation and emergency management professionals nationwide, Matherly & Mobley (2011) identified a lack of transportation for vulnerable populations during emergencies.

Furthermore, various efforts have been made by the federal government to provide travel accommodations for the carless during disasters since Hurricane Katrina (FEMA, 2008; GAO, December 2006). However, these measures likely have not overcome a general perception of unpreparedness and lack of coordination regarding evacuations among the transportation-disadvantaged community that were reinforced by events surrounding Hurricane Katrina (Cutter & Smith, 2009; Elder, *et al.*, 2007; Dombrowski, *et al.*, 2006).

Finally, the transport of many special needs individuals can commonly demand additional resources which makes it more difficult to provide emergency transportation to these groups (Wolshon, *et al.*, 2005b; Gerber, *et al.*, 2010). For instance, patients in medical facilities generally require special attention and equipment to safely evacuate, which complicates the evacuation procedures of these institutions (GAO, July 2006). A need to secure wheelchairs in improvised evacuation vehicles can be a nearly insurmountable challenge (NYSOEM interview, 2012). Further complicating the evacuation of the special needs population is the likelihood that limited mobility evacuees also have difficulties receiving critical information on how to prepare and respond to a disaster, based on literacy, poverty, age, isolation, (Matherly, *et al.* 2001; Matherly & Mobley 2011). It has been recommended that the limitations in local evacuation plans, a lack of coordination among various levels of government, and considerable disparities which obstruct communications between authorities and vulnerable populations during emergency situations would be best addressed with a community-based volunteer organization (Matherly & Mobley, 2011; CCC, 2012).

5. Proposal for a Transportation Reserve Corps

Chapter 4 describes the barriers to coordination and utilization of multi-modal transportation to effectively evacuate carless households during large-scale disasters. Despite these barriers, government leaders have found that involvement and cooperation of community members in disaster preparedness, response and recovery are critical resources in safeguarding communities from disasters (CCC, 2012). Specifically, the use of networks of emergency transportation providers (Appendix E), and community-based disaster organizations (Appendix F) to limit the disconnection in critical communications between emergency officials and vulnerable populations (Matherly & Mobley, 2011). In this light, Chapter 5 will introduce the idea of a community-based organization powered by volunteers, such as a **Transportation Reserve Corps**, an innovative and effective manner in which transportation could be provided to those in need of such services during an evacuation.

5.1 What is a Transportation Reserve Corps (TRC)?

A **Transportation Reserve Corps** (**TRC**) is envisioned to be a volunteer-driven, community-supported organization for assisting primarily with the movement of people, but also supplies and goods during an extreme event or disaster—large or small. A **TRC**'s main objective is to assemble trained and licensed transportation coordinators and drivers (especially in situations where there are not sufficient drivers and vehicles to evacuate a population at risk) to conduct evacuations of buildings, neighborhoods, districts, cities or even entire metropolitan regions. A **TRC** seeks to integrate planning for households without automobiles, multi-modal evacuation, and coordinated volunteerism with disaster preparedness, response and recovery. In this way, a **TRC** expands upon the scope of existing evacuation organizations that utilize volunteers, such as Evacuteer in New Orleans (Their 2012). Figure 5-1 illustrates the key components of a **TRC**.

5.2 Goals and Limitations of a Transportation Reserve Corps

The goals of a **TRC** are to establish a framework for the movement of people and goods during an extreme event or disaster; to establish better transportation coordination during an urban evacuation; to effectively deploy and maximize utilization of existing vehicle fleets in the case of an urban evacuation; to better serve the carless population and those who cannot self-evacuate during an urban evacuation; to raise awareness among transportation providers about a region's various vehicle fleets, equipment, communication systems, and volunteer drivers to aid in better coordination and sustainability of the local, state and regional transportation systems and resources.

Beyond urban evacuation, a **Transportation Reserve Corps** could provide other support functions related to disaster preparedness, response, and recovery. These include disaster traffic management, debris removal (employing volunteers trained to operate heavy machinery), pandemic relief (when citizens are confined to homes to slow spread of disease, but food and supplies must be distributed), and assistance in returning people to their homes after an evacuation.

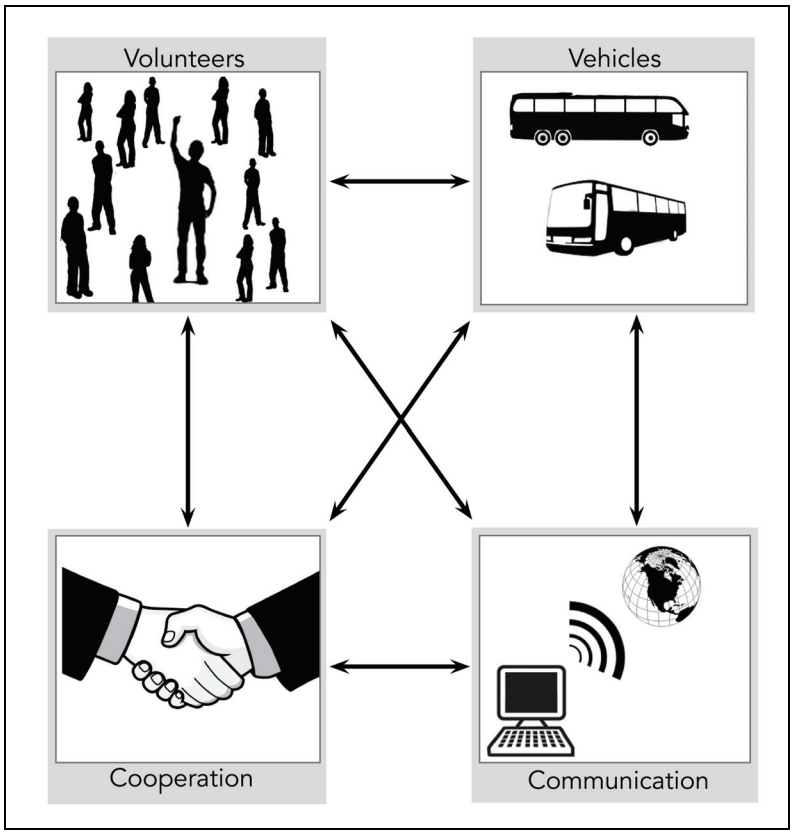


Figure 5-1. Key Components of a Transportation Reserve Corps

The goals of a **TRC** in no way interfere with existing local evacuation plans. On the contrary, a **TRC** can provide outstanding support for communities that possess emergency plans. A **TRC** would provide the greatest benefit to communities that have a thorough understanding of evacuation routes and sheltering locations and have identified both the disabled and the carless in their communities and possess a plan for these individuals. A **TRC** can serve as an important component of existing emergency infrastructure such as the Incident Command System (ICS)[6]. It is important to

[6] An Incident Command System (ICS) is a conglomeration of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure that can assist in resource management during an incident. ICS is designed be applicable to small as well as large and complex incidents. The system can be used by various jurisdictions and agencies to organize field-level incident

remember that in a community with undeveloped plans and systems for emergency events and disasters, such plans must first be developed by local governments before a **TRC** could be established.

TRC functions would not supersede or replace emergency procedures at facilities that already have thorough evacuation plans such as hospitals or nursing homes. Instead, it could aid in this type of an evacuation through resource coordination or could act as a "back-up" when drivers and vehicles have been exhausted. Furthermore, **TRC** volunteers are not designed to take the place of on-duty, professional emergency responders or vehicle drivers expected to act during an emergency, but rather a **TRC**'s volunteers' roles are to supplement and/or relieve these first responders. This is an important function of a **TRC** because a large-scale disaster may demand the evacuation or movement of people and goods exceeding the capacity of existing emergency response networks. A **TRC** would be first and foremost mindful of employee union restrictions and collective bargaining agreements with the various organizations with which they are affiliated such as local, county, state and federal governments, public transit agencies, tour and coach operators, as well as others; but in the case of a large-scale urban evacuation, where hired drivers can only work 8-hour shifts without a mandated rest period, a **TRC** would be prepared and ready to relieve workforces when routine shifts end or supplementary drivers are needed. A **TRC**'s most valuable resources are its drivers; however, a **TRC** is not designed to train and certify drivers and assumes that drivers already possess the proper licensure. A **TRC** may, however, offer training for various emergency preparedness topics.

5.3 Functions of a Transportation Reserve Corps

A **Transportation Reserve Corps** is envisioned as a disaster preparedness, response, and recovery organization.

5.3.1 Preparedness

Preparedness organizations provide coordination for emergency management and plan incident response activities prior to emergency situations. Preparedness organizations can differ in size, structure and mission. They can range from small committees of individuals to large organizations representing a variety of committees, planning groups, or other organizations. Preparedness organizations often meet regularly and coordinate with one another to ensure a jurisdiction's or multiple jurisdictions' preparedness needs are being met. The needs of a jurisdiction usually suggest how a preparedness organization will be structured and how it will conduct business. Preparedness organizations can operate across multiple jurisdictions and may include those who have the authority to manage infrastructure, nongovernmental organizations

management operations. As regional, state and federal resources assemble to assist an affected locale, the ICS, which is put in place as the command structure for the initial local disaster response, is shifted to a Unified Command System (UCS) (DHS, 2008). For simplicity, we will use the term ICS, rather than UCS, throughout the rest of the report when referring to a hypothetical **TRC**'s role in emergency response.

(NGO)[7], and private companies. Mutual aid agreements are often established between these preparedness organizations so that each will be aware of the capacity, expectations, and responsibilities of the others. Examples of other preparedness organizations are Citizen Corps and Community Emergency Response Teams (CERTs) (DHS, 2008).

A **TRC** is envisioned as a preparedness organization because it will plan for emergency response before an incident occurs. It will establish plans and procedures for coordinating multi-modal transportation in line with its mission; it will establish protocols necessary to promote interoperability and consideration for driver and passenger safety; it will adopt standards and guidelines for requesting and providing vehicles, drivers and other resources; it will identify and inventory volunteers and vehicles and establish priorities for their uses; it will provide training, preparatory exercises, program evaluations, and corrective actions; it will establish mutual aid agreements with transportation providers; it will contribute to the development of new technologies; and it will review and evaluate responses after the emergency incident to strengthen preparedness actions in the future (DHS, 2008).

5.3.1.1 Volunteer Personnel

Volunteers are the backbone of a **Transportation Reserve Corps**. A volunteer could be any person trained to operate a high-capacity vehicle such as a train (light rail, commuter rail, or Amtrak), school bus, coach bus, public transit vehicle, taxi, commercial van, or emergency vehicles and possesses the proper licensure to do so. Volunteers could include current employees of transit agencies, private transportation companies, or first responders that would, for some reason or other, not be expected to report for work during a large-scale evacuation; retired or former employees of transit agencies, private transportation companies, or first responders; a person who drives a high-capacity vehicle on a part-time basis for an organization such as church group or community organization; or a person who gains a commercial license and training for the sole purpose of joining a **TRC**.

While commercially licensed drivers are those volunteers most critical to the mission of a **TRC**, a **TRC** would also need volunteers able to offer logistics and communication support to coordinate drivers and vehicles in the event of an emergency. Examples of other types of volunteers might include those who would communicate with transportation organizations or direct drivers, information technology specialists, administrative support staff, mechanics, those who could direct traffic, those who could

[7] A nongovernmental organization (NGO) is an independent entity that serves a public purpose, not a private benefit that may or may not work with government. NGOs are formed based on interests of members, individuals, or institutions. Examples of NGOs include faith-based charity organizations and the American Red Cross. NGOs play a major role in assisting emergency managers before, during, and after an emergency and provide relief services to sustain life, reduce physical and emotional distress, and promote the recovery of disaster victims (DHS, 2008).

assist passengers, and others duties that a **TRC** deems necessary to operate effectively in the event of an emergency.

Volunteer Recruitment

Many members of a **TRC** would presumably be first responders or current employees of transportation organizations; therefore, building relationships with these potential volunteers' employers would be a first step in recruiting volunteers. Volunteer recruitment would also involve networking with organizations that represent current and retired transit employees. For example, Port Authority of New York and New Jersey (PANYNJ) has a "'retiree crew"—a list of former employees who are retired but are former vehicle drivers. Networking with various transportation unions is another important means of recruiting volunteers. Non-transportation unions, such as longshoremen's' unions and stagehands' unions whose members are trained to quickly move heavy materials and likely have commercial driver's licenses (CDL) should also not be overlooked. In fact, it was suggested that individuals could be given information about a **TRC** or given the option to join a **TRC** at the time of application for a CDL (NYC Office of Emergency Management interview, 2012). A **TRC** could also consider recruiting members of volunteer fire departments, because they are trained to drive certain types of emergency and high-capacity vehicles (PANYNJ interview, 2012).

Recruitment efforts could target people who have the ability to drive a particular type of vehicle that may lack a sufficient number of drivers in the case of a large-scale evacuation. For example, considerable use was made of motor coaches in the New Orleans and Houston evacuations during Hurricane Katrina; however, motor coach operators reported that because the need was so great, drivers worked for weeks on end and were often forced to sleep on buses (Cox, 2006).

Depending on the level of volunteer interest, a **TRC** may offer some type of incentive for volunteers. The MRC does not offer incentives for service, however, in New York State volunteer firefighters who make a five-year commitment to a local fire company are eligible to be reimbursed for tuition, depending on grade point average, for a first-time associate's degree through a grant from the Department of Homeland Security (Gee, 2012). An incentive like this is important because it could help entice younger volunteers to join a **TRC**. Modest incentives could include free give-a-ways donated to a **TRC** such as hats or t-shirts, valuable emergency management training, and appreciation dinners (County of Erie Emergency Medical Services interview, 2012).

Volunteer Enrollment

Key components of a volunteer enrollment plan are illustrated in Figure 5-2 and include the following:

- Online registration

A simple online self-enrollment process could supply **TRC** management with preliminary information about an applicant such as contact information, employment,

languages spoken, vehicle and emergency training, geographic reach, emergency expertise and interest, and licensure information. Applicants would be required to electronically 'sign' the online application to certify that all information is correct and the applicant has the authority, for example, to drive certain types of vehicles or to become a volunteer (New York State Department of Transportation [NYSDOT] interview, 2012; County of Erie Emergency Medical Services interview, 2012).

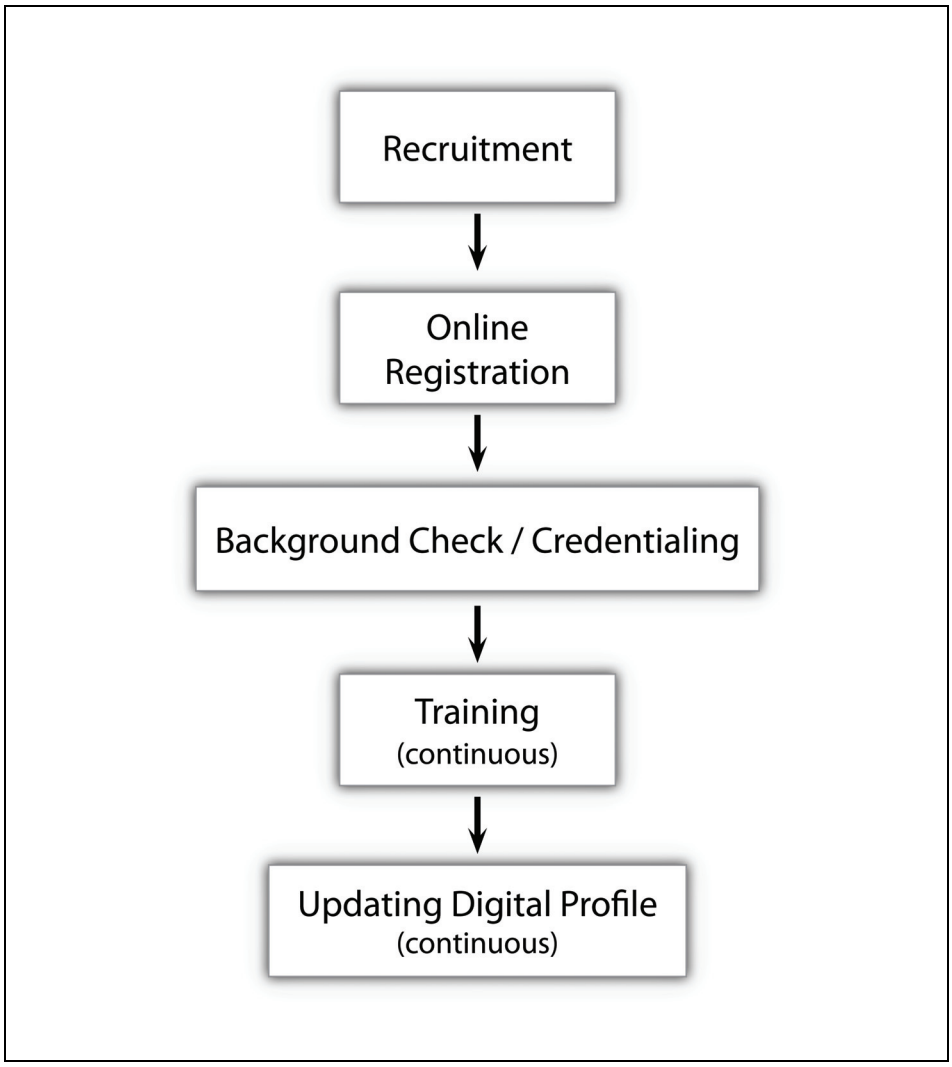


Figure 5-2. Transportation Reserve Corps Volunteer Enrollment Process

- Licensure and credential checks

Credentialing is an administrative process for validating personnel qualifications. In the broadest sense, a "credentialing process is an objective evaluation and documentation of an individual's current certification, license, or degree; training and experience; and competence or proficiency to meet nationally accepted standards, provide particular services and/or functions, or perform specific tasks under specific conditions during an incident" (DHS, 2008, p. 40). During an emergency incident and especially in cases

involving mutual aid, credentialing authorizes individuals to perform specific functions or to have increased access (DHS, 2008). Because mutual aid is envisioned to be a key component of a **TRC**, credentialing needs to be carefully considered.

Once a volunteer completes the online registration, a secondary and more complicated issue is that of checking a volunteer's credentials. Based on the information provided in the online application, a **TRC** would be responsible for conducting licensure and background checks on all potential volunteers. This is a costly but nonetheless critical step prior to enrollment (American Red Cross Greater Buffalo Chapter interview, 2012).

A **TRC** would first need to determine the level of credentialing necessary to cover the unexpected nature of disasters and the variety of duties for which a volunteer would be asked to perform.[8] Credentialing could involve, but is not limited to, verifying commercial driver's licenses (CDL), verifying clean driving records, determining if fees/debts/penalties have been paid, checking a volunteer's past criminal activity and/or convictions, checking references from former or current employees, and ensuring that applicants were not terminated from past employment for misconduct. Depending on the position for which a volunteer is applying, the level of credentialing could differ. For example, a volunteer who seeks a position in a **TRC** inventorying vehicles would require a different level of credentials than a volunteer driver who may be asked to transport a bus of school children during an emergency. Likewise, credential checks may be more straight-forward for drivers currently employed by transit agencies or private transportation companies or first responders who have to keep their qualifications up-to-date for the sake of their employment. Checking retired or former drivers could require a greater level of detail if certain credentials have lapsed over time (American Red Cross Greater Buffalo Chapter interview, 2012).

A **TRC** is envisioned to be a transportation-based volunteer organization and as such, to fulfill its mission, requires that the majority of volunteers are able to operate high-capacity vehicles. This means that verifying commercial driver's licenses (CDLs) is arguably the most important part of the credentialing process. Through the interview process it was revealed that in New York, if a driver is employed or volunteers for a non-profit organization in which transportation is incidental to the mission of the organization; and the driver is only responsible for driving the organization's members, residents, or clients, the driver does not need to obtain a CDL (NYSDOT interview, 2012). If a driver has a CDL, he or she can then apply for various endorsements available such as passenger, chauffer, or hazmat endorsements. Various levels of endorsement may be required depending on the vehicle type a CDL holder seeks to drive. For example, in New York, a passenger endorsement is needed to transport people by coach. Each of the endorsements requires an additional fee. Furthermore, in

[8] It is important to note that credentialing differs from the incident badging process. When access to a site is controlled through special badging, the badging process is based on verification of identity, qualifications, and deployment authorization (DHS, 2008). In an emergency, a **TRC** would need to be aware of situations that require special badging.

order for outside personnel to operate public transit vehicles in New York State, additional credentials are required. These pieces of information are important because they underscore the fact that although a person may be trained to drive a high-capacity vehicle, he or she may not have the right endorsements or may not have a CDL at all. This information also reveals that it could be cost prohibitive for a **TRC** to pay for people to acquire a CDL, or to pay to maintain volunteers' CDLs (NYSOEM interview, 2012; County of Erie Emergency Medical Services interview, 2012; NYC MTA interview, 2012).

If an application fails to meet established credential criteria, it would be returned and may be resubmitted at a later date with additional documentation, when the applicant's qualifications are amended, or if he or she wants to volunteer for a different position. For applications that are approved by a **TRC**, the applicant is notified, an identification card or other credential is issued to the individual, and a record is created on the individual in a **TRC** volunteer database that includes expiration date and reissue date as appropriate (DHS, 2008).

Credentialing volunteers is not uncommon. Organizations that utilize volunteers, especially spontaneous volunteers, are responsible for both ensuring each volunteer's eligibility to participate in a response, and governing the activation and use of volunteers. These organizations include governmental agencies, volunteer management agencies (e.g. Red Cross, Medical Reserve Corps), and first responders (e.g., hospitals, fire and police departments). Careful credentialing is of the utmost importance to ensure that a response is not impeded by unaddressed safety and security considerations or legal implications (DHS, 2008).

- Training

Emergency preparedness training is envisioned as the third step in a **TRC** volunteer enrollment process. Government agencies, NGOs and private organizations involved in emergency management, such as a **TRC**, are strongly encouraged to participate in *National Incident Management System* (NIMS)[9] training and exercises. In fact, NIMS training must be adopted by any organization that wishes to receive federal preparedness assistance (such as grants). Standardized NIMS training courses, some of which are offered online, focus on the structure and operational coordination processes and systems. More advanced courses, often taught in person by emergency management experts, are dependent on organizational engagement with emergency management and response. These trainings are discipline-specific and agency-specific

[9] On February 28, 2003, President George W. Bush issued Homeland Security Presidential Directive 5 (HSPD–5), *Management of Domestic Incidents*, directing the Secretary of Homeland Security to develop and administer a *National Incident Management System* (NIMS). NIMS provides Federal, state, tribal, and local governments, NGOs, and the private sector with a consistent nationwide template aimed at unified coordination to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity. NIMS is designed to be effective in all incidents, ranging from daily occurrences to incidents requiring a coordinated Federal response (DHS, 2008).

to help ensure that management and volunteers can function together effectively during an incident (DHS, 2008; NYSOEM interview, 2012).

For a **TRC**, training and exercises would need to reflect the responsibilities required of management and volunteers in an emergency situation. For example, since a **TRC** is dependent upon mutual aid, **TRC** management exercises would need to cover the processes and procedures for activating all necessary types of mutual aid agreements. For volunteers, **TRC**-specific training may be required for establishing communication procedures, individual responsibilities (dependent upon unique skill-set and interest) and protocol for safe evacuation of volunteers' families (DHS, 2008).

To improve performance and readiness, emergency response volunteers should participate in realistic exercises—including multijurisdictional incidents, and NGO and private-sector interaction as identified in emergency operations plans—to improve coordination and interoperability. Furthermore, training could be enriched through mentoring or shadowing opportunities allowing less experienced **TRC** management and volunteers to observe those with more experience during an actual incident. It is also recommended that training exercises incorporate corrective actions and best practices from past incident responses (DHS, 2008).

TRC training sessions could be offered quarterly to capture new recruits, and existing volunteers may be required to update their training yearly to renew their enrollment. A **TRC** would need to obtain insurance for some training sessions. Insurance that provides coverage for volunteer members in the event of an injury or accident has been a barrier for some emergency and medical volunteer organizations such as MRC and CERT. Without insurance coverage, volunteer members are exposed to expenses associated with possible uninsured accidents, and a volunteer organization is exposed to possible lawsuits in the event of accidents during trainings. In the best-case scenario, insurance for training sessions would be covered under the local jurisdiction's insurance policy; otherwise, a **TRC** would have to be responsible for purchasing insurance. This is often a costly endeavor (County of Erie Emergency Medical Services interview, 2012).

5.3.1.2 Resource Management

A major function of preparedness organizations is resource management. Preparedness organizations, like a **TRC**, are responsible for inventorying and maintaining current data on their available resources (DHS, 2008). In the case of a **TRC**, major resources would consist of volunteers, high-capacity vehicles, equipment, and fuel.

Preparedness organizations typically use inventory systems to assess and track resources provided by jurisdictions, NGOs or private organizations. Within these systems, resources are organized by category, kind, and type (including size, capacity, capability, skill, and other characteristics) using standardized resource management concepts such as typing, inventorying, organizing, and tracking essential supplies. This

process facilitates the dispatch, deployment, and recovery of resources before, during, and after an incident. This improves efficiency in resource-ordering and dispatching within and across jurisdictions, and among all levels of governments, NGOs, and the private sector. The data is shared with communications/dispatch centers, Emergency Operations Centers (EOCs)[10], and emergency management organizations as appropriate. Carefully inventoried, managed, and coordinated resources (personnel, equipment, and supplies) are imperative to meet incident needs (DHS, 2008).

Volunteers

Establishing a computerized database of volunteers is the first level of resource management for which a **TRC** would be responsible.[11] Once a volunteer is enrolled, a **TRC** would need to be scrupulous about ensuring that a volunteer's contact information, location, licensure, credentials, and training are up-to-date to ensure quick, efficient, and legal deployment in an emergency situation. Each volunteer is envisioned to have a digital profile that includes every piece of information necessary to inform a **TRC** of the person's abilities, training, location and credentialing. One way to reduce data entry for **TRC** staff might be to create a web-based system in which volunteers could update their own information as needed. The system would also send reminder messages to volunteers and **TRC** management as critical expiration dates approach for licensure or training.

High-Capacity Vehicles

The inability for government entities and NGOs to effectively inventory high-capacity vehicles and their locations and match these vehicles with both drivers and evacuees depending on need are repeatedly mentioned as major barriers to effective multi-modal evacuation strategies. Reasons for this include lack of coordination across agencies and organizations; lack of financial resources to undergo a complete inventorying process; and the ineffectiveness of voluntary registries (Hess & Gotham 2007; Litman, 2006; Renne *et al.*, 2008; White, *et al.*, 2008; Renne, *et al.*, 2009; Chaudhari *et al.*, 2009). In a disaster scenario, emergency management reports a lack of knowledge about what resources are available and where to find them (PANYNJ interview, 2012). A **TRC** helps to organize knowledge about vehicle resources and is envisioned as a clearinghouse for gathering this information at a local or region-wide level much like the Emergency

[10] An Emergency Operations Center (EOC) is the "physical location at which the coordination of information and resources to support incident management (on-scene operations) activities normally takes place. An EOC may be a temporary facility or may be located in a more central or permanently established facility, perhaps at a higher level of organization within a jurisdiction. EOCs may be organized by major functional disciplines (e.g., fire, law enforcement, medical services), by jurisdiction (e.g., Federal, state, regional, tribal, city, county), or by some combination thereof." (DHS, 2008, p. 139)

[11] Another important element of volunteer resource management is the clear reflection of any overlap of personnel across different resource pools: "personnel inventories should reflect single resources with multiple skills, taking care not to overstate the total resources" (DHS, 2008, p. 39). For example, a volunteer driver could have credentials to drive a motor coach and an ambulance, but should not be counted twice (DHS, 2008; County of Erie Emergency Medical Services interview, 2012).

Response and Preparedness Program[12] but including private transportation providers as well as public and operating on a more local level.

A **TRC** computerized inventory database of vehicles, much like the volunteer database, would be multi-functioning. It would be a master-list of all high-capacity vehicles and their usual parked locations throughout the region. A **TRC**'s vehicle inventory would also include specialized transport vehicles (for wheelchairs, hospital patients, etc.) as well as high-capacity vehicles for transport of able-bodied passengers (PANYNJ interview, 2012).

A Human Service Coordinated Plan that promotes vehicle sharing among human service organizations for routine movement of their clients is a good example of effective vehicle inventorying and coordination (NYSDOT interview, 2012). In Western New York, the Center for Transportation Excellence[13] is an example of a coordinated community transportation system that could be a model for a **TRC**'s inventorying systems (as well as its repair and vehicle dispatch systems).

Categorizing resources by capability, known as "typing," is an essential part of a **TRC** inventorying process. In the case of a **TRC**, high-capacity vehicles, requested, deployed, and used during a disaster would need to be first typed. Vehicles are categorized by measurable standards, capabilities, and performance levels. In order to be effective in an emergency situation, typing would need to be a continuous process designed to be as simple as possible to ensure accuracy when vehicles are needed in an emergency (DHS, 2008).

A **TRC** would likely adopt the national resource-typing protocol. In addition to broad classifications like "category" (e.g. passenger transportation) and "kind" (e.g. bus) that identify and group like resources together by their function and use, a **TRC** would also need to define its vehicles in a more detailed way. For example, a **TRC** would need to

[12] In 2006, The Federal Transit Administration awarded the American Public Transportation Association a $300,000 grant to establish and administer a transit mutual aid program called Emergency Response and Preparedness Program (ERPP). The goal of the program is to provide immediate assistance to a community in need of emergency transit services, with a focus on evacuation. In 2007 a comprehensive web site http://www.aptaerpp.com./ was launched that allows APTA members (public organizations that are engaged in the areas of bus, paratransit, light rail, commuter rail, subways, waterborne passenger services, and high-speed rail; large and small companies who plan, design, construct, finance, supply, and operate bus and rail services worldwide; and government agencies, metropolitan planning organizations, state departments of transportation, academic institutions, and trade publications) to volunteer, or obtain, vehicles, equipment, or personnel in the event of an emergency, or to supplement existing emergency plans. In 2008, ERPP had a listing of more than 200 systems and suppliers and was initiating development of a visual mapping system to display member locations (GOA 2006, http://www.apta.com).

[13] The Center for Transportation Excellence (CTE) manages non-emergency medical transportation in Western New York for county governments, managed care organizations, and health and human service agencies that serve older adults, persons with disabilities and other individuals lacking adequate transportation (CTE interview, 2012).

understand and document the "components" of each vehicle. Components are elements that make up the resource. A specific component of a vehicle inventoried by a **TRC** might be a wheelchair lift. Another common classification is "measures," or the standards that identify capability or capacity (DHS, 2008). An example of a measure would be the number of passengers a motor coach could safely carry. Vehicles could also be categorized by "type," which refers to the level of resource capability. National resource typing protocol also provides for additional information important to decision-making in emergency situations including limitations of certain vehicles under certain circumstances (DHS, 2008).

Inventoried resources are not necessarily an indication of availability and it is important to remember that the jurisdiction and/or owner of the resources make a final determination of availability (DHS, 2008). In other words, in a catastrophic event, public officials cannot commandeer high-capacity vehicles owned by private companies and organizations. Private companies and organizations with fleets of vehicles must participate voluntarily in emergency response. In a disaster, companies that own coaches or tour buses, for example, most likely would have clients or tour groups that they have an obligation to care for first before they would allow the buses to be used for evacuation of the general population. For these reasons, establishing mutual aid agreements with the owners of high-capacity vehicles as a preparedness measure will become of the upmost importance for a **TRC** (County of Erie Emergency Medical Services interview, 2012).

Nonetheless, it is still critical for efficient **TRC** operations that the location of vehicles be inventoried. Understanding where vehicles are located so they can be quickly and efficiently deployed becomes just as important as understanding the components, capacity, use and measures of the vehicles. Inventorying locations of vehicles may include their usual parked locations, their occasional parked locations, and their locations when in service. Vehicles should be spatially mapped in preparation for deployment.

What is beneficial to a **TRC** is that transportation resources are often already positioned at strategic locations, spread throughout cities and suburbs and linked with population centers and transportation routes (American Red Cross Greater Buffalo Chapter interview, 2012). Other vehicles are positioned in unique locations or used only for special circumstances and therefore may be without drivers. For example, the Federal Transit Administration permits a 20 percent spare vehicle ratio for local public transit authorities (purchased with subsidies). In Western New York, the Niagara Frontier Transit Authority (NFTA) has a stored contingency fleet of about 70 older buses, no longer in regular service and replaced in service by more recently purchased vehicles. These spare vehicles could be used to transport people in the event of an urban evacuation (NYSDOT interview, 2012). Another example is the New York State Department of Corrections, which has among the largest vehicle fleets in the state and is used primarily to move prisoners (NYSOEM interview, 2012). Constantly under budget

constraints, in the event of an evacuation, these vehicles may not have enough drivers and could be inventoried and matched with drivers through a **TRC** inventorying system (NYSOEM interview, 2012). Inventorying all possible vehicles and their locations for use in an urban evacuation is a preparedness effort essential to the mission of a **TRC**.

The establishment and maintenance of a database of high-capacity vehicles may be beyond the capacity of a **TRC** to handle independently. It was suggested that a **TRC** may need to rely on and coordinate with other agencies, such as the Department of Education (for school buses), or the Department of Transportation, to provide information needed for a high-capacity vehicle database, as these organizations likely already maintain such a database in their day-to-day operations. If the aforementioned agencies have already inventoried their vehicles, a **TRC** could focus more of its attention on collecting and maintaining information on private transportation company resources (NYC Office of Emergency Management interview, 2012).

Equipment and Fuel

It is not outside of a **TRC**'s mission to consider inventorying safety, repair and maintenance equipment, and well as fuel supply and location to support a community's vehicle fleet during a large-scale evacuation. Litman (2006) considers oversight and coordination of fuel, emergency repair, and other support services just as important as coordination of high-capacity vehicles, and for good reason. Broken down and out-of-fuel vehicles have the potential to block travel, reducing the traffic-carrying capacity for evacuation and restricting access of emergency vehicles (Litman, 2006). Auxiliary resources for the maintenance of high-capacity vehicles should be inventoried in the same manner as the vehicles themselves using previously described national resource-typing protocol. In much the same way as information about vehicles should be shared by the appropriate public and private entities, information about fuel and equipment could come from private transport operators, highway departments, public transit agencies and others whose job it is to maintain and fuel vehicle fleets for everyday use.

5.3.1.3 Procedures and Protocols

Emergency management organizations develop procedures and protocols, or action-oriented specifications for use in emergency response. Procedures list the specific actions necessary to implement a plan; protocols provide for the order of operations and authorizations needed to sanction the quick execution of a task without having to obtain permission when time is limited. Developing procedures and protocols is another preparedness action for a **TRC** (DHS, 2008).

For a **TRC**, procedures and protocols would be required for a variety of actions-steps needed when a **TRC** is activated in an emergency, and resources are requested. These procedures and protocols include but may not be limited to (1) mechanisms for communicating with command units, volunteers, and transportation organizations, (2) processes for obtaining vehicles and other equipment including methods of obtaining

mutual aid agreements, and (3) establishing routes, pick-up points, sheltering, and check-in locations in coordination with existing emergency plans.

Communication

Properly planned communications systems allow for the movement of information seamlessly between command units and their subsidiary entities, as well as collaborating agencies and organizations. Communications and information systems used in emergency management are designed to be flexible, reliable, and scalable in order to function in any type of disaster, regardless of cause, size, location, or complexity. One of the biggest challenges in an emergency is quality communications; and it is this communication structure that is often the first thing to break down in a disaster (DHS, 2008; NYSOEM interview 2012).

The best systems are suitable for operations within a single jurisdiction or agency, a single jurisdiction with multiagency involvement, or multiple jurisdictions with multiagency involvement. Communications and information systems most effective in emergency management and response allow personnel to maintain a constant flow of information during an incident. Communications systems should be user-friendly, adaptable to new technologies, and reliable in the context of any incident to which emergency management/response personnel would be expected to respond. As shown in Figure 5-3, a **TRC** communications system would service multiple purposes in an emergency (DHS, 2008).

- Communication with Command Unit

During an incident, a **TRC** would need to be first and foremost integrated within a region's emergency management communication plan. Simply stated, an integrated approach should link operational and support units like a **TRC** with command units. A common means of communicating information helps ensure consistency for all emergency management and response agencies and organizations (DHS, 2008).

During a disaster, a communications system, having already been established, would link a **TRC** Emergency Operations Center (**TRC** EOC), such as the EOC depicted in Figure 5-4, with its command unit, the Logistics Section.[14] A Logistics Section Chief would send information to a **TRC** EOC requesting transportation assistance (i.e. vehicles, volunteers) at any given time during an incident. Likewise, a **TRC** could use this system to report back and update the command unit with critical information about the task assigned. This ability to be able to report information to the command unit regarding the status of assistance requested is important because it allows all levels of ICS to have the same information about the availability and location of resources enabling other emergency agencies to make effective, timely, and consistent decisions (DHS, 2008).

[14] Logistics Section is the Incident Command System Section responsible for providing facilities, services, and material support for the incident (DHS, 2008).

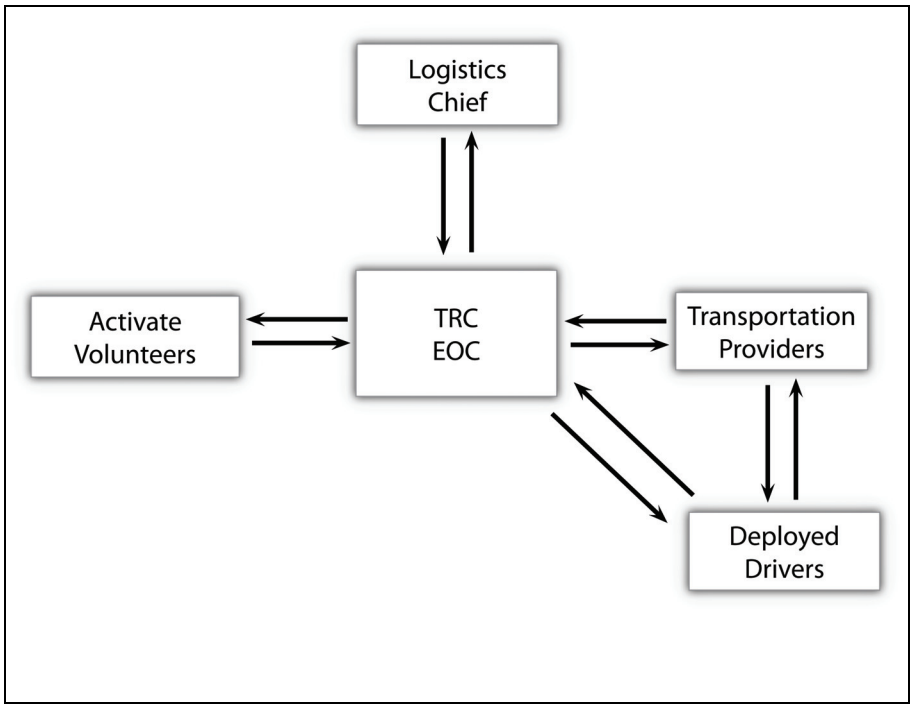


Figure 5-3. ***Transportation Reserve Corps*** *Communications System*

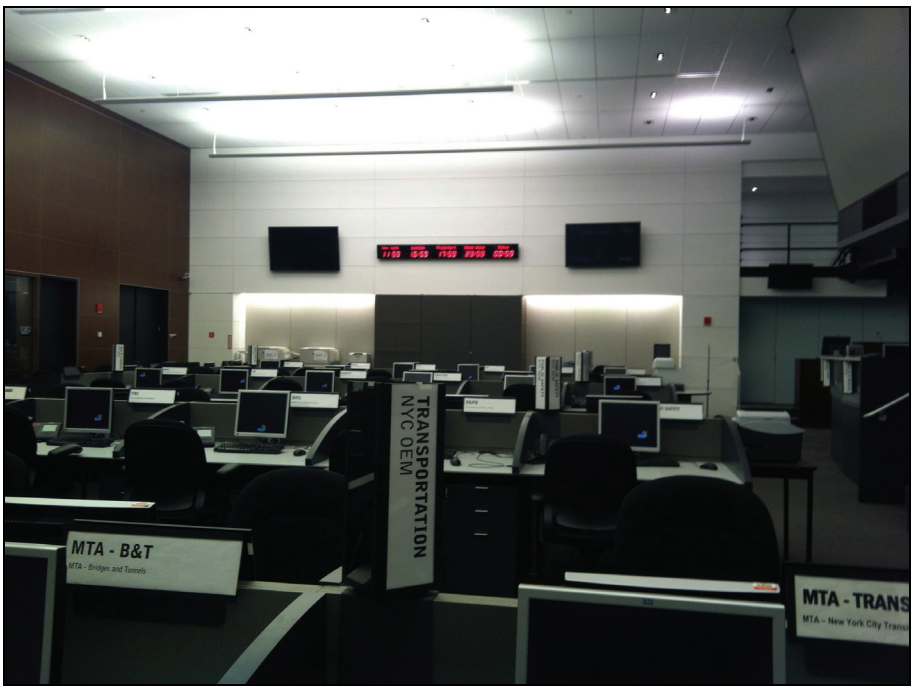


Figure 5-4. Emergency Operations Center, New York City Office of Emergency Management

- Communication with Public Transit Agencies and Private Transport Organizations or Companies

If a command unit reports to a **TRC** EOC that vehicles are needed and a **TRC** EOC identifies appropriate resource(s) using the pre-established inventories, a **TRC** EOC would then communicate the vehicle order to a contact person at the agency or organization which has the necessary vehicle(s) and with which a **TRC** has a mutual aid agreement. As a preparedness measure, a communication system, much like the one established between the Logistics Section and a **TRC** would be established between a **TRC** and all of the transportation organizations under a **TRC** umbrella.

- Communication with Volunteers

A pre-established system of communicating with volunteers would be the next communication preparedness measure a **TRC** would need to consider. If **TRC** volunteers are requested, a message would be sent by a **TRC** EOC via phone call, text message, or email to activate enrolled **TRC** volunteers. These volunteers would be given explicit instructions about how to act in the situation (i.e. location to report, personal items to bring, instructions for the volunteers' families).

- Communication with Drivers and Other Volunteers Off-Site

Another system of communication would link a **TRC** EOC and its volunteers in the field. Having been activated and reported for duty, **TRC** volunteers would need to be in continuous communication with a **TRC** EOC and vice-versa. Communication systems might include a combination of two-way radio communication, a system of cell phone usage, or digital communication. In some cases, especially those that involve volunteer drivers, a **TRC** EOC, rather than communicate directly with drivers, would communicate with a coordinator within the public transit or private company from which a **TRC** volunteer is operating a vehicle.

A **TRC** would need to consider the resiliency and the redundancy of all communication strategies but especially in interaction between volunteers and transportation organizations. Resiliency is the ability of communications systems to endure and continue to operate if there is damage to the system or necessary infrastructure. It requires communications systems to avoid relying solely on sophisticated but vulnerable communication systems. Redundancy—the duplication of identical services or the ability to communicate through a substitute method in the event of system damage—is a method of resiliency. When preparing communication protocol and procedures, a **TRC** would also need to consider that volunteers may respond to an incident far from a **TRC** EOC site and would need to take into consideration operability of communication equipment outside the jurisdiction (DHS, 2008).

Mutual Aid Agreements

Establishing mutual aid agreements is another major preparedness activity for a **TRC**. Mutual aid agreements occur between agencies, organizations, and municipal governments, and across jurisdictional boundaries, as illustrated in Figure 5-5, to

provide a means to quickly obtain emergency assistance. This assistance can be in the form of personnel, equipment, materials, and services. The goal of these agreements is to enable quick, temporary deployment of resources and other support before, during, and after an emergency. It is important to note that a signed agreement does not guarantee the provision of assistance, but rather it provides a tool for use should an emergency situation warrant a need for aid (DHS, 2008). Because a **TRC** does not own its own vehicles, but rather is designed to be dependent upon resources from public transit agencies, private transport companies, and other organizations to function, establishing mutual aid agreements prior to an incident that requires transportation assistance is of the upmost importance. Mutual aid agreements with transportation providers is the most obvious need for a **TRC**, but a **TRC** should not overlook the importance of mutual aid agreements with other entities such as telecommunication companies to provide communication support during an emergency.

For a **TRC**, written mutual aid agreements should include provisions such as the responsibilities of the parties; procedures for requesting and providing assistance; rules for payment, reimbursement, and allocation of costs; protocols for interoperable communications; relationships with other agreements among jurisdictions; treatment of liability and immunity; recognition of qualifications, licensure, and certifications; other sharing agreements; and length of agreement and termination clause (DHS, 2008).

There are several types of mutual aid agreements that a **TRC** could engage in depending on the services needed, the size of the jurisdiction that a **TRC** covers, geographic location, and willingness of the second party to cooperate with a **TRC**. These are:

- Automatic Mutual Aid: Agreements that provide for the involuntary dispatch of requested resources without special approvals. These agreements are usually basic contracts and sometimes may be informal arrangements.
- Local Mutual Aid: Agreements between geographically adjacent organizations or jurisdictions that depend on a formal request for aid often encompassing a larger area than automatic mutual aid (DHS, 2008).

The jurisdiction in which a **TRC** is established may already have established mutual aid agreements with other jurisdictions and/or organizations, including NGOs and the private sector, from which they expect to receive assistance in a disaster scenario. Furthermore, sometimes mutual aid agreements are approved collectively so a **TRC** would need to coordinate with pre-existing agreements such as:

- Regional Mutual Aid: Agreements between multiple jurisdictions, often sponsored by a regional body.
- Statewide/Intrastate Mutual Aid: Agreements that incorporate state, local and nongovernmental resources, often coordinated by state governments.
- Interstate Agreements: Formal state-to-state agreements requesting assistance in the case of a disaster.

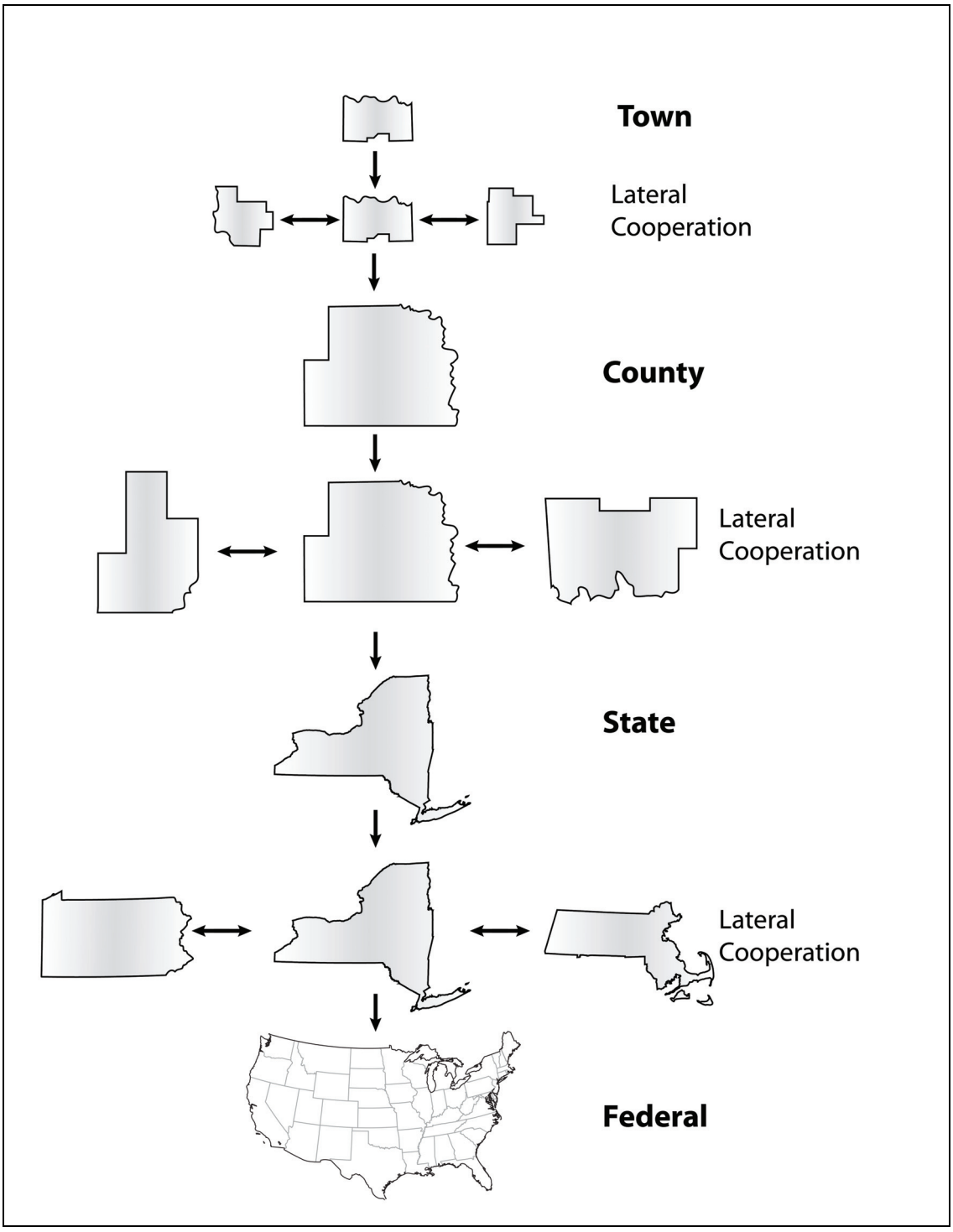


Figure 5-5. Geographical Depiction of Hierarchical and Lateral Mutual Aid

- International Agreements: Agreements between the United States and another nation that allow for the deployment of certain federal resources in a disaster scenario.
- Other Agreements: Any formal or informal agreement used to request or provide assistance and/or resources among governmental agencies, non-profit organizations, or the private sector. (DHS 2008)

Coordination with existing emergency plans and emergency management organizations

A **TRC** would greatly benefit communities that have a thorough understanding of evacuation routes and sheltering locations and have identified both the disabled and the carless in their communities and have a plan for these individuals. Establishing protocols and procedures in coordination with existing emergency plans and emergency response could greatly aid the mission of a **TRC**. Coordination with existing emergency plans would vary by community, and examples of this type of preparation could include establishing procedures for designated volunteer meet-up locations, coordinating with existing evacuation routes, passenger pick-up points, shelter destinations, pre-identified households lacking access to private transportation, and contra-flow and other emergency traffic systems. While the Logistics Section Chief would be responsible for ordering aid from a **TRC**, it is imperative that a **TRC** gather information and develop a system of coordination with other agencies, organizations and plans.

Many examples of establishing greater coordination among emergency management organizations were identified through the interview process for this research process. For example, much research has been dedicated to the importance of understanding and tracking the locations of households that lack automobiles in a community (White, *et al.* 2008; Renne, *et al.* 2009; Matherly, *et al.* 2001; Matherly & Mobley 2011; Renne, *et al.*, 2008; Litman, 2006; Gerber, *et al.*, 2010; DHS, 2006, GAO, December 2006). In New York State, the Office of Health Emergency Preparedness (NYSOHEP) has developed Transportation Assistance Levels (TALS), a system of coding and tracking for patients at hospitals, clinics, nursing homes and other medical facilities to dictate the type of vehicle a patient needs in case of an evacuation. New York State Office of Health and Emergency Preparedness (NYSOHEP) is working to develop the same system for patients living at home (NYSOHEP interview, 2012). Coordinating with an existing system such as this could greatly aid a **TRC** in evacuating patients at home or in facilities.

A **TRC** should also understand how public transit agencies are integrated into local emergency planning and create procedures and protocols for collaborating with these agencies. For example, in New York City, the Metropolitan Transportation Authority (NYC MTA) emergency operations are structured around the city Office of Emergency Management (NYC OEM) plans for integrated evacuation. Coordination with the NYC MTA is essential in carrying out OEM's evacuation plans for relocating carless New

Yorkers to a network of shelters by way of an additional network of approximately 65 evacuation centers, located strategically throughout the city, which serve to process and place evacuees. Inter-agency coordination of emergency transportation resources also occurs between the NYC MTA and the Port Authority of New York and New Jersey (PANYNJ) (NYC MTA interview, 2012; NYC OEM interview, 2012).

5.3.2 Response

A **TRC** is not only an emergency preparedness organization, but it is also an emergency response organization because a **TRC** is designed to address the short-term, direct effects of a disaster. Response activities include immediate actions intended to save lives, protect property, and meet basic human needs during an emergency. Response also includes the execution of emergency operations designed to reduce the loss of life, personal injury, property damage, and other unfavorable outcomes (DHS, 2008).

5.3.2.1 Transportation Reserve Corps' Role in an Incident Command System

Large disasters that start with a single response within a single jurisdiction and rapidly expand on multidisciplinary and multijurisdictional levels require significant additional resources and operational support. An Incident Command System (ICS) provides coordinated and collaborative incident management, especially where additional resources are required or are provided from different organizations within a single jurisdiction or outside a jurisdiction. It is this call for additional resources that is the main function of a **TRC** and therefore a **TRC** must be part of an ICS. When a single incident covers a large geographical area, local emergency management and incident response may be required. These responding agencies are governmental agencies, NGOs, and private-sector organizations. A **TRC** is reliant upon effective cross-jurisdictional and departmental coordination and it is therefore imperative that a **TRC** be absorbed into the already established ICS processes and systems (DHS, 2008).

When a state of emergency is declared in a jurisdiction by the chief elected official, the ICS may be activated. In New York State, declaration of a state of emergency is important for a **TRC** for a number of reasons. First, under Article 2b of New York State Law (New York State Executive Law Article 2-B) when a disaster is declared, the state assumes the liability of volunteer workers. In other words, if a jurisdiction engages people including volunteers for emergency work, then they have essentially "bought" the workers and therefore liability insurance is covered. Secondly, Article 2b gives the chief elected official power to order necessary resources to ensure the safety of responders, and use whatever resources are at hand "out of class," (e.g. a dump truck could potentially be filled with evacuees). Transportation officials stress the overwhelming benefit of having a clear, concise evacuation mandate from government officials in order to effectively execute an evacuation. A **TRC** will need to decide if it can operate effectively, including providing liability insurance to volunteers, if transportation assistance is needed but a state of emergency is not declared (New York State Executive Law Article 2-B, NYC MTA interview, 2012; NYSOEM interview, 2012; NYSOHEP interview, 2012).

Figure 5-6 shows how a **TRC** might fit into an established ICS. When a state of emergency is declared, Incident Command (IC) is at the top of the ICS hierarchy. IC is responsible for overall management of an incident and has overall authority and responsibility for directing incident operations. When multiple agencies or jurisdictions are involved in an incident, the IC is known as Unified Command (UC) (DHS, 2008).

The ICS is normally structured to facilitate activities in five major functional areas: Command, Operations, Planning, Logistics, and Finance/Administration. For the purposes of this study, focus will be on the "Logistics Section" because it is this section that is responsible for all service support requirements including ordering resources such as transportation, supplies, equipment maintenance, fuel, food services, communications and information technology support, and emergency responder medical services. Included within this section is the Ground Support Unit – a logical place for a **TRC**. The Ground Transportation section provides all ground transportation during an incident and is responsible for maintaining and supplying vehicles, keeping usage records, and developing incident traffic plans (DHS, 2008).

Figure 5-7 shows that as part of the ICS, when a state of emergency is declared by the chief elected official of a jurisdiction, a **TRC** will establish an independent Emergency Operations Center. Once activated, a **TRC** EOC will receive word from the Logistics Section Chief about deployment of **TRC** resources using communications procedures previously established. In line with the purpose of the ICS, a **TRC** would only respond with drivers, equipment or vehicles when requested by an appropriate authority, as previously established in preparation for activation. Resources not requested would not be deployed "to avoid overburdening the recipient and compounding accountability challenges" (DHS, 2008, p.49).

When a request for resources from a **TRC** is made, a **TRC**, in line with the procedures and protocols already established, would communicate with transportation agencies and companies or volunteers to mobilize. The nature of the incident, more than anything else, decides the type and quantity of resources to be mobilized.

5.3.2.2 Mobilization and Resource Tracking

When notified through the established channels, **TRC** volunteers and vehicles would begin to mobilize. Mobilized resources are given such details as the date, time, and place of departure; estimated date and time of arrival; reporting location; incident assignment; anticipated duration of deployment; and a resource order number. The system established for resource-tracking and mobilization processes are directly linked. When resources arrive at the place where aid is requested, they are checked in. Notification that the resources have arrived makes its way through the appropriate channels (DHS, 2008).

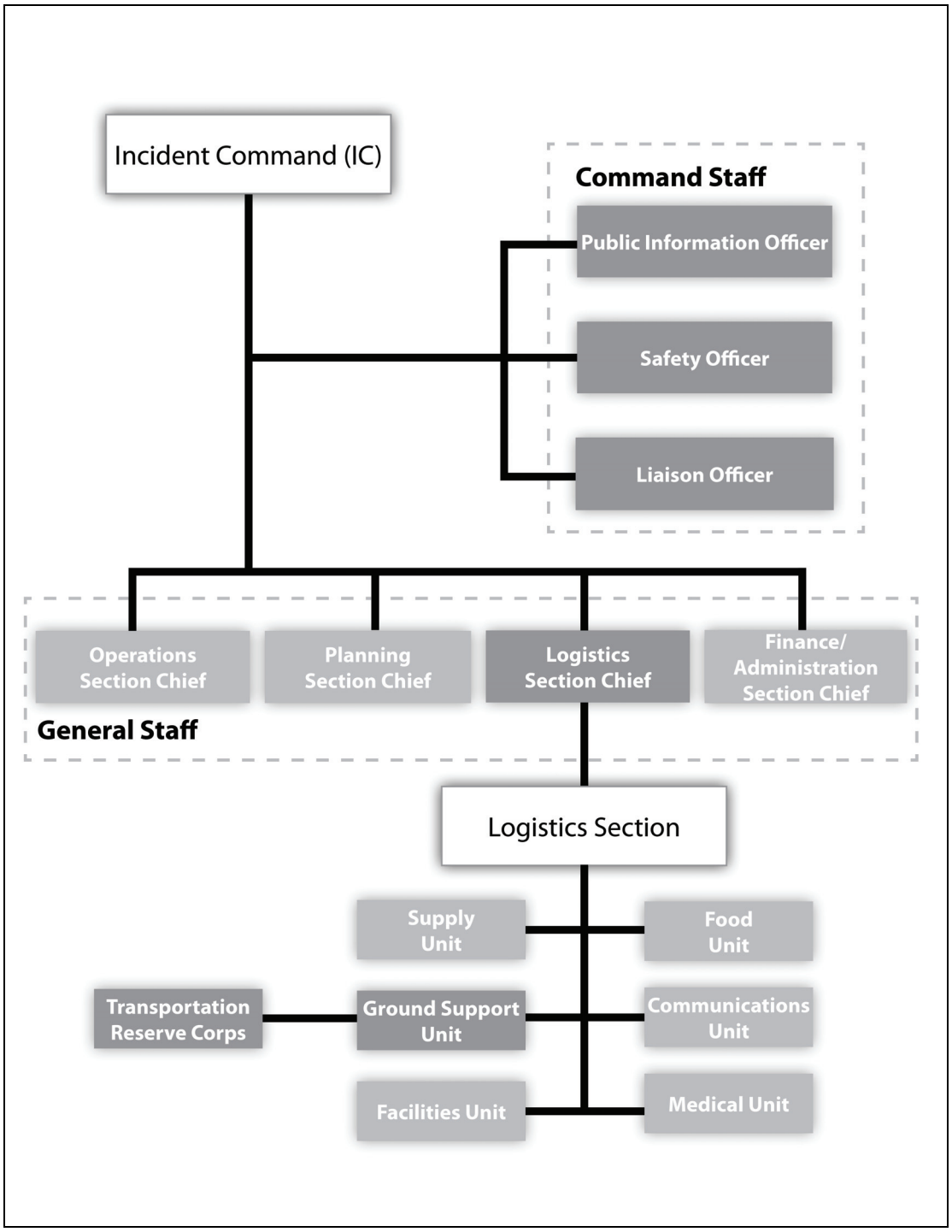


Figure 5-6. Incident Command System and a Transportation Reserve Corps
Note: Adapted from Department of Homeland Security, National Incident Management System (NIMS). Washington, D.C.: U.S. Department of Homeland Security.

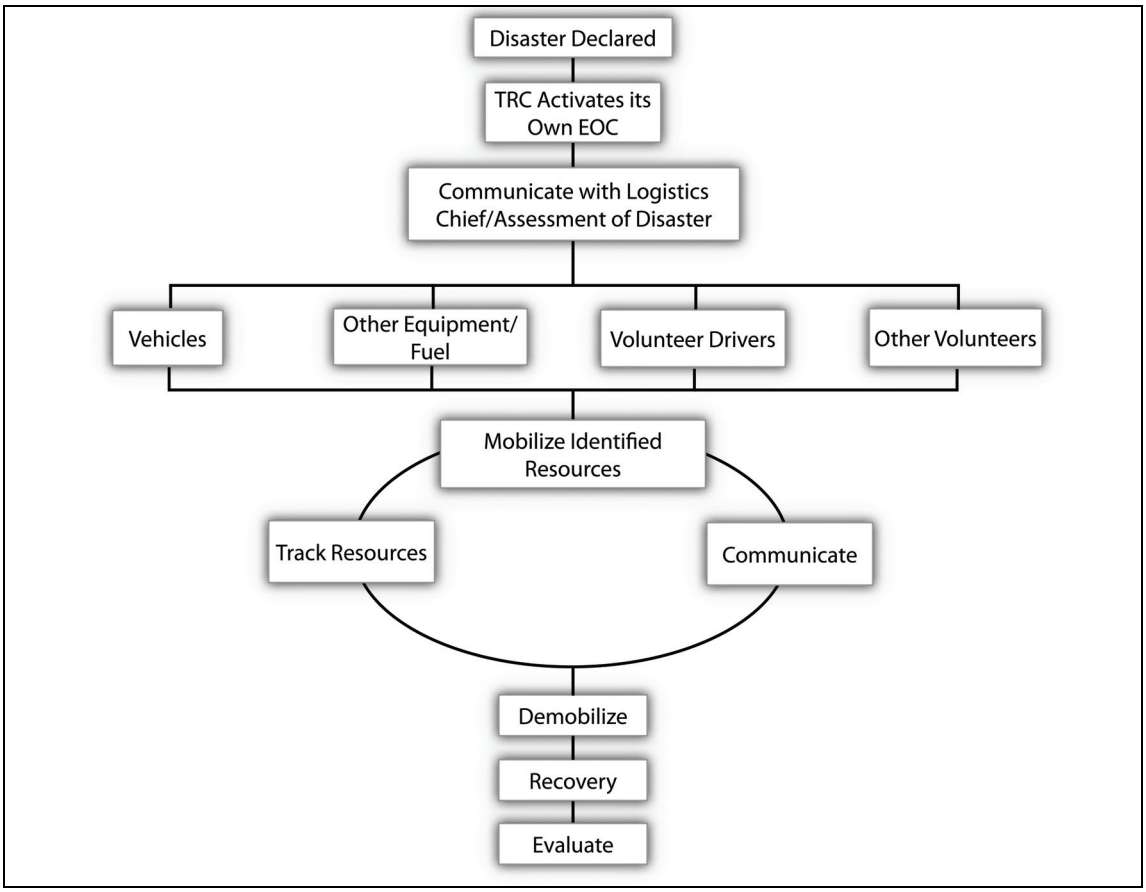


Figure 5-7. A Transportation Reserve Corps' Coordinated Response

Resource availability and location will constantly change as an incident evolves. Again, this requires a **TRC** to coordinate closely with emergency organizations participating in the response effort operation. Resource tracking is one of the most important coordinated process that "provides a clear picture of where resources are located; helps staff prepare to receive resources; protects the safety and security of equipment, supplies, and personnel; and enables their coordination and movement" (DHS, 2008, p. 38). Organizations responsible for resource management, such as a **TRC**, use established procedures to track resources continuously from mobilization through demobilization. Examples include tracking systems that identify the location and status of mobilized vehicles and volunteers and the procedures to demobilize resources and return them to their original locations and status (DHS, 2008). To better coordinate and track the dispersal of their resources, transit authorities, such as the NYC MTA, express the need for GPS devices on all high-capacity vehicles used in an emergency; a feat which remains to be accomplished (NYC MTA interview, 2012).

5.3.3 Recovery

In the broadest sense, recovery following a disaster is the restoration of affected areas and services. This includes the reconstitution of government operations and services;

assistance programs to provide housing and other needs; long-term care and treatment of affected persons; measures to promote social, environmental, and economic restoration; evaluation of the incident to identify lessons learned; post-incident reporting; and development of initiatives to mitigate the effects of future incidents (DHS, 2008).

5.3.3.1 Demobilization

For a **TRC**, immediate recovery would involve demobilization - the orderly, safe, and efficient return of vehicles and volunteers to their original location and status. A **TRC** would need to prepare for a demobilization process as soon as resources are mobilized in order to facilitate accountability, provide for the safety and well-being of volunteers, and provide efficient service (DHS, 2008).

Most of a **TRC**'s resources are nonexpendable and as such must be fully accounted for both during the incident and when they are returned to a home organization for which a **TRC** has a mutual aid agreement. Whether or not a **TRC** will have the capacity to restore vehicles damaged while mobilized to fully functional capability after its tasks are complete or readying these vehicles for the next mobilization is beyond the scope of this study. In the case of volunteer resources, however, a **TRC** would need to provide adequate rest and recuperation time and facilities. A **TRC** might also need to provide occupational health and mental health support for its volunteers (DHS, 2008).

5.3.3.2 Other Recovery Roles for a Transportation Reserve Corps

While a **TRC**'s major role is to better serve the carless population and those who cannot self-evacuate during an urban evacuation, a **TRC** could act in other important disaster recovery roles as long as liability insurance and mutual aid agreements are still in place. These recovery efforts could include traffic management, debris removal (employing volunteers trained to operate heavy machinery), pandemic relief (when citizens are confined to homes to slow spread of disease, but food and supplies must be distributed), and assistance in returning people to their homes after an evacuation (Erie County Emergency Services interview, 2012; FEMA Region II interview, 2012).

5.4 Transportation Reserve Corps Administrative Structure

While other volunteer disaster response organizations, such as an MRC, operate through a nationally-based top-down structure, there may be more interest in developing a **TRC** framework at the state level than at the federal level (FEMA interview, May 2012). Planning for emergencies is primarily an undertaking for local government, but disasters which provoke large-scale evacuations likely exceed a locality's ability to respond effectively (McQuire & Schenk, 2010). Therefore state governments, granted power by the federal government to respond to emergencies and evacuations, may be most effective in providing oversight for a system of **TRC**s (FEMA interview, May 2012). Federal involvement in working with a **TRC** may stem from groups and individuals that advise states on emergency and evacuation planning

(FEMA interview, May 2012). **TRC** response will require swift deployment of volunteer drivers, and **TRC** units would be most effective if they were based at the local or county level. The structure of such an operation on the local level is described in the follow paragraphs.

5.4.1 A Home for a Transportation Reserve Corps

Understanding a **TRC**'s role in preparedness, response and recovery; and understanding a **TRC**'s placement in a community's ICS will help to determine the best administrative model for a **TRC**. The ideal administrative model for a **TRC** would consist of three major elements: an office to contain and manage everyday preparedness operations; an Internet-based management system to facilitate a **TRC** spectrum of preparedness, response, and recovery activities from enrollment and communication with volunteers, to inventorying, mapping, and tracking vehicles; and an EOC ready for activation when a disaster is declared—this may or may not be independent of a community's existing Incident Command (IC).

The first model might be to establish a new, independent home for a **TRC**. The second may be to house a **TRC** within an existing regional governmental agency such as city or county's emergency service organization, regional transportation organization or metropolitan planning organization (MPO). The third might be to house and share administrative functions with a community's existing formal volunteer organization associated with extreme events and disasters, and health and medicine (Citizen Corp, Medical Reserve Corp or Community Emergency Response Teams [CERT]). When deciding upon an appropriate administrative model for a **TRC**, a number of factors such as communication, technology, infrastructure, staffing and financial capacity must be taken into consideration. Dependent upon these factors, a **TRC** may be absorbed into an existing organization, or a **TRC** may benefit from status as an independent start-up organization that shares resources or partners with other emergency response and planning organizations.

Many emergency management professionals agreed, for a myriad of reasons, that a **TRC** would be more feasible if it were tied into an existing organization or sponsored by an existing organization, rather than being established as a start-up, stand-alone organization (FEMA Region II interview, April 2012; American Red Cross Greater New York Region, interview, 2012). There was lack of consensus in our expert interviews, however, in determining the right fit administratively for a **TRC**. In Western New York, for example, there are several agencies that effectively could serve as host organization for a **TRC**. Greater Buffalo Niagara Regional Transportation Council (GBNRTC), the region's metropolitan planning organization (MPO) may be appropriate because of its administrative capacity, its position at the nexus of local, state and federal transportation operations, and its financial resources (NITTEC interview, 2012). MPOs are also important in relation to a **TRC** because of the role they play in promoting coordinated planning in anticipation of unexpected events or natural disasters, and in providing a centralized location for information on transportation system conditions

and local/national responses that might be useful in an emergency (Meyer, 2002). Although GBNRTC's administrative and planning capacities are strong, it lacks a centralized communication system—envisioned as a must for a **TRC**.

It was also suggested that Niagara International Transportation Technology Coalition (NITTEC) could house a **TRC** in Western New York. NITTEC is an organization made up of fourteen agencies in Western New York and Southern Ontario whose goal is to improve regional and international transportation mobility, promote economic competitiveness and minimize adverse environmental effects related to the regional transportation system. NITTEC has a strong communication capacity, and its networked communication system could serve a **TRC** well (NITTEC interview, 2012). Because of their strong communication capacity, organizations like NITTEC sometimes function as the IC in an emergency (NYSDOT interview, 2012). A weakness for NITTEC in relation to its role in housing a **TRC** is that NITTEC's main objective is to move traffic smoothly and improve safety and is responsible to provide services to the fourteen member agencies. Emergency preparedness, response and recovery are not part of its mission.

It was suggested that a **TRC** would best be served by becoming part of an office of emergency management (NY Red Cross interview 2012). In Erie County, for example, the Department of Emergency Services works closely with the entire emergency services community in Erie County, serving the public and first responders; it manages an Emergency Services Training & Operations Center; it maintains a countywide radio system consisting of over 3,000 mobile and portable radios, 14 base stations and several radio towers; it dispatches all ambulance calls in Buffalo and coordinates all ambulance calls throughout Erie County; and it maintains a comprehensive emergency management plan to maximize a timely and effective response to major emergencies and disasters.

During the interview process for this research project, there was considerable debate among emergency management professionals about the feasibility of positioning a **TRC** under the Citizens Corps umbrella as a new and separate entity; or merging a **TRC** with either the Medical Reserve Corps (MRC) or Community Emergency Response Teams (CERT). Some thought merging a **TRC** with CERT made sense because the volunteers are already trained but might not necessarily be used to their full capacity. Merging **TRC** with CERT might also allow a **TRC** to tap into CERT's federal funding stream (NYSOEM interview, 2012). Other emergency management professionals expressed concern over a possible merging of **TRC** and CERT organizations, suggesting that this affiliation would put unnecessary stress on CERT as an additional stream of volunteers would require funding, training, and management (NYC OEM interview, 2012).

It was recommended by other emergency management professionals that a **TRC** would be better served by merging with the MRC. Perhaps the most expensive but arguably most important part of **TRC** operations is a management system—likely Internet-

based—to coordinate drivers, vehicles and route assignment. The Erie County Medical Reserve Corps (SMART team) utilizes a state-wide, comprehensive volunteer management system, *Serve New York*, to enroll, manage, and communicate with volunteers (County of Erie Emergency Medical Services interview, 2012). Existing technological infrastructure such as *Serve New York* could be an enormous benefit to a **TRC** and therefore it might make sense for a **TRC** to be appended onto an existing MRC with sophisticated communication infrastructure.

Another benefit of a **TRC** merging with a local MRC is that the MRC is organized at a county level, rather than a municipal level like CERT (County of Erie Emergency Medical Services interview, 2012). A **TRC** is envisioned to be organized to cover a region, therefore merging with a county-wide organization may be a good match for a **TRC**. Furthermore, MRC volunteers, like **TRC** volunteers, are already certified and trained and therefore become easier to manage in emergency situations, carrying out actions similar to their daily work activities. As MRC volunteers are already a skilled resource, the MRC simply needs to coordinate and utilize this resource, rather than continually train and maintain volunteers to ensure high levels of enrollment and activity. In contrast, CERT is an all-inclusive organization comprised of non-specialized volunteers whose service is contingent on the organization managing them. Moreover, an MRC has a stronger national structure, as opposed to locally-managed CERT groups, which may allow better regional coordination of personnel by allowing staff to check backgrounds of people from outside an affected locality (NYC Office of Emergency Management interview, 2012). The mission of the MRC, however, to provide emergency health services and public health awareness, does not coincide with the objectives of a **TRC**.

In addition to the aforementioned benefits of becoming part of either an existing MRC or CERT, these organizations may be the right administrative fit for a **TRC**. It might make sense for the two to share day-to-day office space, paid administrative staff, funding and training. It was also suggested that a **TRC** may benefit more from a built-in flexibility with either the MRC or CERT rather than partnering directly with these organizations. This model could allow a **TRC** to fall under the Citizen Corps umbrella, but act as a stand-alone entity (NYC Office of Emergency Management interview, 2012; FEMA interview, May 2012).

Recommending a definitive administration model for a **TRC** is beyond the scope of this study, however, it is important to consider **TRC** preparedness goals and how a **TRC** functions within a community's ICS during and after an emergency. This may be achieved by exploring the mission and capacity of other emergency management and transportation organizations to possibly absorb the functions of a **TRC** into operations. It may be the case, however, that no existing organization is the right fit for a **TRC** or has sufficient resources to manage a **TRC**s administrative function given current capacities. In this case, the best scenario might be for a **TRC** to remain a fully independent organization, perhaps under the Citizen Corps umbrella, but partner when

possible with other organizations and pool resources, such as an Internet-based management system and NIMS training.

5.4.2 Transportation Reserve Corps Management and Staff

A local **TRC** management and staff is envisioned to be headed by a Board of Directors or Executive Steering Committee and managed by an Executive Director. Under the Executive Director would be three departments, likely volunteer led: Volunteer, Resource Management, and Communications with various roles and responsibilities. Figure 5-8 depicts this potential administrative structure.

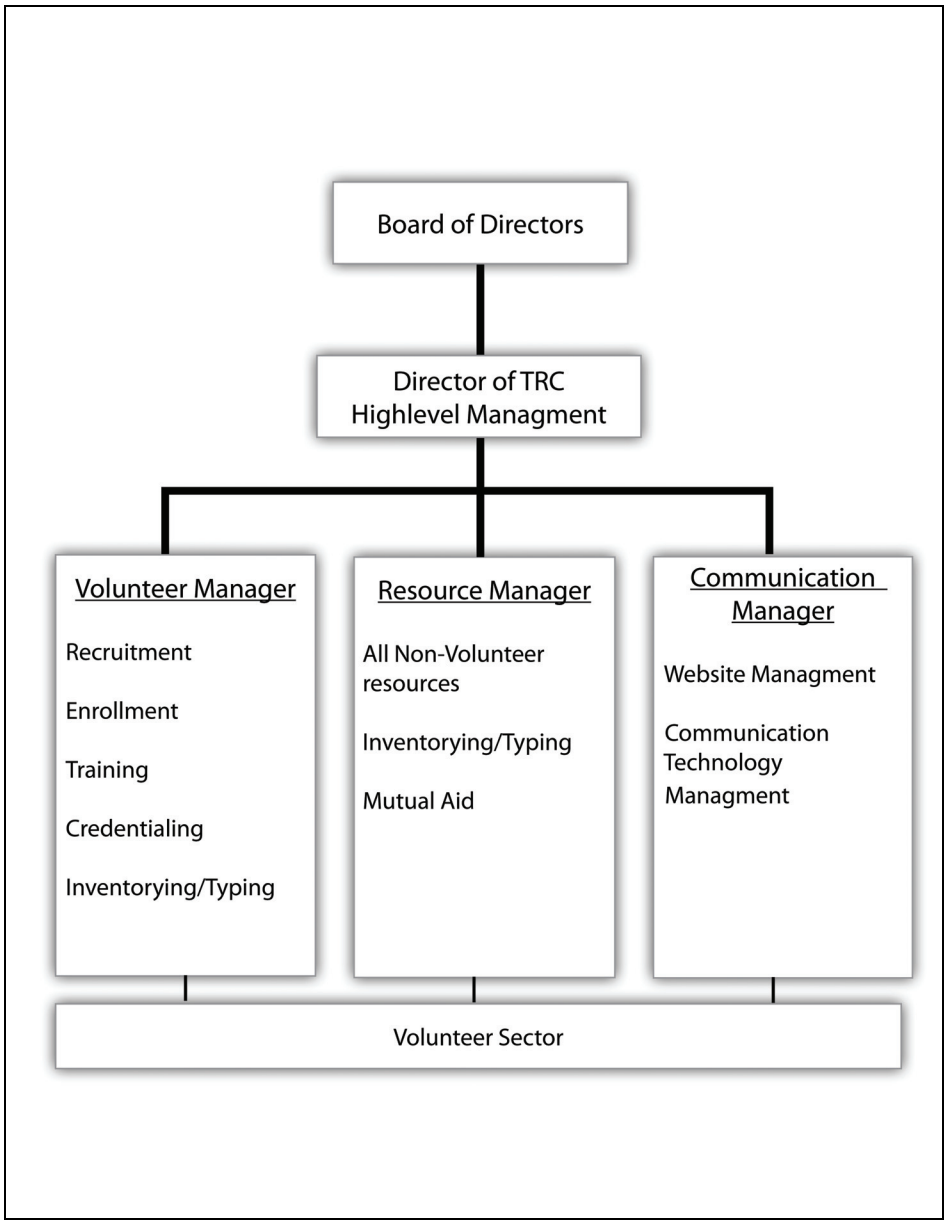


Figure 5-8. Transportation Reserve Corps Administrative Structure

While an MRC may be unprepared or unwilling to completely absorb a **TRC** into its operations, a **TRC** could mimic the MRC's administrative structure (NYSOEM interview, 2012; NYC Office of Emergency Management interview, 2012). For example, Erie County Medical Reserve Corps (SMART team) volunteers are subdivided into sectors depending on their duties. Assisting a medical director, the team operates through nine sectors each having a representative on SMART's executive steering committee; (1) communications, (2) fatality management, (3) logistics, (4) mental health, (5) pharmacy, (6) spiritual care, (7) tactical medicine, (8) veterinary and (9) treatment (County of Erie Emergency Medical Services interview, 2012). A **TRC** may also want to divide its volunteers, depending on roles, into sectors. It is essential that this leadership is strong and clear in its direction, and also collaborates proactively with other response groups and local emergency services (Erie County Department of Emergency Services interview, 2012).

5.4.3 Funding

Funding **TRC** start-up, capital costs, and operations would depend greatly on **TRC** administrative structure. In fact, funding may be one of the main determinants of how and under which entity a **TRC** is organized. For example, Citizen Corps programs, such as MRC and CERT, are funded by the Department of Homeland Security, especially for preparedness and training exercises (American Red Cross Greater Buffalo Chapter interview, 2012; County of Erie Emergency Medical Services interview, 2012; NYSOEM interview, 2012).

In general, interviewees suggested exploring other Department of Homeland Security and Department of Transportation grants (American Red Cross Greater Buffalo Chapter interview, 2012; NYSOEM interview, 2012). If a **TRC** could make the case for public health benefit, Center for Disease Control and U.S. Department of Health and Human Services Health Resources and Services Administration provide emergency preparedness grants (NYSOHEP interview 2012). State offices of emergency management and departments of transportation were also mentioned as potential funding sources for a **TRC** (NYSDOT interview, 2012). On a more local level, it was suggested that there could be funding through Metropolitan Planning Organizations (MPOs) for coordinated transportation planning (NITTEC interview, 2012; NYSDOT interview, 2012). Other interviewees suggested applying for grants through community foundations (NYSOEM interview 2012; American Red Cross Greater Buffalo Chapter interview, 2012) and engaging in local fundraising efforts (County of Erie Emergency Medical Services interview, 2012). It was also suggested that a **TRC** explore possible mutually-beneficial partnerships with local nuclear power plants, which often have a budget for safety exercises, and could benefit from the services of an emergency transportation organization like a **TRC** (FEMA interview, May 2012).

5.5 Considerations for Transportation Reserve Corps Operations Based on Geographic Setting

The geographic setting of a **TRC** is the dominant factor in determining the types of disaster to which its membership must be prepared to respond. The size of an area, in terms of both geographical coverage as well as population, has a tremendous impact on the practicality and functionality of a **TRC**. Other spatial dynamics, such as the likely types of natural disasters for any geographic region, should also play a large role in determining the feasibility and operating considerations of any application of a **TRC** model.

5.5.1 Small Metropolitan Region

Smaller metropolitan areas may generally be considered less threatened by human-induced disasters. As a result, other location-based factors may play a larger role in evaluating the need for a **TRC** within these locales. For instance, if a region lies on a critical transportation route, or along a border, its risk of suffering a catastrophe by way of malevolent acts may be heightened. Similarly, the type and condition of critical infrastructure existing in a region may be more decisive in a **TRC** debate here than in larger cities. For example, if there is an electricity-generating facility operating in the region this could be a target of a malevolent attack.

Smaller cities may represent more tightly-knit communities with long-standing social networks. As a result, people may be more inclined to engage in disaster preparedness and volunteer enrollment may be relatively higher. However, communities may also underestimate disaster risk and consequently lack the political will necessary to establish a community-based volunteer organization (Rahm & Reddick, 2011). This possibility, when coupled with a lower tax base, may make it highly unlikely for local politicians of small metropolitan regions to pursue funding for emergency programs (Wolensky & Wolensky, 1990). **TRC** units within smaller cities therefore may need to take an even more proactive approach to securing funding, recruiting volunteers and collaborating with other entities to be viable and effective.

Lastly, the security of an area likely plays a larger role when framing a **TRC** in smaller regions. If there are adequate resources to shelter residents, a community may experience a lesser need to maintain a non-profit organization whose primary responsibility is to provide emergency evacuation transportation assistance. Also, if a region is isolated from other centers of population it may have to be self-reliant in disaster situations more so than less secluded areas.

5.5.2 Mid-Sized Metropolitan Region

Much like small metropolitan regions, the need for **TRC** employment by mid-sized cities is mainly dependent on other factors. For example, if a mid-sized city is near a critical resource, or on a border or coast, it may be more at risk and could warrant a

TRC more so than other cities of even greater size. Some other considerations for a **TRC** can be inferred from the size of the area.

The resources within and perceived security of an area will in large part determine the appropriateness of a **TRC** for a mid-sized city. These factors may largely be influenced by the geographic location of a mid-sized city, but security is likely to be overestimated by officials (Rahm & Reddick, 2011). The political will necessary to establish a **TRC** may be slightly greater than that of smaller metropolitan regions, but it is more than likely still affected by the same funding constraints. While communities may not be as closely-knit as smaller metropolitan regions, additional resources and personnel maintain a proper community context for carrying out a **TRC**. Furthermore, the largest cities, because of the complex hazards they face, have developed many emergency planning resources since 2001 (PANYNJ interview 2012, NY Red Cross interview, 2012). For this reason, mid-sized metropolitan areas may be the best initial testing ground for a **TRC**.

5.5.3 Large Metropolitan Region

At first glance, due to a higher perceived risk of human-induced disasters, more urgency is given to planning and preparing for disasters in larger metropolitan regions. This implies greater motivation for establishing and maintaining disaster response organizations, which could include a **TRC**. However, since certain large cities are already provided with a high level of disaster-related funding and resources, they may not have as much of a need for community-based disaster response volunteers (NYC OEM interview, 2012). While interviewees concur that disaster planners have been focused on central cities and CBDs because of high population density, there has been less attention paid to disaster and evacuation planning in suburbs. The **TRC** fits well with suburban areas of metropolitan regions, where neighborhood collection points (schools, libraries, churches, community centers) are easy to identify and high capacity vehicles, especially school buses, should be plentiful (Regional Plan Association interview, 2012).

New York City has become a model for disaster response planning in all large cities, especially after the events of September 11, 2001. For this reason as well as its relevance to this report, New York City will be used to illustrate the considerations for a **TRC** in large metropolitan areas. In the New York City area, emergency workers and planners tend to worry more about man-made disasters, including terrorist strikes, active shooters, and other forms of violence, more than natural disasters (PANYNJ interview, 2012, NY Red Cross interview, 2012, NYC OEM interview, 2012). Due to the same events which led to these concerns, government agencies that conduct emergency planning in New York City have been generously funded by state and federal governments since 2001. As a result, New York City has been considered resource-rich when it comes to emergency planning (PANYNJ interview, 2012, NY Red Cross interview, 2012). In this context, New York and other large cities may indeed possess the political will and funding necessary to employ a **TRC**.

Besides planning for man-made events, a high level of funding granted to New York City has also helped improve planning for natural disasters, particularly hurricanes (NY Red Cross interview, 2012, NYC MTA interview, 2012). For example, the *Coastal Storm Plan* designates districts by likelihood of storm surge. For example, if Zone A is threatened with flooding, an evacuation to Zone B is ordered; if Zone B is threatened with flooding, then evacuation from Zones A and Zone B to Zone C is ordered (New York City Office of Emergency Management, 2006; NY Red Cross interview, 2012).

A community may also be better prepared for disasters, but in a way which might limit the applicability of a **TRC** to large cities. Large cities commonly possess extensive public transit systems with large labor forces that, due to experience/expertise and liability, would be the preferred operators of high-capacity vehicles during a large-scale evacuation over volunteer drivers (NYC MTA interview 2012, NYC OEM interview, 2012). Secondly, the number of employed first responders who are licensed to drive any vehicle during an emergency limits the need for a group of volunteers serving this purpose (NYC OEM interview, 2012). As a result, New York City, compared to other places, may not be the most critical location for establishing a **TRC** (NYC OEM interview, 2012). Elected officials, emergency managers and communities of other large metropolitan areas likely share this belief, though probably to a lesser extent.

The number of people involved in a full-scale evacuation of a large city presents a challenge for the possibility of a **TRC**. This point is emphasized by the likelihood that large cities with more extensive public transportation systems may have a higher share of population in need of evacuation transportation assistance. Though in a way this does present a means of justifying a **TRC** for these areas, it also represents a hazard in that, if these resources are disrupted, evacuation will not be necessarily effective.

When thinking about an evacuation from Manhattan, there are only three exits to the west (two tunnels and a bridge) and if Long Island was also evacuating, Long Island residents would pass though Manhattan as well (NY Red Cross interview, 2012). For an evacuation in New York City, the 'solar system' is used. Residents transport themselves (many will walk) to neighborhood meeting points. These neighborhood meeting points are linked in a constellation to evacuation centers distributed across neighborhoods. Evacuees are first moved from neighborhood meeting points to evacuation centers where arriving evacuees are processed, and their sheltering needs (children, pets, special needs, etc.) are recorded. As the extent of the disaster unfolds and an estimate of the number of evacuees begins to take shape, emergency officials will begin to transport evacuees from processing centers to evacuation shelters (NY Red Cross interview, 2012). Although large cities like New York may consider themselves completely prepared for an evacuation, judging from this order of operations, it is easy to presume that a **TRC** could be utilized as a secondary unit to backup other transportation providers within these areas.

5.5.4 Urban Cores

The centers of cities can be assumed to have consistently higher transit dependent and carless residents than outlying areas. As a result, these locations are clearly ideal for a **TRC**. High population densities and relatively high political will could also make **TRC**s within these locales more functional. Naturally, a concentration of people, resources, finance and critical infrastructure within urban centers make them more susceptible to human-induced disasters that, whether accidental or intentional, arrive without any notice. Therefore, **TRC** units adopted within city centers should demonstrate greater focus on recovery operations than in other areas. Furthermore, the communication branch of **TRC** operations may be more relevant to these areas as well. Judging from the experience of Hurricane Katrina when thousands did not evacuate New Orleans for a variety of reasons (Elder, *et al.*, 2007), an organization such as a **TRC** could be used to provide direct, reliable information to inner-city residents, ideally influencing people to evacuate when it is in their best interest.

5.5.5 Rural Areas

Because populations are widely dispersed throughout rural areas, there may be insufficient resources, ability or need to evacuate these regions. Furthermore, limited resources available to local governments and the low perceived disaster risk of these communities likely limit the chances of **TRC** utilization in these areas. However, some types of emergency events, including all natural disasters, can occur just as readily in rural towns than in big cities. Many disasters, such as tornadoes and floods, exclude the possibility of residential safety via the shelter-in-place strategy. The aforementioned concern over isolation, which might promote **TRC** adoption, becomes even more pertinent with respect to rural areas. In addition to the possibility that the locality itself is isolated from other communities, individuals within these areas are spatially separated from each other as well. Consequently, certain operations of a **TRC**, such as outreach and inventorying special needs populations and vehicle assets, have an increased importance when applied to rural areas.

The usefulness of a **TRC** in a rural region can be drastically altered by the existence and condition of critical infrastructure. For example, Gilboa Dam in a rural part of New York's Schoharie County, recently underwent enhanced emergency planning following a determination that the dam was structurally deficient (PANYNJ interview, 2012). As the areas surrounding this dam consequently are more at-risk of disastrous flooding, establishing a **TRC** in these areas could be warranted. The existence of critical infrastructure also justifies funding for rural regions that may otherwise lack such means.

5.5.6 University Campuses

University campuses are quite unique when it comes to disasters and evacuation planning (NYSOEM interview, 2012). Though these institutions can have large populations (students, faculty, and staff) which could be targeted by malevolent acts,

emergency management teams may be understaffed and their disaster preparedness can suffer as a result (University at Buffalo Emergency Management interview, 2012). Unlike other institutions, such as large employment sites where most workers arrive in personal automobiles and self-evacuate, or school districts which already have buses on hand for evacuation, many university campuses may be unable to provide resident and commuting populations with evacuation transportation (NYSOEM interview, 2012). This deficiency may be exacerbated by a lack of collaboration between departments on university campuses (University at Buffalo Emergency Management interview, 2012). Also, unlike other institutions, like medical facilities for instance, universities often do not possess tested evacuation plans or do not have procedures in place to secure transportation resources from other entities (NYSOEM interview, 2012). For all these reasons, university campuses can be viewed as a setting where a **TRC** has a distinctive value.

5.6 Considerations for Transportation Reserve Corps Operations Based on Geographic Location

5.6.1 Coastal Areas

Coastal regions, particularly those on the Gulf Coast, suffer from a heightened risk of the disaster type which causes the greatest number of evacuations—hurricanes (Dotson & Jones, 2005). Other coastal areas, especially those on the west coast, face the possibility of catastrophic flooding by tsunami. Based on their location and high population densities, coastal areas may also be in relatively higher danger from malevolent acts. Considering the industrial operations and shipping which occurs along coasts, these regions may also be more prone to technological disasters such as chemical spills, transportation accidents and infrastructural failures. Correspondingly, **TRC** formation in these areas is particularly justifiable. While taking an all-hazards approach, **TRC** units in coastal areas should pay special attention to preparation for hurricanes and tropical storms. These units should consider the geographic extent and advance notice of these natural disasters when planning their response operations. In doing so, coastal **TRC** units should take special precautions to collaborate with other local entities as well as those from neighboring jurisdictions.

5.6.2 Eastern U.S.

Containing a large percentage of the national population, **TRC** units in East Coast cities should take special considerations for no-notice events, both malevolent acts and technological disasters alike. A wide range of natural disasters must also be accounted for by **TRC** units in eastern states. Those of special concern include hurricanes, floods, tornadoes, and in some locations, earthquakes. Accordingly, **TRC** units based in East Coast cities should adopt an all-hazards approach to preparedness activities while planning for events that come with advance warning, in which response activities would be emphasized, as well as no-notice events, which could incorporate more recovery responsibilities. Eastern U.S. cities are more likely than mid-Western or

Western metropolitan areas to have other cities within close proximity, easing the way for reciprocal agreements for resource sharing if evacuation is warranted.

5.6.3 Western U.S.

TRC units in the western part of the U.S. should assume an all-hazards approach in order to adequately respond to all no-notice emergency incidents resulting from either technological hazards or violent attacks. Natural disasters of special concern for **TRC** units of the western U.S. include earthquakes, tsunamis, wildfires and drought. As most of these events are erratic or come with little or no warning, western **TRC** units should extend their planning for no-notice events to the realm of natural disaster preparedness. Greater usage of a **TRC** for recovery operations should be assumed when planning for no-notice events.

5.6.4 Central U.S.

The Midwest has a high frequency of tornadoes. Fittingly, **TRC** units in these locations should be prepared to respond to short-notice, unpredictable events and possibly adjust their operations to react to recovery needs. With large populations residing along major rivers, a **TRC** should also plan to respond to and recover from floods. Although the majority of the Midwest is rural, as with all other metropolitan regions, cities in the Midwest should be prepared for all hazards coming without notice by way of technological catastrophes or intentional acts of violence.

5.6.5 Targeted Evacuations

A **TRC** may be effectively utilized for a targeted evacuation of a specific site or segment of the population. This possibility is dictated by the circumstances of the extreme event. For example, a spreading wildfire in a rural area may call for the evacuation of a defined group of residents. It would also be entirely natural for a **TRC** to evacuate a select group of people within a geographic region who do not need special medical attention but may have other special needs, such as mobility impairments. One especially challenging scenario for evacuation is the simultaneous evacuation of several hospitals and/or nursing homes because of vehicle needs, in which case mutual aid agreements become important (PANYNJ interview, 2012).

5.7 Additional Considerations for a Transportation Reserve Corps Model

A **TRC** model must be adjusted to fit various settings and geographic regions. Every setting is threatened, to variable extents, by its own assortment of evacuation-worthy disasters. The geographic setting of any **TRC** will establish the types of disaster for which its volunteers must ready themselves. Other factors, such as the size of a city or region, determine the degree to which a **TRC** must be concerned with any given threat. Apart from the setting, the type and extent of a disaster will also necessitate variations in **TRC** response. By elucidating these expected adjustments, a determination can then

be made as to which settings are most conducive to, or prohibitive of the establishment of a **TRC**.

There are numerous other factors which affect **TRC** functionality not included in this discussion. The socioeconomic composition and political backdrop of an area have a vast and complex effect on the suitability and role of a **TRC**. The most relevant of these factors is the share of households with vehicle access. As personal and household characteristics like these are variable within every region and relatively unrelated to size and location, they are excluded from this discussion. Additionally, variations in state and local laws, will have a significant and unavoidable effect on how a **TRC** can operate within an area. Chapter 7 introduces these and other challenges that a **TRC** may face.

6. Challenges for a Transportation Reserve Corps

The majority of emergency management professionals consulted in the development of this report stressed the many challenges confronted a **TRC**. These discussions, supplemented by a review of relevant laws and literature, have been used to highlight key challenges that a **TRC** will inevitably confront, either in its establishment or its operations. These challenges have been identified throughout the report, but Chapter 6 will offer a more comprehensive discussion of each. These difficulties are organized into four categories; (1) the question of providing liability coverage and insurance for a **TRC**, its volunteers, and its vehicles, (2) ensuring that **TRC** volunteers hold the training and credentials necessary to respond to emergency events, (3) the need to secure resources through legal agreements, inter-organizational reciprocity and reimbursement and (4) ensuring that the organization is sustainable and functional. In the following sections, these categories will be further subdivided and described before suggesting ways in which a **TRC** can address these challenges.

6.1 Insurance and Liability

Since the events of September 11, 2001, the involvement of citizen volunteers in disaster response has permeated many components of disaster planning. However, the necessary financial costs of insuring volunteers, through workers' compensation or liability coverage, is likely to be sufficiently burdensome to preclude many citizens from engaging in disaster response (Rolf, 2007). This complex dilemma can be extended to a **TRC** and its volunteers (County of Erie Emergency Medical Services interview, 2012; American Red Cross Greater New York Region, interview. April 19, 2012.). To ensure that this problem does not incapacitate a **TRC**, its responders and the vehicles that they use must be insured. This section provides a brief overview of the legal framework regarding the insurance of volunteers engaged in disaster response before revealing remaining obstacles to, and possible steps for the effective mitigation of this problem by a **TRC**.

Any entity that deploys individuals to the scene of an emergency may ultimately be called upon to account for any injuries or damages suffered as a result of the actions or negligence of its responders. Unless its agents are acting outside the scope of official duties, a government agency, through the theory of vicarious liability, will retain this responsibility. Therefore, any government body involved in emergency response, such as the proposed **TRC**, should have well-defined and unambiguous insurance coverage (Rolf, 2007). Some volunteer groups provide insurance for select volunteers, or during specific events. Even this partial coverage presents a substantial, and potentially debilitating, expense. Other volunteer organizations, like the Erie County SMART team, seek legislative approval or recognition by local or county government which provides

liability coverage (County of Erie Emergency Medical Services interview, 2012). Under a State of Emergency Declaration, the governor possesses the power to engage state reserve funds or to request federal financial assistance when the costs of liability exceed the capacity of local government, or the insurance provider (New York State Executive Law Article 2-B).

6.1.1 The Volunteer Protection Act

Following a decades-long national trend of increased volunteer involvement in disaster response (Corporation for National and Community Service, 2006), U.S. Congress passed the Volunteer Protection Act (VPA) in 1997 (Cohen, 1997). This law was introduced to protect government agencies and non-profit organizations representing volunteers, as well as the volunteers themselves, from incurring damages resulting from the oversight or error of emergency volunteers (Rolf, 2007). This federal law supersedes corresponding state laws that are less robust or incomplete, although states retain the option of opting out of the VPA under certain conditions (Nonprofit Risk Management Center (NRMC), 2001). However, the protections provided by the VPA are weak because volunteers representing entities that do not or cannot ensure their responders are left uninsured. As a result, both volunteers and nonprofit groups have had to endure lawsuits pertaining to volunteer malfeasance since the VPA was enacted (although these parties are typically found to be innocent under the VPA) (Rolf, 2007).

Naturally, the VPA does not ensure liability coverage against acts that are criminal, reckless or grossly negligent (Cohen, 1997). In terms of non-governmental or not-for-profit organizations, this can include acts in which the organization, or its affiliates, had (1) actually caused foreseeable harm to the suing party, (2) committed an act which violated its stated duty of care and was the immediate cause of the harm in consideration, (3) a responsibility, in agreement with its stated duty of care, to assist the suing party, and (4) not exhausted all available and practical measures of prevention (Nonprofit Risk Management Center, 2009). Under state statutes, many exceptions to this law arguably may remove VPA protections from a majority of claims that disaster volunteers defend (Nonprofit Risk Management Center, 2009). In a review of all state laws, the NRMC (2001) identified unlawful actions while operating an automobile as one of the most common, and likely the most injurious, of all exceptions to the VPA granted under state statutes. Additionally, organizations must often meet certain conditions in order to qualify for liability exemptions. The most common among these requirements include: (1) prior written authorization by government officials, (2) provisions to indemnify volunteers included in the bylaws of the organization, (3) the nonprofit supplies select volunteers with necessary training and (4) the organization provides volunteers with a specified amount of liability insurance (Nonprofit Risk Management Center, 2001).

6.1.2 Common Exceptions to the VPA under State Laws

In many states, immunity from liability is already provided to responders of certain organizations, such as the Red Cross. In certain states, like California, it is acknowledged that any individual may be called upon to assist in an emergency and therefore immunity coverage is granted to all volunteers, regardless of affiliation (Nonprofit Risk Management Center, 2001). In effect, any volunteer working for a registered organization is granted the same liability as state-employed first responders. In South Dakota, for example, any citizen volunteer is granted immunity from automobile accidents, in ways similar to that of official first responders in other states (Rolf, 2007). This immunity coverage for motor vehicle operators is rare; most states, including Texas, Virginia and Vermont, deny liability immunity outright from any responder operating a motor vehicle at the time of an accident (Nonprofit Risk Management Center, 2001). The commonness of this law, coupled with the fact that the VPA does not pre-empt state laws in this respect (Cohen, 1997), introduces a complex challenge for a **TRC**. Although in some states, a **TRC** may still be able to receive suitable coverage by meeting one or more pre-conditions (Nonprofit Risk Management Center, 2001). Nevertheless, in many instances a **TRC** might be expected to provide liability coverage for volunteer drivers in order to be viable.

6.1.3 Volunteer Protections under New York State Law

Under Article 2-B of New York State law, if a jurisdiction engages people for emergency work, then it has essentially 'bought' the labor of workers, and liability is thus provided (NYS OEM interview, 2012). Likewise, if a volunteer emergency worker begins working without being invited, the worker is liable for his/her own actions (New York State Executive Law Article 2-B). This law also grants the chief elected official with power to use any resource for any purpose, as long as due diligence is taken to ensure safety (NYS OEM interview, 2012). For example, a dump truck could be used to transport evacuees, as long as all proper precautions are taken. Under Article 2-B, emergency workers cannot change job class (*e.g.,* a police officer cannot become a nurse); this restriction would likely extend to volunteers in a **TRC** (NYS OEM interview, 2012). However, without a state of emergency declaration none of the conditions in Article 2-B are applicable (New York State Executive Law Article 2-B). In this event, disaster response organizations would need to formulate *ad hoc* agreements with government agencies or other entities (NYS OEM interview, 2012).

6.1.4 Good Samaritan Laws

Good Samaritan laws or, laws which restrict the opportunity for those who were assisted by another to file a lawsuit against the person giving them assistance if additional injuries occur, have been adopted at some level by all 50 states (Rolf, 2007). Under the Good Samaritan laws of some states, such as Nebraska, liability immunity is offered to anyone who assists in a disaster while other states, like Connecticut, only grant immunity to licensed medical professionals (Rolf, 2007, NRMC, 2001). Several states, like Vermont, go so far as to require those who are witness to another person

enduring severe physical harm to assist the person being injured (Rolf, 2007). Good Samaritan laws may therefore be used as leverage for a **TRC** in some states as well as a possible avenue for additional liability indemnity in other states.

6.1.5 Worker's Compensation and Disaster Volunteers

In the event that an emergency volunteer is harmed while responding, liability coverage is typically granted through worker's compensation. For local governments and nonprofit organizations however, the high cost of premiums and large number of workers often bar these entities from insuring their responders (Rolf, 2007). Compensation for injured responders may ultimately be assumed by state or federal governments, if a formal state of emergency is declared (New York State Executive Law Article 2-B). However, in the case of volunteer responders, this liability coverage is commonly granted only to those volunteering for the local government directly (Nonprofit Risk Management Center, 2001). One exception occurs in New Hampshire, where any person assisting in an emergency is granted worker's compensation similar to any formal state employee as long as the individual or overseeing entity is granted written consent by a government official to respond to an incident.

6.1.6 Additional Resources and Assurance

Even if volunteer emergency responders are provided with insurance coverage, this does not ensure that an insurer will actually uphold these protections. For one, the scale of an emergency may exceed the capacity of an insurance provider (Rolf, 2007; New York State Executive Law Article 2-B). There is also a possibility that an insurance company will simply fail to pay, as in the experience of many victims in the aftermath of Hurricane Katrina (Rolf, 2007). Fortunately, there are some mechanisms in place to minimize the likelihood that insurance providers will breach contracts.

6.1.6.1 Public-Private Partnerships

Numerous private, public, nongovernmental and volunteer organizations can partner together in mutual assistance, including insurance provision, by establishing memoranda of understanding (MOUs) or mutual aid agreements (MAAs). According to NIMS, these agreements should address liability, immunity and worker's compensation. Most MAAs offer some level of indemnity to deployed volunteers although these contracts can be nullified if one entity challenges the decision of the other entity to deploy volunteers (Rolf, 2007). In essence, if an unlawful act were to occur, these MAAs ensure that neither entity will sue the other, and that all involved parties will accept liability for the individual accused of the wrongful acts (Rolf, 2007). MOUs and MAAs are also useful for **TRC**s attempting to borrow vehicles from other organizations or outside jurisdictions (NYSOEM interview, 2012).

6.1.6.2 New York State Insurance Disaster Coalition

The National Association of Insurance Commissioners (NAIC) publishes a handbook which offers best national practices to instruct state insurance regulators on the

development of comprehensive disaster response plans (National Association of Insurance Commissioners, 2003). The disaster response of insurance providers in New York State has been regarded as a standard-setting state, especially after the events of September 11, 2001 (Insurance Journal, 2001). All insurance providers in New York State are compelled to align their disaster response business continuity plans with guidelines offered by the New York State Insurance Disaster Coalition (New York State Department of Financial Services, 2012). This coalition provides an outlet whereby public and private entities, most importantly life and property insurance providers, can pool resources for more proactive and collaborative disaster insurance planning network (Insurance Journal, 2001). The Disaster Coalition serves disaster victims through temporary work groups and committees, each specializing in a facet of disaster preparedness and response, including technology, training and communication, among others (New York State Department of Financial Services, 2012).

The disaster coalition could present a potential resource for a **TRC** to more fully serve disaster victims, assuming a **TRC** could team with such partnerships in an exchange of critical information for its own insurance and reimbursement purposes. An EOC, acting as a central contributor to the Disaster Coalition, could also be relied upon for such information, as these centers already maintain records of disaster operations for their own purposes, including transportation provided to victims (Stormwest Exercise, 2012). In recent years, New York State has formed a separate Insurance Emergency Operations Center (IEOC) to supplement the state Emergency Operations Center currently under the direction of the State Department of Financial Services (NYSDFS, 2012). This department, through its IEOC, supplies the Governor and SOEM with disaster loss estimates when making such crucial decisions as how to allocate state resources and when to declare a federal disaster (NYSDFS, 2012) It would seem clear that an established connection and tested communication link with this group could be another benefit afforded to a **TRC** through this collaboration. Nevertheless, a **TRC** should be equipped to maintain its own records in anticipation of any financial reimbursement secured from validation of disaster response operations, a vital task.

Although there are opportunities for addressing the problem of liability and insurance, it likely presents the most challenging obstacle for establishing a **TRC**. For example, although New York Metropolitan Transportation Authority (NYC MTA) is greatly cooperative in providing resources and personnel during emergencies, its drivers are likely overtaxed during emergency operations. In New York City, police and fire department personnel who are qualified to drive large-capacity vehicles often are brought in to relieve NYC MTA drivers during an emergency (as in Hurricane Irene, 2011). Consequently, emergency planners in New York City expressed concern in requesting volunteers to drive during chaotic and potentially dangerous emergency response operations, stating that it would be more appropriate to ask fire and police officers to do so rather than putting unaffiliated volunteers at risk (NYC OEM interview, 2012). For similar reasons, other emergency management officials recommend that a **TRC** could offer a secondary crew of drivers after primary workers

of bus companies and transit agencies, who already have their liability covered, have worked an entire shift (County of Erie Emergency Medical Services interview, 2012).

6.2 Training and Credentialing

Following disasters, many citizens and residents will instinctively offer themselves in ensuing response and recovery efforts (Orloff, 2011). However, unaffiliated and perhaps inadequately trained volunteers may become an impediment when they lack support systems or governing bodies to instruct them on how they can best assist in disaster response. Volunteers can themselves become reliant on an already strained existing organizational structure of disaster response operations (FEMA Region II interview, April 2012). Moreover, volunteers must verify their affiliation with an organization and their certified disaster training in order to be utilized in disaster response under NIMS and Incident Control System (ICS) frameworks (Cohen, 1997, DHS, 2008). Consequently, without being previously incorporated into disaster response plans, emergency management officials are unlikely to deploy volunteer groups (Rolf, 2007; FEMA Region II interview, April 2012).

The precedent set by other civilian volunteer, community-based disaster response organizations, such as the Citizen Corps and CERT, has been to only deploy volunteers after they have undergone proper training (Rolf, 2007). Typical training entails basic first aid, CPR, and NIMS/ICS coursework. Training operations for Citizen Corps Councils and CERT teams are funded by the federal government as these programs are managed nationally by the DHS (Rolf, 2007). Like these groups, a **TRC** must require its volunteers to meet minimum credentialing and training. This credentialing likely entails some level of emergency training via NIMS/ICS courses as well as a commercial driver's license (CDL) (County of Erie Emergency Medical Services interview, 2012; NYSOEM interview, 2012).

6.2.1 Commercial Driver's License

Various license endorsements which supplement basic CDLs are available to sanction auxiliary motor vehicle operation. These come at an additional cost and include auxiliary licensing for passenger, chauffeur and HAZ-MAT drivers. Due to these costs, and the costs of maintaining CDL status for individual drivers, it may be prohibitive for an organization like a **TRC** to pay for CDL training of its volunteers (County of Erie Emergency Medical Services interview, 2012). Therefore, drivers already employed by a school district or public transit authority may be the best resource for a **TRC** as their credentials are already recorded by their employer. Retired or unaffiliated CDL drivers would then be used as a secondary source of **TRC** personnel, if at all, to limit training costs (County of Erie Emergency Medical Services interview 2012, NYSOEM interview, 2012, NYC OEM interview, 2012).

6.2.2 Disaster Training

Like other emergency responders, **TRC** volunteers may need to show proof of formal disaster-response training if they are expected to be called upon in emergency situations (County of Erie Emergency Medical Services interview, 2012, NYSOEM interview, 2012). A **TRC** could possibly take advantage of certain training modules offered by CERT such as disaster psychology, first aid or search and rescue (County of Erie Emergency Medical Services interview, 2012). More in-depth training would be pursued under the National Incident Management System (NIMS), a command structure a **TRC** should also utilize in order to maintain both creditability and financial viability (Erie County Emergency Services interview, 2012; NYSOEM interview, 2012, NYC OEM interview, 2012).

6.3 Securing Resources

While previous sections of this report provide a richer discussion of possible sources of funding and transportation assets, the following paragraphs focus on formal arrangements which, although they themselves present challenges, serve as likely solutions to the limitations a **TRC** will face in obtaining material and financial resources. These are discussed in two forms: (1) legal agreements and reciprocity, and (2) reimbursement.

6.3.1 Legal Agreements and Reciprocity

Theoretically, any law obstructing disaster response operations of a **TRC** could be lawfully disobeyed during a state of emergency. For instance, according to New York State Article 2-B, the Governor possesses the power to wholly or partly suspend any ordinance, order, law or statute for a period of no more than 30 days during a state-declared disaster emergency if ordinary compliance with said law would in some way hinder disaster response operations (New York State Executive Law Article 2-B).

Contrary to what many people believe, local governments do not have the legal capacity to commandeer vehicles during a catastrophic event (County of Erie Emergency Medical Services interview, 2012, NYSOEM interview, 2012). During a disaster, coach or tour bus companies, for example, most likely have clients that would be a first priority before managers would be willing to offer resources for a general evacuation (County of Erie Emergency Medical Services interview, 2012). Furthermore, during a large-scale evacuation, most transportation resources, especially ambulances, will be in use and services will not be available to all those in need (University at Buffalo Emergency Management interview, 2012; Stormwest Exercise, 2012).

6.3.2 Mutual Aid Agreements

Due to these limitations, a **TRC** would need to establish mutual aid agreements with organizations and outside jurisdictions that could bring more vehicles into evacuation (University at Buffalo Emergency Management interview, 2012). Vehicle providers, like

public transit agencies for instance, are commonly cooperative during emergencies, the level of commitment required to establish these mutual aid agreements cannot be overlooked (Erie County Emergency Services interview, 2012; NYC OEM interview, 2012; County of Erie Emergency Medical Services interview, 2012). Once established, these agreements have often successfully supported vehicle sharing (University at Buffalo Emergency Management interview, 2012).

In establishing mutual aid agreements with private employers, it is important to be cognizant of collective bargaining agreements (CBAs) agencies have made with their employees (NYSOEM interview, 2012). In general, volunteers should not be used when a paid employees is ready, willing and able to drive a high-capacity vehicle. In setting up a **TRC**, it is likely necessary to formulate a way to work around these CBAs to be fully functional. Some MRC units when encountering the same problem have granted exemptions for their volunteers from all CBAs in organizational bylaws (Florida Department of Health, 2011).

6.3.3 Reimbursement

Like other facets of disaster response and recovery, the network of insurance providers and government agencies providing financial reimbursement for disaster victims and affected jurisdictions follows a bottom-up approach (McCarthy, 2011). Municipalities and counties must first validate that a disaster has exceeded its capacity before requesting state assistance. Likewise, states must provide documentation to FEMA verifying they have exceeded their response capacity before a presidential disaster can be declared, which would then allow for an allocation of federal funds to an affected state (McCarthy, 2011).

Disaster preparedness planning by local authorities represents the first line of defense a jurisdiction has in preventing financial incapacitation from a disaster (Jarret & Lieberman, 2007). However, unlike individual households and firms who risk financial ruination if they do not prepare for such events through insurance agreements, governments have lesser risk of losing their assets and may therefore be less compelled to enter into such contracts (Cohen & Werker, 2008). Furthermore, elected officials, in prioritizing policies over disaster preparedness investments, may be unreliable in compensating affected individuals and local governments during the aftermath of a disaster (Schugart, 2006). For these and other reasons, a **TRC** should take an approach advocated by other local disaster response institutions, like hospitals and county Offices of Emergency Management; to be prepared for an extended period of self-preservation during an emergency while maintaining complete records of all expenses incurred (Rickard & Fehn, 2007; Stormwest Exercise, 2012).

6.4 Sustainability of a Transportation Reserve Corps

The most likely event requiring the deployment of a **TRC** is undoubtedly a once-in-a-lifetime disaster of large proportions that may not occur within the lifetimes of most of

its members. With this limited primary purpose, it may be difficult for a **TRC** to procure funding or sustain the effectiveness of its operations (NYSOEM interview, 2012; FEMA Region II interview, April 2012). Therefore, unless it is absorbed by another organization with a complementary mission, a **TRC** should be aggressive in its efforts to secure funding and diversify its responsibilities in order to ensure long-term viability.

Though there seems to be an adequate number of available grants for public organizations engaging in disaster response (NYSOEM interview, 2012) the likelihood of an entity obtaining such grants is enhanced by demonstrating additional abilities in all stages of disaster planning. Therefore, a **TRC** should incorporate disaster preparedness and recovery in addition to its response activities. Day-to-day preparedness efforts however, such as updating databases and continuing communications with other entities, is an important function which should be pursued to ensure the vitality of a **TRC**. (NYSOEM interview, 2012; County of Erie Emergency Medical Services interview, 2012).

6.4.1 Learning from the Experiences of Other Civilian Disaster Response Organizations

To alleviate the sustainability challenge, a **TRC** should, in this respect, follow the example set by MRC rather than CERT teams during their establishment (NYSOEM interview, 2012; NYC OEM interview, 2012). Like MRC units, the proposed **TRC** should be comprised of working professionals who are already licensed and credentialed in the disaster response duties they assume (NYC OEM interview, 2012). CERT teams on the other hand, are comprised of a variety of individuals who most often require training provided by CERT prior to deployment in a disaster (County of Erie Emergency Medical Services interview, 2012; NYC OEM interview, 2012; Rolf, 2007). A lack of experience also limits the degree to which prevailing emergency management officials incorporate CERT units (FEMA Region II interview, 2012; NYC OEM interview, 2012; University at Buffalo Emergency Management interview, 2012). By utilizing volunteers who are already credentialed, which limits the need for funding and increases the effectiveness of an organization, the long-term viability of a **TRC** is reinforced.

6.4.2 Coordination with Other Entities

Collaboration and knowledge-sharing with a range of existing community-based volunteer groups (such as the numerous partners and affiliates of the Citizen Corps Council) and governmental agencies handling disaster response is essential for the sustainability of a **TRC** (Erie County Emergency Services interview, 2012). Because other disaster volunteer groups, like CERT teams, do not communicate fully with emergency management officials, these authorities may be hesitant to call on volunteer groups when disasters occur (NYSOEM interview, 2012; University at Buffalo Emergency Management interview, 2012). In recognition of this, **TRC** leadership should be prepared to engage local emergency management in a continued collaboration while

maintaining the credibility and demonstrating the value of their organizations (Erie County Emergency Services interview, 2012).

6.4.3 Volunteer Engagement

The commitment and enthusiasm of volunteers must be maintained if a **TRC** is to be viable over the long-term. Of course, without financial compensation, this can be a challenge. Other volunteer disaster organizations often are not entirely successful at keeping members active and engaged (University at Buffalo Emergency Management interview, 2012; NYSOEM interview, 2012). For emergency workers, the timing of extreme events and disasters of course cannot be predicted, and there may be a long time between disasters. Consequently, volunteer organizations must plan training and exercise activities so that volunteers do not disengage. Some training and exercises for volunteer emergency workers should be "fun" and exciting instead of routine; if not, volunteers may not attend in large numbers (NY Red Cross interview, 2012).

To boost volunteer involvement, other community-based disaster volunteer organizations utilize a variety of methods. Firstly, some groups use a number of communication tools, including email, phone calls, pagers and social media, to reach out to registered volunteers regarding day-to-day operations (County of Erie Emergency Medical Services interview, 2012). In addition to training exercises, volunteer disaster response organizations also organize recruitment and outreach events in order to increase volunteer participation and support (County of Erie Emergency Medical Services interview, 2012, NYC OEM interview, 2012). Souvenir gifts and appreciation events are sometimes offered to volunteers at organizational events as incentives for individuals to remain involved (County of Erie Emergency Medical Services interview, 2012). A **TRC** should be compelled to provide their volunteers with some recognition of their involvement in the admirable cause of a volunteer organization.

6.4.4 Volunteer Response

In the experience of some emergency management officials, there is a perception of shortage of personnel during an emergency, indicating that the municipal employees and volunteers on whom many emergency plans rely may not be accessible amidst the chaos of a disaster (FEMA Region II interview, April 2012). While this serves to vindicate the establishment of a **TRC**, it also presents a challenge, assuming that, like other emergency responders, **TRC** volunteers may prioritize the safety of themselves and their loved ones over their responsibilities as a **TRC** volunteer and in so doing may fail to respond when a disaster strikes (NYS OEM interview, 2012, FEMA Region II interview, April, 2012). To moderate the number of nonparticipating responders during emergencies, **TRC** volunteers should have a tested and reliable family emergency plan in place, including evacuation and sheltering arrangements. With the safety of their loved ones ensured, volunteers will be more likely to focus on their job and do it to the best of their ability (American Red Cross Greater Buffalo Chapter interview, 2012).

The idea behind a **Transportation Reserve Corps** is to address the fundamental challenges that communities face in coordination and utilization of multi-modal transportation to effectively evacuate carless households during large-scale disasters. While a **TRC** is offered as a solution to such challenges as identifying available resources, a lack of coordination among emergency management and transportation providers, and deficiencies in command structure, the establishment of a **TRC** raises a new set of challenges. Chapter 6 suggests that these challenges are best addressed through further research and best practices especially those used by other large volunteer emergency response organizations such as the MRC and CERT. Chapter 7 offers actions steps for how some of these challenges can be addressed moving forward.

7. Conclusion

The research for this project was conducted by gathering information using a multi-pronged approach—forming a project advisory committee, conducting a literature review, and collecting and synthesizing relevant information using a series of in-depth interviews with emergency management, healthcare, and transportation professionals. The intention was to 1) provide a rich, context-aware understanding of the policy, planning, and decision making around disaster planning, response, and recovery especially as it pertains to coordinated multimodal evacuation; and to 2) introduce and test the idea of a **Transportation Reserve Corps**; refine its objectives, and assess its value, practical feasibility, and potential organizational structure. Chapter 6 discussed the potential difficulties to overcome in establishing a **Transportation Reserve Corps**, in the context of the greater embedded challenges that are a consequence of the often unpredictable nature of disasters (as well as constraints that exist within our own complicated legal and political systems). Despite these challenges, we suggest in this chapter the potential role that a **TRC** could play within a community's emergency management hierarchy; we also provide specific actions steps needed to conduct a pilot test of a **TRC**.

7.1 Refining a Transportation Reserve Corps

The motivation behind a **TRC** was to create a brain center for multi-modal evacuation—a new organization providing transportation for everyone, especially those most vulnerable, via high-capacity vehicles and volunteer drivers, during a large-scale evacuation. What our research revealed was that a **TRC** must be intrinsically linked to and guided by a community's greater emergency management system and hierarchy and its transportation providers (both public and private). A **TRC**'s organizational structure, and the way in which it communicates and coordinates resources, are dependent upon its relationships with these entities. Understanding this, a number of key lessons were learned:

1. A **TRC** is a preparedness, response, and recovery organization, although the majority of its activities have a preparedness focus.

Initially, a **TRC** was envisioned as a mainly emergency response organization— aiding the carless in the event of a large-scale evacuation. During this research project we determined that focusing on preparedness activities such as training volunteers, identifying vehicle fleets, and establishing mutual aid agreements are the best way to begin to address the fundamental barriers that community's face in transporting the carless during an evacuation. A **TRC** positioned to focus much of its effort on preparedness activities while also functioning as a response and recovery organization is the most effective model for achieving its objectives.

2. A **TRC** coordinates multi-modal transportation for the carless.

A **TRC** is not a transportation provider in the traditional sense. A **TRC** will not own, nor can it acquire high-capacity vehicles during an evacuation, instead, its primary role is *coordinator* of high-capacity vehicles, drivers, equipment and fuel that already exist in a community. A **TRC** uses a highly sophisticated system of training, credentialing, and mutual aid that involves public transit agencies and private transportation providers, private citizens, and any related and supplemental organizations to accomplish its objectives.

3. **TRC** volunteers will not replace first responders or professional vehicle operators.

It became clear throughout our research that volunteers should not be used when a paid employee is ready, willing and able to drive a high-capacity vehicle and that a **TRC** must be cognizant of all collective bargaining agreements. The role of a **TRC** was refined to *supplement* employees (when there are not enough) or *provide relief* (in other words, act as the second-string or back-up crew) when human resources have been exhausted or need rest.

4. **TRC** should not be a stand-alone organization.

Establishing a new, stand-alone non-profit was not recommended as a best practice in any of the interviews. To avoid the effort and expense involved with establishing a new organization, a **TRC** should instead fall under an umbrella volunteer, emergency management, planning, or transportation organization or agency to maximize resources and avoid redundancy.

5. A **TRC** should have state-of-the-art and interactive resource management technology linked with a multifaceted communication system.

Because a **TRC** is tasked with coordinating diverse and complex data, technology infrastructure is critical, and the technology must have the capacity to facilitate all volunteer management (enrollment and data profile updating), volunteer communication via various methods (telephone, email, text messaging), vehicle resource typing and management, and an emergency response communication system used to converse with emergency management officials, transportation providers, and volunteers during an incident. To limit cost and redundancy, whenever possible a **TRC** should explore utilizing already established technology and communication systems. A smartphone app could be developed for a **TRC**, in which volunteers, evacuees, and **TRC** managers communicate through hand-held mobile devices.[15]

6. Adopt and house existing high-capacity vehicle inventories.

[15] However, certain disasters may make cellular communication systems inoperable, and not everyone who may be affected by a disaster is in possession of a smartphone.

Better understanding types, numbers, and locations of high-capacity vehicles, safety and maintenance equipment, and fuel could improve the likelihood that these resources are utilized to their upmost potential during an evacuation. We learned that inventories are kept by various public transit agencies and private transport companies, but rarely in a comprehensive way for a metropolitan area within or across jurisdictions. Organizing these separate inventories in one place is an important preparedness activity for a **TRC**, and one that it critical to its operational capacity. A **TRC** must form relationships with organizations that have existing vehicle inventories, collect this information in one place, and strive to make this information as exhaustive as possible and readily useable during an extreme event.

7. A **TRC** may be best suited, at least initially, to mid-sized metropolitan areas.

We initially envisioned a **TRC** as a one-size-fits-all organization that could be established anywhere in the United States. Our research gathered through the interview process, however, suggests that a **TRC** is best suited to mid-sized metropolitan areas, where some or all of the supporting structure (organizations, leadership, written plans, vehicles, expertise) for a **TRC** is in place. These elements may not be in place in small cities and rural areas. On the other end of the spectrum, we were told in several interviews (PANYNJ interview 2012, NY Red Cross interview, 2012) that funding for emergency planning in the largest metropolitan areas in the U.S. (especially New York City) since September 2001 has been extraordinary. This funding has allowed emergency planning and disaster preparedness and response capabilities that put the largest cities in a better position than mid-sized areas.

7.2 Key Action Steps

Having refined and detailed a **TRC**'s approach to transportation resource coordination for multi-modal evacuation, and identified its challenges, there are several actions steps we recommend for further research and to begin implementation of a **TRC**.

1. Advocate for the Inclusion of Multi-Modalism in Emergency Planning

It has been well-documented that many state and local governments do not have the appropriate plans, training, and exercises to evacuate households without automobiles, nor is multi-modalism sufficiently incorporated in meaningful ways into evacuation plans (DHS, 2006; DOT, 2006). Qualitative information gathered through our interviews mirror the sentiments of these documented findings. Our research underscores the urgency of incorporating multi-modalism in disaster planning not only because it is imperative to the functionality of a **TRC**, but also because it is important in and of itself—helping to increase equity among citizens during large-scale evacuations. We recommend that local evacuation plans incorporate all modes of transportation, that local plans pay special attention to a community's carless population, and that public

transit agencies and private transport providers be required to plan for emergency evacuations.

2. Develop a Plan for Broad Recruitment

As the framework for a **TRC** continues to develop, we suggest developing creative ways to recruit volunteers, since volunteers, especially vehicle drivers, are the backbone of a **TRC** and will always be needed. One such broad recruitment technique brainstormed during the interview process was the idea to include an "Are you interested in joining a **TRC**?" check box on CDL applications, automatically putting CDL holders into a database identifying them as interested volunteer drivers. These individuals can then be contacted by emergency organizations such as a **TRC** to further explore suitability for and interest in serving as a volunteer during times of need.

3. Additional Research

We recommend additional research about establishing a **TRC** emphasizing four key topics.

Organizational Structure and Business Plan
There is much discussion in this report about the proper "home" for a **TRC** hierarchically within a federal or state agency and locally within a county or municipal department or NGO. We discuss potential models presented to us through the interview process and examine how other volunteer-based disaster organizations (such as CERT and MRC) have organized themselves. Nevertheless, further research is needed to provide a clearer understanding of the best place for a **TRC**. Factors to consider for research purposes should focus on the most logical position for a **TRC**'s placement in a community's ICS, opportunities for shared infrastructure and volunteers, access to funding, existing liability insurance, shared scope and mission, and long-term sustainability. A **TRC**'s position on the local level would likely dictate its position (if any) within a state or federal agency.

Identify Permanent Funding Sources
Concurrent with other action steps, experts should seek federal, state, and local funding sources to pilot and permanently establish a **TRC**. Suggestions for funding a **TRC** brainstormed during interviews included U.S. Department of Homeland Security, U.S. Department of Transportation, U.S. Center for Disease Control, U.S. Department of Health and Human Services Health Resources and Services Administration to provide emergency preparedness grants. State offices of emergency management and transportation, local Metropolitan Planning Organizations (MPOs) for coordinated transportation planning, community foundations, local fundraising efforts, and mutually-beneficial partnerships, i.e. partnering with local nuclear power plants.

Funding **TRC** start-up, capital costs, and operations would depend greatly on a **TRC**'s organizational structure. Previous discussions about a possible home for a **TRC** within a larger umbrella organization and a **TRC**'s administrative structure on a local level have (1)attempted to keep costs minimal (i.e. having limited number of paid staff people), and (2) tied many expenses of running a **TRC** into operations costs of related entities (i.e. shared communications infrastructure).

Mutual Aid

A **TRC** rests upon the idea of a system of mutual aid to maximize the use of resources, both within a local jurisdiction and outside of it, stretching perhaps over county lines and state lines depending upon the availability of resources in a community. We have discussed some of the challenges of mutual aid, but we also know that it can be a powerful tool in emergency management. Further research should examine best practices in the use of mutual aid agreements throughout the country, taking into consideration identified challenges such as liability, reciprocity and reimbursement, and legality—especially in instances where adjacent states have conflicting laws—that could require modifications to state and federal legislation.

Vehicle Modifications

Regardless of the implementation of a **TRC**, we gathered important pieces of information regarding vehicle modification and technological additions that could assist multi-modal evacuation of the carless population during large-scale disasters. One concrete example is the need for global positioning system (GPS) devices on all high-capacity vehicles being utilized in an evacuation, especially in large cities such as New York, which does not currently have this capacity (NYC MTA interview, 2012). Redundancy plans should also be considered, such as the use of low-band radios to supplement GPS (American Red Cross Greater Buffalo Chapter interview, 2012) due to the possibility of damaged technological infrastructure during an incident that requires a large-scale evacuation.

Another important issue is the modification of high-capacity passenger vehicles to accommodate large numbers of wheelchair-bound and bed- or stretcher-bound residents. Currently, few types of high-capacity vehicles other than ambulances and special vans have the capacity to transport people confined to beds or wheelchairs. This is a significant issue if large numbers of hospitals and nursing homes require evacuation. It was suggested that research be done to understand how high-capacity vehicles used to regularly transport able-bodied individuals (i.e. school buses or coach buses) could have built-in mechanisms to easily remove seats and fasten wheelchairs or beds into the cabin in order to serve this population in the case of an emergency (NYSOHEP interview, 2012). High capacity vehicles (such as buses) that are no longer in service could be modified to be used in this way in a disaster.

4. Pilot a Transportation Reserve Corps

The final action step is to launch a pilot test of a **TRC**. Using the outcomes of our research, we present recommendations on a suggested process to establish a pilot program.

Choose a location

A good pilot location for a **TRC** would be a county or metropolitan area that, on the local level, has a solid evacuation plan that includes multi-modal transportation, has a certain level of vehicle inventorying, and has adequate technology and communication systems in place. The location should also have some logistical advantages; for example, a possible site might be a community that has a nuclear power plant, such as the rural town of Ontario in Monroe County, NY, home to the R.E. Ginna Nuclear Power Plant (FEMA interview, May 2012). Nuclear power plants often have funding from the nuclear power industry funds emergency planning and safety exercises. Another possibility might be a location that has a public transit authority that has various types of high capacity vehicles—and perhaps even surplus vehicles on reserve for disasters—and enhanced coordination and oversight.

Consideration for a pilot program might also include jurisdictions located in an area whose geography may be a challenge during an evacuation, such as Long Island (NYSOHEP interview, 2012; NY Red Cross interview, 2012); or in an area that has recently experienced evacuation procedures as a result of Hurricane Irene and Tropical Storm Lee in 2011[16] (Rensselaer County Public Safety interview, 2012). Anecdotally, many of the issues faced during the evacuation of certain areas and certain populations during these two storms reflect the very scenarios in which a **TRC** could be valuable in the future.[17] Soliciting interest from communities about a potential pilot of the program could also help to determine a suitable location.

[16] Thirty-seven counties in New York state were included in the federal disaster declaration following Hurricane Irene and Tropical Storm Lee, they included: Albany, Bronx, Broome, Chemung, Chenango, Clinton, Columbia, Delaware, Dutchess, Essex, Franklin, Greene, Hamilton, Herkimer, Kings, Montgomery, Nassau, New York, Oneida, Orange, Otsego, Putnam, Queens, Rensselaer, Richmond, Rockland, Saratoga, Schenectady, Schoharie, Suffolk, Sullivan, Tioga, Tompkins, Ulster, Warren, Washington, and Westchester counties (Empire State Development & New York State Department of Environmental Conservation, 2012).

[17] Hurricane Irene and Tropical Storm Lee caused a major healthcare facility evacuation as fifty-one health facilities had to be evacuated between New York City and the Southern Tier of NYS. Multi-agency coordination and EOCs were established to help coordinate sending facilities and receiving facilities (NYSOHEP interview, 2012). Drivers and high-capacity vehicles were in fact lacking, and ambulances from other states were needed and utilized (NYSOEM interview, 2012). In some places, FEMA reimbursements were used but proved to be cost-prohibitive (NYSOHEP interview, 2012). These storms also proved to be a test of new emergency plans in New York City (NY Red Cross interview 2012). Although special needs evacuation began days in advance of the general evacuation, the special needs population was not fully evacuated by the deadline set by emergency officials. This experience might have been due in part to an insufficient supply of necessary resources, *i.e.* a relatively small fleet of low-capacity paratransit vehicles—only recently incorporated into New York City's evacuation plans. This

Community Outreach

Educating government officials, transportation providers, and the public, especially potential volunteers, about the importance of incorporating multi-modalism into evacuation plans; and introducing the concept of a **TRC** is an important step prior to and after choosing a pilot location. Professionals in the fields of transportation, emergency management, and healthcare interviewed for this project were receptive to the idea of a **TRC**, but further outreach is needed to educate, receive feedback, start to form relationships with important emergency management and transportation partners, and stir-up excitement and interest in becoming a volunteer.

Conduct a Tabletop Exercise[18]

Further exploring the concept of a **TRC** through a tabletop exercise was suggested in expert interviews (NYSDOT interview, 2012). A simple tabletop exercise is an analysis of the response to an emergency situation in an informal, stress-free setting. Key stakeholders are assembled and action steps are followed in the simulation of an emergency. For example, in the case of a **TRC**, equipment would not be used, resources would not be deployed, and time pressures would not be mandated. Instead, this simplest type of exercises would be used for the purposes of planning, preparation, and coordination. The most important element of a tabletop exercise is to provoke discussion and problem identification and solution. Participants will examine and resolve problems based on the functionality of a **TRC** as described in this report and identify where a **TRC** needs to be refined. Above all else, effective facilitation is a key factor to the success of a simple tabletop exercise (Environmental Protection Agency [EPA], 2005). It is recommended that a tabletop exercise be performed once a **TRC** pilot location is identified. A tabletop exercise for **TRC** could be performed in conjunction with a regularly scheduled emergency planning practice event, such as the Stormwest Exercise witnessed by the authors.

limited success in completely evacuating the special needs population could also be attributed to a lack of effective planning on the part of institutions, such as hospitals and nursing homes. In the likelihood that facilities failed to properly communicate their transportation needs during an emergency, the NYC MTA response to these institutions was in effect nullified (NYC MTA interview, 2012). Furthermore, in New York City, police and fire department personnel, who are qualified to drive high capacity vehicles, were brought in to relieve NYC MTA drivers during these two storms (NYC OEM interview, 2012).

[18] There are other types of tabletop exercises, such as an enhanced tabletop exercise, much like the Stormwest exercise witnessed as part of the research for this project. An enhanced tabletop exercise is a coordinated response to an emergency in a time-pressured, realistic simulation that involves several agencies with the objective to test the capability of an organization's operational plan in the event of an emergency. Emphasis is placed on communication between all the participating agencies (EPA, 2005). An enhanced tabletop exercise could certainly be of great value to a **TRC** once an organizational structure is better established.

Preparedness Activities

Chapter 5 presents a myriad of preparedness activities in which a **TRC**, in order to be effective, would need to be engaged. In a plan for a **TRC**, preparedness efforts would (1) be ongoing and (2) constitute the majority of staff and volunteer time. As part of the pilot, logical preparedness efforts that fall under the categories of volunteers, resource management, and procedures and protocols could begin to be tested and employed. Such efforts may include:

1. Administration
    - Form Executive Steering Committee.
2. Volunteer Personnel
    - Test recruitment strategies
    - Set up a system to enroll, credential, and type volunteers.
    - Begin volunteer training exercises.
3. Resource Management
    - Research, consolidate and update existing vehicle inventories.
4. Procedures and Protocols
    - Form relationships with emergency management organizations, coordinate with existing emergency plans, and become incorporated into the jurisdiction's Incident Command structure.
    - Set up a communication system(s) with unit command, volunteers and transportation providers.
    - Understand what mutual aid agreements already exist in the community, and how these agreements can be improved and increased.

*Establish a **TRC** Pilot Exercise*

Moving beyond a tabletop exercise, we recommend that **TRC** involvement in a disaster undergo a pilot test. This could take place in connection with a regularly-scheduled emergency planning exercise. The exercise should strive for broad involvement, realistic scenario development, and useful tests of relationships and communication systems. Networking and information sharing are important outcomes of a pilot exercise.

Assessment

An assessment should evaluate all elements of the tabletop exercise. Understanding successes and failures will help further refine the functions and structure of a **TRC**.

8. References

Abdelgawad, H. & B. Abdulhai. 2010. Managing large-scale multimodal emergency evacuations. *Journal of Transportation Safety & Security,* (2)2: 122-151.

American Red Cross (ARC). 2012a. *2011 Annual Report: American Red Cross, Eastern North Carolina Region*. Retrieved May 21, 2012 at http://www.redcross.org/images/MEDIA_CustomProductCatalog/m13740210_ENC_annual_report.pdf

American Red Cross (ARC). 2012b. *Government Relations*. Retrieved May 21, 2012 at http://www.redcross.org/about-us/governance/government-relations

American Red Cross Greater Buffalo Chapter interview. February 24, 2012.

American Red Cross Greater New York Region interview. April 19, 2012.

Bailey, D., Swiacki, S., Byrnes, A., Buckley, J., King, D., Piper, V., Marino, M., Mundle, S., Pierlott, G., & Lynd, A. 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. Final Report.* FTA-PA-26-8001-2007. Philadelphia: Milligan & Company, LLC, and Mundle & Associates.

Baker, E.J. 1991. Hurricane evacuation behavior. *International Journal of Mass Emergencies and Disasters, 9*(2): 287-310.

Becker, M. and T.J. Pignataro. 2000. Lake-effect Snow Band Leaves Mark on Region. *Buffalo News.* December 2, 2010.

Berube, A. and S. Raphael. 2005. "Access to Cars in New Orleans." Working Paper, Berkeley, CA, and Washington, DC: University at California, Berkeley, Brookings Institution.

Blum, E.D. 2008. *Love Canal Revisited: Race, Class, and Gender in Environmental Activism*. Kansas: University Press of Kansas.

Carter, T.M. 1979. Community warning systems: the interface between the broadcast media, emergency service agencies and the National Weather Service. *Report Series 79-02.* Washington, D.C.: NHWS.

Centers for Disease Control and Prevention (CDC). 2011. Emergency preparedness and response: Being prepared for an earthquake. Atlanta, Georgia: Centers for Disease Control and Prevention.

Center for Transportation Excellence interview. March 22, 2012

Chaudhari, J., Booth, J., Ye, Z., Kack, D., & Posadas, B. 2009. *Evacuation preparedness of public transportation and school buses in rural coastal communities of the north gulf region.* (Working Paper). Bozeman, MT: Montana State University, Western Transportation Institute.

Citizen Corps Council (CCC). 2009. *United communities: Preparing the nation.* PowerPoint presentation downloaded March 15, 2012 from http://citizencorps.gov/citizencorps/councils/councilindex.shtm

Citizens Corps Council (CCC). 2011. *Citizen corps councils: Happy birthday, Citizen Corps!.* Retrieved March 15, 2012 from http://citizencorps.gov/citizencorps/councils/councilindex.shtm

Citizens Corps Council (CCC). 2012. Retrieved March 15, 2012 from http://www.citizencorps.gov/

Clarke, C.C. & Habib, M.A. 2010. *Evaluation of multi-modal transportation strategies for emergency evacuations.* Paper prepared for presentation at the Best Practices in Urban Transportation Planning Session of the Annual Conference of the Transportation Association of Canada. Halifax, Nova Scotia, 2010.

Cohen, C. & E.D. Werker. 2008. The political economy of "Natural" Disasters. *The Journal of Conflict Resolution, 52*(6): 795-819.

Cohen, H. 1997. Volunteer Protection Act of 1997. Washington,D.C.: Congressional Research Service.

Corporation for National and Community Service, Office of Research and Policy Development. 2006. *Volunteer Growth in America: A Review of Trends Since 1974.* Washington, D.C.: Corporation for National and Community Service.

County of Erie Emergency Medical Services interview. March 9, 2012.

Cova, T. J., Drews, F. A., Siebeneck, L. K., & Musters, A. 2009. Protective actions in wildfires: Evacuate or shelter-in-place?. *Natural Hazards Review*,*10*(4), 151-162.

Cox, W. 2006. *Emergency Evacuation Report Card 2006.* Washington, D.C.: American Highway Users Alliance

Cutter, S. L., & Smith, M. M. 2009. Fleeing from the hurricane's wrath: Evacuation and the two Americas. *Environment: Science and Policy for Sustainable Development*, *51*(2): 26-36.

DeBlasio, A.J., Regan, T.J., Zirker, M.E., Day, F.B., Crowder, M., Bagdonas, K., Brodesky, R. & Morin, D. 2002. *Effects of Catastrophic Events on Transportation System Management and Operations, New York City – September 11 2001.* Washington D.C.: U.S. Department of Transportation.

Department of Homeland Security (DHS). 2006. *Nationwide Plan Review, Phase 2 Report*. Washington, D.C.: Department of Homeland Security.

Department of Homeland Security (DHS). 2008. *National Incident Management System (NIMS).* Washington, D.C.: U.S. Department of Homeland Security.

Department of Transportation (DOT). 2006. *Report to Congress on Catastrophic Hurricane Evacuation Plan Evaluation.* Washington, D.C.: U.S. Department of Transportation in cooperation with the U.S. Department of Homeland Security.

Department of Transportation (DOT). 2007. *Using Highways for No-Notice Evacuations*: Routes to Effective Evacuation Planning Primer Series. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

Division of the Civilian Volunteer Medical Reserve Corps (DCVMRC). 2011. *Division of the Civilian Volunteer Medical Reserve Corps Strategic Plan 2011-2013.*

Division of the Civilian Volunteer Medical Reserve Corps (DCVMRC). 2012. Retrieved January 25, 2012 from *https://medicalreservecorps.gov/*

Dombrowski, M., Fischhohh, B. & Fischbeck, P. 2006. Predicting emergency evacuation and sheltering behavior: A structured analytical approach. *Risk Analysis, 26*(6), 1675-1688.

Dotson, L.J. & Jones, J., U.S. Nuclear Regulatory Commission. Division of Preparedness and Response, & Sandia National Laboratories. 2005. *Identification and analysis of factors affecting emergency evacuations*. Washington, DC: Division of Preparedness and Response, Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission.

Durham, T. & Suiter, L.E. 1991. Perspectives and roles of the state and federal governments. *Emergency Management: Principles and Practices for Local Government*. Washington, D.C: International City Management Association.

Ecology and Environment, Inc. 2007. *Niagara County Comprehensive Emergency Management Plan.* Lancaster, NY: Prepared by Ecology and Environment, Inc. for County of Niagara.

Elder, K., Xirasagar, S., Miller, N., Bowen, S. A., Glover, S., & Piper, C. 2007. African Americans' decisions not to evacuate New Orleans before Hurricane Katrina: A qualitative study. *American Journal of Public Health*, *97*(Supplement 1), S124.

Empire State Development & New York State Department of Environmental Conservation. 2012. *Hurricane Irene – Tropical Storm Lee Flood Mitigation Grant Program Guidelines. Albany:* ESD and NYSDEC.

Environmental Protection Agency (EPA). 2005. Emergency Response Tabletop Exercises for Drinking Water and Wastewater Systems. Washington, D.C: Environmental Protection Agency.

Erie County Department of Emergency Services. 2010. *Erie County Comprehensive Emergency Management Plan Evacuation Annex*. Buffalo, NY: Erie County Department of Emergency Services.

Erie County Department of Emergency Services interview. January 18, 2012.

Fackler, M. 2011, March 11. Powerful quake and tsunami devastate northern Japan. *The New York Times.* March 11, 2011.

Fairchild, A.L., Colgrove, J. & Jones M.M. 2006. The challenge of mandatory evacuation: Providing for and deciding for. *Health Affairs, 25*(4): 958-967.

Federal Emergency Management Agency (FEMA). 2011. *National Disaster Recovery Framework: Strengthening Disaster Recovery for the Nation.* Retrieved January 4, 2012 from *www.**fema**.gov/pdf/**recoveryframework**/ndrf.pdf*

Federal Emergency Management Agency (FEMA). 2008. *National Association of State Departments of Agriculture Emergency Response Plan: Mass Evacuation Incident Annex.* Retrieved January 4, 2012 from *http://www.fema.gov/pdf/emergency/nrf/nrf_massevacuationincidentannex.pdf*

Federal Emergency Management Agency (FEMA). 2006. *Declared Disasters and*

Emergencies. Database, Washington, DC: Federal Emergency Management Agency.

Federal Emergency Management Agency (FEMA). 2010. *Glossary/Acronyms for National Disaster Housing Strategy.* Retrieved March 29, 2012 from http://www.fema.gov/glossary/acronyms

Federal Emergency Management Agency (FEMA), interview. May 4, 2012.

Federal Emergency Management Agency (FEMA) Region II interview. April 20, 2012.

Florida Department of Health, Office of Public Health Nursing. 2011, January. *Florida Medical Reserve Corps Network: A Guide to Developing and Managing a Local MRC Unit (Part 2 - Appendices)*. Tallahassee, Florida: Florida Department of Health.

Franco, C., Toner, E., Waldhorn, R., Inglesby, T.V., O'Toole, T. 2007. The National Disaster Medical System: Past, Present, and Suggestions for the Future. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science.* (5)4, 319-326.

Gee, D. J. 2012, April 6. Free tuition at ECC set for volunteer firefighters. *The Buffalo News*. April 6, 2012.

Gerber, B., Norwood, F. & Zakour, M. 2010. *Disasters, Evacuations and Persons with Disabilities: An Assessment of Key Issues Facing Individuals and Households.* Evacuation Study for People with Disabilities. Washington, DC: National Institute on Disability and Rehabilitation Research, United States Department of Education.

Gillett, N.P., Weaver, A.J., Zwiers, F.W. & Flannigan, M.D. 2004. Detecting the effect of climate change on Canadian forest fires. *Geophysical Research Letters, 31*(L18211): 1-4.

Glaser, B. G., & Strauss, A. L. 1967. *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine.

Glotzer, D., Psoter, W., Weiserbs, K., & St Jean, R .2007. The shelter-in-place decision-all things considered. *Australian Journal of Emergency Management, The*, *22*(4):8.

Goodwill, J. A., & Reep, A. 2005. *Transit Emergency Planning and Response Assessment Initiative.* Tampa, FL: Center for Urban Transportation Research, University of South Florida.

Government Accountability Office (GAO). July 2006. *Disaster Preparedness: Limitations in Federal Evacuation Assistance for Health Facilities Should be Addressed*. GAO-06-826.Washington, D.C.: Government Accountability Office.

Government Accountability Office (GAO). Dec 2006. *Transportation-Disadvantaged Populations: Actions Needed to Clarify Responsibilities and Increase Preparedness for Evacuations.* GAO-07-44.Washington, D.C.: Government Accountability Office.

Government Accountability Office (GAO). May 2006. *Disaster Preparedness: Preliminary Observations of the Evacuation of Vulnerable Populations due to Hurricanes and Other Disasters*, GAO/GAO-06-790T . Washington, D.C.: Government Accountability Office.

Hasan, S., Ukkusuri, S., Gladwin, H. & Murray-Tuite. P. 2011. Behavioral model to understand household-level hurricane evacuation decision making. *Journal of Transportation Engineering, 137*(341), 341-348.

Heller, D.S. 2010. Evacuation planning in the aftermath of Katrina: Lessons learned, *Risk, Hazards & Crisis in Public Policy*, 1(2):131-174.

Henstra, D. 2010. Evaluating local government emergency management programs: What frameworks should public managers adopt? *Public Administration Review, 70*(2): 236-246.

Hess, D. B. & Gotham, J.C. 2007. Multi-modal mass evacuation in upstate New York: A review of disaster plans. *Journal of Homeland Security and Emergency Management*: 4(3):1-19.

Hess, D.B. & Arendt, L. 2006. *Enhancements to Hospital Resiliency: Improving Emergency Planning for and Response to Hurricanes.* Buffalo, NY: Multidisciplinary Center for Earthquake Engineering Research.

Hick, John L., Dan Hanfling, Jonathan L. Burstein, Craig De Atley, Donna Barbisch, Gregory M. Bogdan, and Stephen Cantrill. 2004. Health care facility and community strategies for patient care surge capacity. *Annals of Emergency Medicine.* (44)3, 253-261.

Higgins, L. L., Hickman, M.D. & Weatherby C.A. 1999. Role of public transportation operations in emergency management: Research report. Texas Transportation Institute Report No. 1834-2. College Station, TX: Texas A&M University.

Hoard, M., Homer, J., Manley, W., Furbee, P., Haque, A., and Helmkamp, J. 2005. Systems modeling in support of evidence-based disaster planning for rural areas. *International Journal of Hygiene and Environmental Health*, 208: 117-125.

Hoard, M. and R. Tosatto. 2005. Medical Reserve Corps: Strengthening Public Health and Improving Preparedness. *Disaster Management and Response.* (3)2, 48-52

Hoetmer, G.J. 1991. *Introduction to Emergency Management: Principles and Practices for Local Government*. Washington, D.C: International City Management Association.

Insurance Journal. 2001. NAII says NY disaster planning approach sets example for all states. Retrieved November 28, 2012 from http://www.insurancejournal.com/news/east/2001/11/21/12579.htm

Jarret, J.G & Lieberman, M.L. 2007. When the wind blows: The role of the local government attorney before, during and in the aftermath of a disaster. *Stetson Law Review, 36*: 294-328.

Kailes, J. I., & Enders, A. 2007. Moving Beyond "Special Needs" A Function-Based Framework for Emergency Management and Planning. *Journal of Disability Policy Studies*, *17*(4), 230-237.

Lichterman, J.D. 2000. A "Community as Resource" strategy for disaster response. *Public Health Reports, 115*(2-3): 262-265.

Lindell, M.K., Lu, J.C & Prater, C.S. 2005. Household decision making and evacuation in response to Hurricane Lili. *Natural Hazards Review, 6*(4): 171-179.

Lipton, E. 2005. U.S. report lists possibilities for terrorist attacks and likely toll. *New York Times.* March 16, 2005.

Litman, T. 2006. Lessons from Katrina and Rita: What major disasters can teach transportation planners. *Journal of Transportation Engineering*, *132*(1), 11–18.

Mannan, M.S., & Kilpatrick, D.L. 2000. The pros and cons of shelter-in-place. *Process Safety Progess, 19*(4), 210-218.

Matherly, D. & Mobley, J. 2011. Transportation and emergency management tool kit for communications with vulnerable populations: Key research findings. *Transportation Research Record: Journal of the Transportation Research Board*. *2234*, 62-70.

Matherly, D., Mobley, J., Ward, B.G., Benson, B., Aldrich, N., Nichols, E., Robinson, G. & Thomas, R. .2001. *TCRP Report 150*: *Communication with Vulnerable Populations: A Transportation and Emergency Management Toolkit.* Washington D.C.: Transportation Research Board.

McCarthy, F.X. 2011. Federal Stafford Act disaster assistance: Presidential declarations, eligible activities and funding. Washington, D.C.: Congressional Research Service.

McGuire, M. & Schneck, D. 2010. What if Hurricane Katrina hit in 2020: The need for strategic management of disasters. *Public Administration Review, 70*(s1): s201-s207.

Menino, T.M., The Mayor's Office of Homeland Security & the Boston Public Health Commission. 2005. *Ready Boston: An Emergency Preparedness and Evacuation Guide for City Residents.* Boston, Mass.: Mayor's Office of Homeland Security.

Meyer, M.D. 2002. The role of the metropolitan planning organizations (MPO) in preparing for security incidents and transportation system response, white paper. Atlanta: Georgia Institute of Technology.

Mignone, A. T., & Davidson, R. 2003. Public health response actions and the use of emergency operations centers. *Prehospital and Disaster Medicine*, *18*(3), 217-219.

Millitello, L.G., Patterson, E.S., Bowmann, L. & Wears, R. 2007. Information flow during crisis management: Challenges to coordination in the emergency operations center. *Cognition, Technology & Work, 9*(1): 25-31.

National Association of Insurance Commissioners (NAIC). 2003. The NAIC state disaster response plan handbook, *NAIC Research Quarterly*.

National Council on Disability. 2005. *Saving Lives: Including People with Disabilities in Emergency Planning.* Washington, D.C.: National Council on Disability.

National Guard Bureau. 2009. *Vigilant Guard: National Guard Bureau Emergency Response Training Exercise*. Accessed March 29, 2012 at http://dmna.ny.gov/blog/resources/vg_news_mag.pdf

National Voluntary Organizations Active in Disasters (NVOAD). 2012a. *NVOAD Membership Criteria.* Retrieved March 15, 2012 from http://www.nvoad.org/index.php?option=com_content&view=article&id=126&Itemid=68

National Voluntary Organizations Active in Disasters (NVOAD). 2012b. *NVOAD State Directory.* Retrieved March 15, 2012 from http://www.nvoad.org/index.php?option=com_content&view=article&id=88&Itemid=91

New York City Metro Transit Authority (NYC MTA) interview. April 20, 2012.

New York City Office of Emergency Management (NYC OEM) interview. April 20, 2012.

New York City Office of Emergency Management. 2006. *Planning for Emergencies: Coast Storm Plan*. New York City: Office of Emergency Management.

New York State Department of Financial Services (NYSDFS). 2012, April 9. *Circular Letter No. 1.* Albany, NY: New York State Department of Financial Services.

New York State Department of Transportation (NYSDOT) interview. March 16, 2012.

New York State Emergency Management Office (NYSEMO). 2006. *June 2006 Floods: Fact Sheet*. Report Brief, Albany, NY: New York State Emergency Management Office.

New York State Emergency Management Office (NYSEMO). 2004. *Empire County Comprehensive Emergency Management Plan: A Sample Plan*. Albany, NY: New York State Emergency Management Office.

New York State Executive Law Article 2-B

New York State Office of Emergency Management (NYSOEM) interview. March 30, 2012.

New York State Office of Health and Emergency Preparedness (NYSOHEP) interview. March 15, 2012.

Niagara International Transportation Technology Coalition (NITTEC) interview. February 3, 2012

Nonprofit Risk Management Center. 2009. State Liability Laws for Charitable Organizations and Volunteers, 4th ed. (Sept., 2001 with additional information added in 2005, 2008 and 2009). Washington, D.C.: Nonprofit Risk Management Center.

Office of the Surgeon General: Office of the Civilian Volunteer Medical Reserve Corps Program. 2008. *Guidance for Medical Reserve Corps Units Regarding National Incident Management System Compliance.* Washington, D.C.: Office of the Surgeon General.

Oreskes, N, 2004. Beyond the ivory tower: The scientific consensus on climate change. *Science, 306*(5702); 1686.

Orloff, L. 2011. *Managing Spontaneous Community Volunteers in Disasters: A Field Manual.* Boca Raton, FL: CRC Press.

Peterson, C. 2006. Be safe, be prepared: Emergency system for advance registration of volunteer health professionals in disaster response. *OJIN: The Online Journal of Issues in Nursing*, *11*(3).

Points of Light Foundation & Volunteer Center National Network [PLFVCNN]. 2002. *Preventing a Disaster within the Disaster: The Effective Use and Management of Unaffiliated Volunteers.* Washington, D.C.: PLFVCNN.

Port Authority of New York and New Jersey (PANYNJ) interview. April 19, 2012.

Quarantelli, E. L. 1985. *Needed innovation in emergency medical service in disasters of the future*. Preliminary Paper #95. Disaster Research Center, University of Delaware.

Rahm, D. & Reddick, C.G. 2011. U.S. city managers' perceptions of disaster risks: Consequences for urban emergency management. *Journal of Contingencies and Crisis Management, 19*(3): 136-146.

Rand Corporation. 2007. *Hurricane Katrina: Lessons for Army Planning and Operations.* Santa Monica, Calif.: Rand Corporation.

Rand Health. 2009. *Rural hospitals struggle to attract patients and remain viable*. Santa Monica, Calif.: Rand Corporation.

Rasid, H., Haider, W., & Hunt, L. 2000. Post-flood assessment of emergency evacuation policies in the Red River basin, Southern Manitoba. *Canadian Geographer/Le Géographe canadien*, *44*(4), 369-386.

Redlener, I., Johnson, D., Berman, D.A., Grant, R. 2005. Follow-up 2005: Where the American public stands on terrorism and preparedness after hurricanes Katrina & Rita. New York, NY: National Center for Disaster Preparedness at Columbia University.

Regional Plan Association interview. November 7, 2012.

Renne, J. 2006. "Best Practices in Evacuation for the Carless Society." Working paper, New Orleans, LA: University of New Orleans Transportation Center.

Renne, J.L.,Sanchez, T.W., & Litman, T. 2008. National study on carless and special needs evacuation planning: A literature review. *Planning and Urban Studies Reports and Presentations.* Paper 8. New Orleans, LA: University of New Orleans Transportation Center.

Renne, J., Sanchez, T.W., Jenkins, P. & Peterson, R. 2009. Challenge of evacuating the carless in five major U.S. cities identifying the key issues. *Transportation Research Record: Journal of the Transportation Research Board*. 2119: 36-44.

Rensselaer County Public Safety, interview. March 16, 2012.

Revkin, A.C. 2004, December 27. With no alert system, Indian Ocean nations were vulnerable. *The New York Times.* December 27, 2004.

Riad, J. K., Norris, F. H., & Ruback, R. B. 1999. Predicting evacuation in two major disasters: Risk perception, social influence, and access to resources. *Journal Applied Social Psychology*, *29*(5), 918–934.

Rickard, L. & A. Fehn. 2007. Unresolved issues in disaster planning for hospital clients. *The Health Lawyer 19*(6): 10-13.

Rittel, H.W.J. & Webber, M.M. 1973. Dilemmas in a general theory of planning. *Policy Sciences, 4,* 155-169.

Rolf, C.A. 2007. Protecting the protectors: Liability, insurance, and laws pertaining to volunteers involved in homeland security and disaster management. *Rivier Academic Journal, 3*(1), 1-20.

Sander, L. & Saundy, S. 2007, August 2. Bridge disaster in Minneapolis kills at least 7. *The New York Times.* August 2, 2007.

Shughart II, W. F. 2006. Katrinanomics: The politics and economics of disaster relief. *Public Choice*, *127*(1-2), 31-53.

Seelye, K.Q. 2011, August 23. Above all else eastern quake rattles nerves. *The New York Times.* August 23, 2011.

Sims, J.H. & D.D. Baumann. 1983. Educational Programs and Human Response to Natural Hazards. *Environment and Behavior, 15*(2) 165-189.

Somers, S., & Svara, J. H. 2009. Assessing and managing environmental risk: Connecting local government management with emergency management. *Public Administration Review*, *69*(2), 181-193.

Sorensen, J.H. 1991. When shall we leave? Factors affecting the timing of evacuation departures. *International Journal of Mass Emergencies and Disasters, 9*(2), 153-165.

Sorensen, J. H., Shumpert, B. L., & Vogt, B. M. 2004. Planning for protective action decision making: evacuate or shelter-in-place. *Journal of Hazardous Materials*, *109*(1), 1-11.

Stein, R. M., Dueñas-Osorio, L. & Subramanian, D. 2010. Who evacuates when hurricanes approach? The role of risk, information, and location. *Social Science Quarterly, 91*, 816–834.

Sternberg, E. & G. Lee. 2009. New York City's Healthcare Transportation During Disaster: A Preparedness Framework for a Wicked Problem. *Prehospital and Disaster Medicine.* (25) 2, 95-107.

Stormwest Exercise, April 24, 2012 at Erie County Emergency Operations Center.

Thames Shipyard and Repair Co. v. United States. 2003. Retrieved February 6, 2012 at http://openjurist.org/350/f3d/247/thames-shipyard-and-repair-company-v-united-states

Thier, Dave. 2012. New Orleans Group Promotes Hurricane Awareness. *New York Times.* March 6, 2012.

Tierney, K., Lindell, M.K. and Perry, R.W. 2001. Facing the Unexpected: Disaster Preparedness and Response in the United States. Washington, D.C.: Joseph Henry Press.

Tomer, A. 2011. *Transit Access and Zero-Vehicle Households*. Washington D.C.: Metropolitan Infrastructure Initiative Series and Metropolitan Opportunity Series. Metropolitan Policy Program at Brookings.

University at Buffalo Emergency Management interview. March 30, 2012.

Urbina E. & Wolshon, B. 2003. National review of hurricane evacuation plans and policies: A comparison and contrast of state practices. *Transportation Research Part A: Policy and Practice*, 37(3), 257-275.

U.S. Census Bureau. 2010. American Community Survey, 5-Year Estimates. Washington, D.C.: U.S. Census Bureau.

U.S. Census Bureau. 2011. American Community Survey. Washington, DC: U.S. Census Bureau

U.S. House of Representatives. 2006. *A Failure of Initiative: The Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina.* Washington, D.C.: U.S. House of Representatives.

Vale, L. J., & Campanella, T. J. 2005. *The resilient city: How modern cites recover from disaster*. New York: Oxford University Press.

Weston, R. F. Inc. 1989. Identification and analysis of factors affecting emergency evacuations. *National Environmental Studies Project Nuclear Management and Resources Council*.

White, R. A., Blumenberg, E., Brown, K.A., Contestabile, J.M., Haghani, A., Howitt, A.M., Lambert, T.C., Morrow, B.H., Setzer, M.H., Stanley, Sr., E.M. & Velásquez III, A. 2008. *The Role of Transit in Emergency Evacuation.* Special Report 294, Washington D.C.: Transportation Research Board.

Wolensky, R.P., & Wolensky, K.C. 1990. Local government's problem with disaster management: A literature review and structural analysis. *Policy Studies Review, 9*(4), 703–25.

Wolshon, B. 2002. "Planning for the Evacuation of New Orleans." *Institute of Transportation Engineers Journal.* February 2002, 44–49.

Wolshon, B., Hamilton, E.U., Levitan, M. & Wilmot, C. 2005a. Review of policies and practices for hurricane evacuation. II: Traffic operations, management, and control. *Natural Hazards Review, 6*(1), 143-161.

Wolshon, B., Urbina, E., Wilmot, C., & Levitan, M. 2005b. Review of policies and practices for hurricane evacuation. I: Transportation planning, preparedness, and response. *Natural Hazards Review, 6*(1), 129-142.

Appendix A: Roundtable Discussion Summary

The research for this project was formally presented in a roundtable discussion in order to solicit comments and suggestions from experts on disasters and transportation planning. The presentation took place at the Regional Plan Association in New York City on Thursday, November 15, 2012, a little more than two weeks after Hurricane Sandy devastated the New York metropolitan region. Disaster planning was fresh in the minds of the expert team and the idea for a **Transportation Reserve Corps** was received with keen interest given recent events. The following passages summarize and synthesize the roundtable discussion.

Following a research presentation by Dr. Daniel B. Hess about multi-modal transportation, evacuation, and the idea of a **TRC**, a discussion was led by Edward Blakely whose long resume includes leadership of recovery efforts in New Orleans following Hurricane Katrina. Roundtable discussion attendees[19] included:

- Nadia Aslam, UTRC-Region 2, City College of New York
- Richard Barone, Regional Plan Association
- Edward Blakely, Regional Plan Association and University of Sydney, Australia
- Eric Goldwyn, Columbia University
- Daniel B. Hess, University at Buffalo
- David King, Columbia University
- Alex Marshall, Regional Plan Association
- Rae Zimmerman, New York University
- Matthew Wattles, University at Buffalo

In general, roundtable participants were highly supportive of a **TRC** as a model for addressing gaps in the ability to safely evacuate people during a notice or no-notice event. While attendees were supportive of multi-modal transportation planning for disasters, there was general agreement that barriers to multi-modal evacuation planning exist. Attendees were more supportive of a **TRC** than the research team expected in New York City.

A.1 Disaster Planning

Disaster plans must not stop after an evacuation has been conducted, and all disaster planning must consider "receiving areas" —shelters and other locations—where evacuees will be housed and provisions will be supplied at such locations. During

[19] Dr. Rae Zimmerman attended the roundtable discussion and is also a member of the Project Advisory Committee.

Hurricane Katarina, for example, it was impossible to provide food and supplies for people at shelters such as the Superdome. For certain disasters, people must be moved far from an urbanized area but in other cases people should stay centralized so it is easier for emergency management organizations to provide shelter, food, and supplies. In Japan, many disaster plans require people to evacuate "inward" (remaining in cities within shelters) rather than "outward" (traveling outside cities to other sites).

Military bases, many of which are underutilized or empty, are a potential location for evacuees, however it was pointed out that evacuees could be refused shelter at a military base (this happened during Hurricane Katrina in 2005). The evacuation of people to military bases reinforced the importance of considering federal guidelines when developing a **TRC**. For example, a **TRC** may potentially need to move large numbers of people across state borders. During Hurricane Katarina, the state of Alabama refused evacuees from Louisiana.

A.2 Evacuation Behavior

The discussion group had insight about people's natural responses to disasters and how response concerns relate to a **TRC**. It was suggested that many families already possess evacuation plans and that **TRC** volunteers may find it difficult to focus on assigned duties when their families may be in danger. Since many families already have pre-determined evacuation plans, a **TRC** should assume that certain people have already received help from family members.

Family and automobile-based evacuations also interfere with a **TRC** because families using their private vehicles will crowd streets and highways, making it difficult for high-capacity vehicles to efficiently conduct evacuation.

A **TRC** should also prepare for people to evacuate with family pets. Certain people may refuse to evacuate if they cannot keep pets with them. There was a general consensus that **TRC** volunteers must be trained to cope with people who do not comply—for various reasons—with evacuation orders. It is important that **TRC** volunteers understand how to help evacuees remain calm and help evacuees feel comfortable, especially older adults.

Evacuation planners should also consider the cultural mix of a place. Cultural practices can influence travel behavior, and this should be accounted for in evacuation planning. For example, male and female members of the Jewish community often ride in separate automobiles. Evacuation plans should address such cultural factors wherever possible.

A.3 Transportation Reserve Corps Operations and Funding

Roundtable participants identified additional sources of vehicles that could be used by a **TRC** during an evacuation.

A.3.1 Rental Cars

Rental cars should be considered in metropolitan inventories of vehicles suitable for use during evacuations, and rental car companies should collaborate with **TRC**s on evacuation planning. Rental car establishments are located near airports (usually on high ground) near population centers.

A.3.2 Taxis and Jitneys

Taxis and jitneys should also be considered as potential vehicles for a **TRC**. During Hurricane Sandy, restrictions were lifted so that taxis were permitted to operate as shared-ride vehicles. However, roundtable participants argued that the system did not work well because drivers could not make objective decisions about which passengers to pick up. A more structured system for shared-ride operation is needed if taxies are to be used for evacuation during a disaster, and taxi drivers must be trained to choose passengers most in need.

A.4 Volunteers

For recruiting volunteer members, roundtable participants suggested turning to existing civic organizations such as first responders and food distribution volunteers. Such groups are already known to be willing volunteers. Thinking on a large scale, it was suggested that volunteers be portable across state lines. A nationwide network of volunteers could be accessed from various parts of the country and pre-planned volunteer mobility systems could move volunteers to places in need.

A.5 Funding

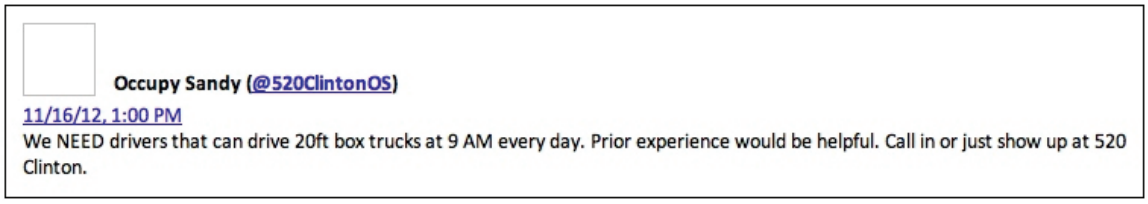
It was also suggested that a potential funding source for a **TRC** could be donations from American Automobile Association (AAA) members. For example, an AAA membership renewal (or new member enrollment) could ask members to contribute $1 to support evacuation and transportation during natural and manmade disasters. These donations could be used locally to support **TRC**s.

Another funding source for a **TRC** could be revenues from a "disaster zone" tax, which would be paid (by developers, property owners, and/or residents) for economic activity in places that are susceptible to disasters, such as coastal flood or hurricane zones.

A.6 Urban Transportation During Disasters

While a **TRC** was originally envisioned to help a metropolitan area cope with transportation related to a disaster, roundtable members suggested another function for a **TRC**. A **TRC** could assist with regular operations for a region's urban transportation

system (involving the movement of both people and goods) before, during, and after a disaster in the event that part or all of the urban transportation system is unusable or shut down for safety reasons. In this way, the **TRC** could serve as a general back-up transportation system, in the event that a disaster causes damage to part of a transportation system or damage to a neighborhood or district. Disasters are likely to produce uneven impacts across a metropolitan area. In New York City the events of September 11 (2001) and Hurricane Sandy (2012) caused devastation in certain neighborhoods while other neighborhoods were left untouched. This role of a **TRC** was supported by a tweet shared by a roundtable member from Occupy Sandy recruiting volunteer truck drivers.



A.7 Next Steps

Roundtable discussion attendees support further refinement of a **TRC** through research about legal and regulatory mechanisms and eventual staging of a tabletop planning exercise and full practice exercise. Roundtable discussion participants suggested additional analytic research to support the **TRC** concept. For example, GPS data from taxi use before/during/after Hurricane Sandy can be combined with GIS to investigate taxi driver behavior to better understand the promise and potential of using taxis for lifeline transport and evacuation during disasters.

Appendix B: Disaster Typology

Emergency evacuations of 1,000 people or more typically occur over three times per month in the United States (Weston, 1989). In a 12.5 year study (from 1990 to 2003), Dotson & Jones (2005) summarize the range of incidents which ultimately led to an evacuation. This research provides a fittingly sound starting point to form a disaster typology with respect to compulsory emergency evacuations. The study identified 230 evacuations within the U.S. during this time frame. Of these, 58 percent were caused by natural disasters, 36 percent by technological hazards and 6 percent were caused by malevolent acts or civil disasters (Dotson & Jones, 2005). Some disaster types are more likely to incite a large-scale evacuation than others; virtually any emergency incident could, in theory, provoke such a response. For this reason, a range of known disaster incidents is included below. Following an overview of the three general types of disasters (natural disasters, technological hazards and malevolent acts), a range of specific disaster incidents is discussed.

B.1 Natural Disasters

Historically, extreme events caused by nature constitute the majority (greater than 90 percent) of disasters endured in the U.S. (White, *et al.*, 2008). These include severe storms, flooding, earthquakes, tornadoes, droughts, disease outbreaks, etc. In New York State, 83 major natural disasters have occurred since 1953 (White, *et al.*, 2008), or, nearly 93 percent of all disaster incidents over this time period (FEMA, 2011). Natural disasters were the cause of more evacuations (58 percent) than any other type of incident (Dotson & Jones, 2005).

With increased understanding and realization of its effects, the once debatable notion of anthropogenic climate change has been a consensus among the scientific community for years (Oreskes, 2004). Ongoing global climate change will likely produce a growing number of unpredictable and violent natural disasters, a concern which the disaster management community has long recognized (Hoetmer, 1991). This reality is compounded by global population growth, which inevitably makes more people more vulnerable to natural disasters.

B.1.1 Earthquakes

Because earthquakes occur with little or no warning, a pre-incident evacuation is virtually impossible. However, depending on earthquake severity, shelters or potential shelters may be critically damaged, and an evacuation may be called for after an earthquake occurs (Center for Disease Control, 2011). The safety of individuals and building safety are primary concerns, as structural damage may compromise lifeline utilities (such as gas, water, and electric lines) may be damaged, and aftershocks may occur. This damage may also disrupt critical infrastructure, blocking transportation routes or impairing vehicles, which may limit the efficacy of a post-incident evacuation.

According to Dotson & Jones (2005), earthquakes resulted in two evacuations of at least 1,000 people in the U.S. between 1990 and 2003. More typically, earthquakes cause individuals to be evacuated from individual buildings rather than the greater metropolitan area. This was the case in late August of 2011 when an earthquake centered in Virginia caused tens of thousands of workers to vacate their office buildings (Seelye, 2011). Despite common perceptions, in many areas fortunate enough not to have experienced a catastrophic earthquake throughout the history of the U.S., the threat of earthquakes is not trivial. Upstate New York, for instance, rests upon hundreds of seismic faults, many of which are active (National Guard Bureau, 2009). The Clareden-Linden fault line which runs midway between Rochester and Buffalo is estimated to have a 40 percent chance of producing a 6.5 magnitude earthquake (National Guard Bureau, 2009).

B.1.2 Hurricanes

High winds, storm surge and flooding are key features of tropical storms and hurricanes which are most critical to the evacuation decision (Cutter & Smith, 2009). In most cases, hurricanes form with significant warning to allow adequate time to carry out an evacuation before landfall. As in other natural disasters, the availability, type and construction of buildings has an impact on evacuation decisions. In addition, the locality of an affected population (*i.e.*, relative position to the coast) also weighs heavily on the evacuation choice. For instance, in areas where a storm surge is not of concern and wind speeds are reduced, a shelter in place option is more suitable than evacuation (Cutter & Smith, 2009). Noting the relevance of all these factors, it can be said that hurricanes or tropical storms commonly require an evacuation, both before and after storms strike. According to Dotson & Jones (2005), 33 percent of all large-scale evacuations between 1990 and 2003 in the U.S. were the result of tropical storms or hurricanes. Due to the immense area affected by these storms, hurricanes also demand the most extensive evacuations compared to other incidents (Dotson & Jones, 2005).

B.1.3 High Winds/Tornado

Among the most violent and severe weather systems in the U.S. are tornados. Though the National Weather Service issues advisories and warnings for high winds and tornados, these rarely lead to a large-scale emergency evacuation. Alternatively, many communities in high-risk areas are equipped with public alarm systems which advise people to shelter themselves in safe, underground areas rather than mobilizing while a tornado looms. Pre-incident evacuations are rare, though not impossible, for tornados. It is more likely that a tornado would cause an evacuation after it occurs, resulting from destruction of buildings and homes in its path. From 1990 to 2003, 26 evacuations of 1,000 or more people were caused by tornadoes in the U.S. (Dotson & Jones, 2005).

B.1.4 Flood

Like tornadoes, the National Weather Service issues warnings and advisories for flooding, but these warnings may not allow adequate time to conduct a large-scale

evacuation, especially when flash flooding occurs. Even gradual floods which strike with advance notice most likely do not allow sufficient time to mobilize all affected individuals. However, a well-prepared community may be able to effectively conduct a mandatory evacuation if given notice merely hours in advance of a flood. A post-flood evacuation is likely to occur in situations where homes are destroyed by water inundation. Dotson & Jones (2005) found that 47 large-scale evacuations were caused by floods, about 20 percent of all evacuations during this period.

B.1.5 Tsunami

Tsunamis result from earthquakes and may result in catastrophic flooding. Adequate time may be given to relocate people from an area projected to be inundated, depending on the proximity of the earthquake which triggers a tsunami, though it would likely not be within the 72-hour time frame recommended by FEMA (2008). During the Indian Ocean Tsunami in 2004 (Revkin, 2004) and more recently the tsunami which devastated northern Japan in March 2011 (Fackler, 2011), there was insufficient warning to conduct a large-scale evacuation within the most highly impacted areas. Like other natural disasters, an evacuation of affected populations (due to destruction of buildings and infrastructure) may occur following the tsunami.

B.1.6 Wildfire

Wildfires are perhaps the disaster type most directly linked to rising global temperatures. For instance, a marked increase in the area of forest burned annually in Canada over the past 40 years was shown to have a correlation with rising air temperatures (Gillet *et al.*, 2004). Wildfires are dangerously unpredictable and violent in nature. There is a debate on how best to respond to wildfires. Sheltering in place is often a viable option for residents threatened by wildfires (Cova *et al.* 2009). As fire spreads rapidly and unpredictably, the warning time for wildfires may not be sufficient to allow for a large-scale evacuation. However, when acting under the precautionary principle, many government officials may mandate evacuation for areas likely to be impacted. Considering that any resident sheltering in place who loses their home in such an event is very likely to lose their life as well, pre-incident evacuation is more likely than post-incident evacuation. Dotson & Jones (2005) identified 56 instances where large-scale evacuation was caused by wildfires between the years 1990 and 2003.

B.2 Technological Disasters

Another name for a technological disaster is a man-made disaster, attributed all or in part to human error, negligence, or malfunction or failure of a man-made mechanism. For example, a train derailment could also result in a release of hazardous material or, an airplane crash could ignite and proliferate fires. Although technological disasters of any variety are innately unpredictable, it is possible to determine locations with a high likelihood of being impacted. For instance, areas surrounding nuclear power facilities or transportation corridors where hazardous waste releases are most likely to occur are

easily identified as places with a high risk of enduring a technological hazard (Hoetmer, 1991). Similarly, these failures may be human-induced or prompted by malicious intent.

B.2.1 Hazardous Waste Release or Nuclear Meltdown

Whether through a spill, leak or dump a disaster involving hazardous waste or nuclear material may likely result in a need for evacuation (Sorensen, Shumpert & Vogt, 2004). A release of hazardous waste may be insidious, with consequences not surfacing immediately but inconspicuously, as in the notorious Love Canal incident of the 1970s' in Niagara Falls, NY (Blum, 2008). However, these incidents could just as readily evoke immediate alarm for an incident population, such as a release of highly toxic airborne contaminants or a nuclear meltdown.

Enacted in response to a hazardous gas release which killed over 25,000 people in India in 1984, the U.S. Superfund Amendments and Reauthorization Act (SARA) mandated localities with facilities using hazardous materials to engage in disaster planning (Hoetmer, 1991). Commonly, instead of ordering an evacuation which may result in bottlenecks and further expose evacuees to contaminants, it is usually better for local decision-makers to command a shelter in place order for at-risk residents and institutions (Sorensen, 2004). However, in the case of nuclear meltdowns, as radiation effects worsen with exposure time, a common practice is to mandate evacuations. Dotson & Jones (2005) identified 33 evacuation instances which were incited by a fixed site release of hazardous materials (although nuclear meltdown did not occur during the study years).

B.2.2 Explosions/Fires

Explosions and fires by their very nature occur with little or no warning and therefore preclude pre-incident evacuation. However, like other disasters listed, if these events damage homes or other critical infrastructure, a post-incident evacuation may be warranted.

B.2.3 Transportation Accidents/ Malfunctions

Train, airplane, and automobile crashes; failures in the public transportation system; or infrastructure failures (such as the interstate highway bridge collapse in Minneapolis which claimed seven lives in August, 2007 [Sander & Saundy, 2007]) are all types of technological disasters. Dotson & Jones (2005) identified a total of 40 instances between 1990 and 2003 in which transportation accidents or malfunctions resulted in large-scale evacuations (including 25 railroad accidents). Transportation-related disasters occur without warning and therefore preclude pre-incident evacuations. However, they often incite post-incident evacuations if the damages are great enough (for example, if homes are destroyed or if a derailed train leaks hazardous materials).

B.2.4 Infrastructural Failures

Infrastructural failures are another type of technological disaster and include such incidents as power outage, building collapse, disruption of the public water system, gas or electric lines or broadband network. Though these instances preclude pre-incident evacuations due to their spontaneous nature, they leave open the possibility of post-incident evacuations if the duration or extent of the event will put lives of citizens at risk. Dotson & Jones (2005) identified 11 instances where disasters of this variety led to large-scale evacuations in the U.S. from 1990 to 2003, six of which were due to pipeline failures.

B.3 Malevolent Acts (Civil Disasters)

Malevolent acts and civil disasters are deliberate, human-induced acts of violence which have existed for all of human history (Hoetmer, 1991). These acts include wars, massacres, riots, terrorist attacks and cyber-attacks. Malevolent acts of all varieties likely result in the displacement of refugee populations, property destruction, extensive injuries and disease, not to mention long-lasting economic and social disturbance (Hoetmer, 1991).

Civil disasters occur with little or no warning (as surprise is an elemental objective in any attack) and therefore preclude a pre-incident evacuation. However, in the case of wars and riots, the variable nature and long duration of these events leaves open the possibility of an evacuation during the incident. However, most often emergency incidents of this variety would primarily require post-incident evacuations, especially when damage to homes, critical infrastructure or risk of contamination or disease warranted such an action. From 1990 to 2003, 13 evacuations were caused by malevolent acts, 5 alone from the terrorist attacks of September 11, 2001 (Dotson & Jones, 2005).

Appendix C: Erie County Evacuation Plan Summary

C.1 General Information

- The level of action will be determined by **scope (**the number of people involved and the geographic area impacted); **urgency** (demand for immediate action); and **duration of displacement**.
- In a small, localized emergency, the **Chief Executive in the city, town or village**, has the authority to issue an evacuation order and the municipality will have the capacity to handle the situation using their own **local emergency plan**. **The Erie County Emergency Services Office** is notified even though they may receive limited or no request for assistance. Ultimate authority rests with the **local Chief Executive**, though other **emergency service officials/first responders** (law enforcement personnel, fire officers, and public health officials) can order and conduct evacuations using reasonable judgment when public safety is immediately threatened.
- In an emergency affecting more than one municipal jurisdiction and requiring large-scale evacuation to other parts of the county or to other counties, the **Erie County Executive** will issue an evacuation. **Erie County Emergency Services** will manage the evacuation operation.
- The population ordered to evacuate will be instructed to use their private vehicles for transportation to the reception area, and offer transport to neighbors and friends without transportation. Arrangements will be made to provide public transportation to all persons needing this service, including the elderly and the handicapped.
- Strategically located pick-up points along evacuation routes will be established and publicized for persons without private transportation.
- A number of special groups in institutions, such as patients in hospitals that cannot be moved, may have to shelter in place.
- Arrangements will be made by the **Erie County Emergency Services Department** with the **American Red Cross** to shelter and feed all evacuees, if need be. However, it is anticipated that the many persons ordered to evacuate will arrange for their own needs, in motels or with family and friends, outside the disaster area.
- After the evacuation is completed, essential workers may maintain critical services or rescue and recovery operations in the hazardous area as safety considerations permit.
- Crossing county, state, or international boundaries may be required in order to locate safe shelters. The **International Joint Committee on Emergency Planning** could help with this aspect because of its working relationships with Niagara County, and the Niagara Region of Canada.

- Erie County has an annex to address sheltering of animals during times of emergency.
- Where available, military support (as approved by the Governor) will be available to support evacuation efforts.
- Evacuation of people at risk for emergency situations that occur with little or no warning will be implemented on an ad hoc basis.
- The areas likely to be evacuated will be defined after the emergency is determined. The travel routes will be designated, depending upon the potential or actual emergency. The means used to transport carless evacuees will be listed. For some seasonal and weather-related hazards, standard designated evacuation routes will be used to evacuate people.
- Return of the evacuated population to their homes will be on the order of the **Erie County Executive**.
- Once the area is deemed safe for return, provisions will be made to release the evacuated residents and businesses in an orderly manner to ensure that no un-invited guests get into the site ahead of the evacuees. Residents will provide identification that they live or work in the evacuated area in order to return.

C.2 Responsibilities

- **Evacuation Coordinator** – Assigned to **Erie County Emergency Services** or local disaster coordination.
    - Reviews information about the emergency situation and makes recommendations to the **Emergency Manager** (see below) on the appropriate evacuation options to implement.
    - Identifies assembly areas for picking up carless.
    - Identifies evacuation routes including routes to designated mass care facilities, traffic capacity, and access from risk areas.
    - Coordinates with **law enforcement officials**.
    - Assists with the implementation of the animal care annex
- **Emergency Manager** - makes recommendations to the **Chief Executive Officer (CEO)** about the appropriate evacuation option to implement.
- **Chief Executive Officer (CEO)** - declares a state of emergency for that community or the county. If it's local, the **CEO or the IC** (see below) will inform the **County Executive**.
- The **Incident Commander (IC)** - acts on behalf of the **CEO** and is in charge of the resources needed to bring the emergency to a safe conclusion without jeopardizing the safety of the resources.
- The **Public Information Officer (PIO)** - designated by the **CEO** to update the media of the status of the emergency on a regular basis and disseminates the following types of instructional materials and information to evacuees:
    - List of items that evacuees should take with them
    - Departure times.
    - Pick-up points for people requiring transportation assistance.

- Evacuation routes
- Location of mass care facilities outside of the evacuation area.
- Appropriate actions to protect and care for companion and farm animals

- **American Red Cross** - primary agency to provide shelter. They will utilize pre-established locations such as schools, hotels, and other large buildings in every general area within and outside Erie County. They will supply food and other items needed by the evacuees. Erie County does not have the capabilities to support ancillary pop up shelters.
- **Law Enforcement –** Provides traffic control i.e. route assignment, departure scheduling, road capacity expansion, entry control for outbound routes, perimeter control on inbound routes, traffic flow, dealing with breakdowns, and establishment of rest areas.
  - Secures, protects, and houses evacuated prisoners.
  - Assists in the evacuation of the risk area.
  - Protects property in the evacuated area.
  - Limits access to the evacuated area.
  - Coordinates with the **Evacuation Coordinator.**
  - Secures evacuated areas.
- **Public Works** - Verifies the structural safety of routes (roads, bridges railways, waterways, airstrips, etc.) that will be used to evacuate people.
- **Mass Care Coordinator** – Activates staff and opens mass care facilities outside the evacuation area when directed to do so by appropriate authority.
- **Health Department** –
  - Ensures patient population is reduced in hospitals, nursing homes, and other health care facilities
  - Ensures transport and medical care are provided for the patients being evacuated.
  - Ensures continued medical care is provided for patients who cannot be moved when hospitals, nursing homes, and other health care facilities are evacuated.
- **On-Scene Operations** –Provide on-scene direction and control operations that help facilitate decision-making and the coordination of the overall emergency response by the **Erie County Emergency Services** staff.
  - **First Responders** – First person on location to take initial action.
  - **On-Scene Commander** – First Officer on location that takes command.
  - **Evacuation Coordinator** – Assists with coordination of command actions.
- **Administration and Logistics**
  - Records and reports associated with tracking the status (evacuation notices, number evacuated, number of evacuees in mass care facilities, etc.) of evacuation events.
  - Maps that depict the routes that have been designated as evacuation routes.
  - The provisions needed to sustain operations and to meet the needs of evacuees i.e. food, water and water trailers, medical supplies, animal needs, sanitation devices, portable generators and lighting devices, gas and diesel

fuel, public works equipment and vehicles such as bulldozers, graders, dump trucks, snowplows, etc.

- **Mutual aid agreements** with neighboring jurisdictions that address the support (law enforcement personnel, vehicles to transport evacuees, mass care staff and facilities to shelter evacuees, etc.) to be provided by the jurisdictions to facilitate evacuation operations.

Adapted from

Erie County Department of Emergency Services. 2010. *Erie County Comprehensive Emergency Management Plan Evacuation Annex*. Buffalo, NY: Erie County Department of Emergency Services.

Appendix D: Niagara County Evacuation Plan Summary

D.1 General Information

Village, town, or city government has the first line of responsibility to respond in an emergency in its locality and the obligation to utilize all available resources to protect its citizens.

The municipality will notify the **Niagara County Office of Emergency Management (OEM**) of any emergency situation for which they believe requires assistance.

The Director of Emergency Management will identify, monitor, and place on standby resources for immediate deployment assistance. The county will request assistance from **State Emergency Management Office (SEMO)** for any limited resources.

Based on magnitude, intensity, time until onset and duration; and on the recommendation of the **Director of Emergency Management**, the **chairman of the County legislature (the chief executive officer)** may issue an evacuation order. The Chairman also controls the use of any and all county-owned resources and facilities for disaster response, requests and accepts assistance from other political subdivisions and the state when the situation escalates beyond the capability of county resources; and coordinates and provides assistance to other local governments that have exceeded their own emergency response capabilities.

If time and circumstances renders evacuation impractical, the citizens of the county residing in or near a hazard area may be directed by the **Incident Commander (IC)** to seek protection against potential dangerous exposure generated at the hazard area. Citizens may take shelter in their own homes or other designated buildings located within the hazard area. The **Director of Emergency Management** will maintain a current **American Red Cross** listing of shelter facilities within the County.

The **OEM** will coordinate with the **Cornell Cooperative Extension** during any emergency to manage the evacuation or in-place sheltering of livestock or to accomplish the quarantine of livestock in the event of an animal epidemic.

Special Needs - Niagara County has developed and promotes the inclusion of individuals who have disabilities, special needs, live in institutionalized settings, are elderly, are from diverse cultures, have limited English skills, are children and are carless in all phases of the emergency management cycle.

Resource Management - The **OEM** maintains an inventory, ordering, and tracking system for fire, EMS, and public works resources, and may request resources from other agencies as necessary. The **OEM, SEMO,** and **New York State Office of Fire Prevention and Control** identify and manage the use and return of loaned resources.

Mutual Aid - Niagara County maintains an ability to integrate resources, equipment and information from intrastate and interstate mutual aid agreements, state-provided assistance, and federal assistance. Mutual-aid agreements are the means for one jurisdiction to provide resources, facilities, services, and other required support to another jurisdiction during an incident. It is strongly encouraged that Niagara County departments, municipalities, and first responder agencies develop mutual-aid agreements with those in neighboring jurisdictions from which they expect to receive or to which they expect to provide assistance during an incident.

Niagara County will use the **National Incident Management System (NIMS) Resource Typing Definitions** which allows jurisdictions to share resources among mutual aid partners. The NIMS defines standardized mechanisms and establishes requirements for processes to describe, inventory, mobilize, dispatch, track, and recover resources over the life cycle of an incident.

Incident Command System (ICS) defines the operating characteristics, interactive management components, and structure of incident management and emergency response organizations engaged throughout the life cycle of an incident. Niagara County endorses the use of the ICS, as developed by the NIMS, and formally adopted by the state of New York, for emergencies requiring multi-agency response.

Volunteers - Niagara County also works to ensure the adequate coordination of the activities of volunteers during times of disaster and the effective utilization of donated goods. The **American Red Cross** will partner with the **NYOEM** to manage the use of volunteers during emergency response and recovery.

Standard Operating Guidelines - Each County department with a role in emergency management is required to have its own **Standard Operating Guidelines (SOGs**). These SOGs address activation of personnel, shift assignments at the EOC, assignment to the field, including the Incident Command Post (if applicable), coordination with other agencies, drills, exercises, and ICS training. The Director of Emergency Management develops and maintains a list of County department roles in County response and recovery activities.

Name	Responsibilities During an Evacuation
Chairman, County Legislature	• Orders evacuation • Designates **PIO**
County Manager	• Liaison between **EOC** and **Legislature**
Director of Emergency Management	• Notify the **Region V Office of SEMO** of the evacuation order • Direct the coordination of the evacuation operation procedures for: – Warning/notifying/informing the public – Establishing of evacuation routes – Closing schools, hospitals, other public facilities, – Providing means of transportation, – Notifying the **American Red Cross** chapter to open up predestinated shelters to house and feed evacuees – Providing general and special care for evacuees, – Providing security, law enforcement, and fire protection for shelter areas, – Providing operational support to the **IC**, – Arranging support from state and federal agencies if required, – Designating a transportation coordinator – Initiating the general return to evacuated areas – Initiating recovery • In coordination with the **IC**: – Estimate the total number of persons to be evacuated/need transportation/shelter – Identify the number and type of vehicles required for the evacuation of carless – Notify the transportation coordinator of the transportation support requirements.
Incident Commander (IC)	• Direct the evacuation operations within the disaster area • May be assisted by an evacuation coordinator to carry out the many varied responsibilities involved in the operation • Coordinate through the **Emergency Operations Center (EOC)** public notification and warning of evacuation and public information • Stage the evacuation movement, based on those in greatest danger and logistical and transportation considerations • Coordinate, with the sheriff and through the **EOC**, the evacuation movement to shelters • Coordinate the provision of security, law enforcement and fire protection for evacuated areas with local police and fire agencies.
Public Information Officer (PIO)	• Establish and run a **Public Information Center (PIC)** - a "one-stop" center where citizens and news media can obtain information and assistance. • Make **Emergency Public Information (EPI)** materials available for distributing to the public and for use by the news media, including information for the visually impaired and non-English speaking populations. • Make written and/or oral agreements with the news media for dissemination of EPI and emergency warnings and • Establish points of contact and essential information and instructions about protective actions to be taken by the public
Transportation Coordinator	• Mobilize the required number and types of vehicles to evacuate carless • Coordinate operation with the **IC**, through the **EOC**, to provide buses and designate bus pickup points.

	• Establish a dispatching system to control the movement of buses from the emergency zones to the shelters.
Sheriff	• Designate evacuation routes from the evacuation zones to shelters; • Control the movement of all traffic on these routes by establishing traffic control points • Coordinate road services support though the **EOC** with the **Public Works Department** and contact towing services; • Provide security and law enforcement for the evacuation area and at shelters; • Provide emergency zone perimeter control and coordinate through **EOC** with **IC** • Provide traffic control for return movement.
Emergency Medical Services	• Provides emergency medical treatment • Provides medical transportation • Sorts out and allocates treatment to emergency victims, report casualties to **EOC** • Establish and operate emergency medical care centers for essential workers
Public Works	• Administers public works, highway, and engineering activities for the County during response and recovery activities • Provides emergency repair and maintenance to County facilities/critical facilities, potable water, sanitation, and electricity • Ascertains structural integrity of buildings, bridges, roads and evacuation routes, designates and demolished hazardous structures • Provides traffic capacity estimates
Red Cross	• Management of temporary shelters, food service, emergency workers, medical and health services, transportation and occupational supplies**:** • Recruitment of volunteers Employment and Training • Management of Donations

Adapted from

Ecology and Environment, Inc. 2007. *Niagara County Comprehensive Emergency Management Plan.* Lancaster, NY: Prepared by Ecology and Environment, Inc. for County of Niagara.

Appendix E: Networks of Emergency Transportation During Disasters

The existing network of disaster response organizations is robust, however each institution possesses its own strengths and weaknesses. The following section provides examples of a few of these networks. There are numerous other organizations not described here (e.g., fire and police departments, ambulance companies, medical facilities). While the preparedness level of these types of organizations has necessarily improved over the past decade, the optimal level of coordination between governments and other involved organizations necessary for an ideal response remains to be proven (U.S. House of Representatives, 2006; GAO, December 2006; CDC, 2011. The most critical gap in this network may lie within the failure to adequately accommodate people without independent means of travel with emergency transportation (Wolshon, *et al.*, 2005; GAO, December 2006; Gerber, *et al.*, 2010; Matherly & Mobley 2011).

E.1 The Vigilant Guard

In order to test the functionality of coordination between local, state, regional and federal authorities during a disaster, the National Guard Bureau and the United States Northern Command jointly sponsor the Vigilant Guard national exercise program (National Guard Bureau, 2009). Primarily intended as training for National Guard forces and state emergency management officials, the Vigilant Guard engages a broad range of disaster responders, including local police, fire departments, military police, transit police, HAZMAT teams, army engineers, and scholars. Each year the Vigilant Guard undergoes four exercises throughout the nation. In 2009, the first such exercise in New York State took place in Buffalo and its surroundings (National Guard Bureau, 2009).

Catastrophic events like Hurricane Katrina and the September 11, 2001 attacks motivated the Vigilant Guard exercise in Western New York (National Guard Bureau, 2009). The scenario Vigilant Guard employed for this exercise involved a 5.9 magnitude earthquake centered in the northern part of the city of Buffalo. The impacts from this modeled tremor were substantial and extended throughout Erie County and into southern Niagara County. The ensuing response solicited support from Army and Air National Guard units, HAZ-MAT teams, firefighters, police officers and medical personnel (National Guard Bureau, 2009). As proven by this demonstration and others like it being conducted throughout the U.S. each year, emergency planners are concerned about a large-scale, no-notice event which would cause extraordinary damage and likely result in a need to move large numbers of people, including those without cars, from an affected area.

E.2 Emergency Operations Centers

An Emergency Operations Center (EOC) is overseen by a group of officials who work together to coordinate actions during emergency response; an EOC is housed in a physical location pre-positioned with telecommunications equipment where these actors meet during a crisis (Mignone & Davidson, 2003; Militello *et al.*, 2007). EOC teams are typically comprised of county government employees and leaders, fire and police chiefs, and professionals from area hospitals, the American Red Cross, utility companies and other institutions (Militello *et al.*, 2007). EOCs can also be pre-designated locations commonly housed within the offices of local Emergency Medical Services, fire departments or an Emergency Management division. Such facilities can be fitted with provisions for public communication as well as the technology and staff needed to monitor weather, traffic and other critical information. EOCs are also furnished with multiple stations, each equipped with a computer and telephone, for representatives of most organizations essential in disaster response (NYC OEM interview, 2012). Likewise, representatives from these institutions are an essential piece in commanding an EOC, especially in conveying information to state Offices of Emergency Management and the federal government (Mignone & Davidson, 2003).

When an incident occurs, emergency managers meet at an EOC to collect comprehensive up-to-the-minute information and make decisions on response strategy, coordinate actions, and collaboratively manage resources (Mignone & Davidson, 2003). The choices of these decision-makers are critical as local resources will solely be responsible for emergency response anywhere from 24 to 72 hours after an incident occurs (Mignone & Davidson, 2003; NYSOEM interview, 2012). As regional, state and federal resources assemble to assist an affected locale, the Incident Command System (ICS) which is put in place as the command structure for the initial local disaster response is shifted to a Unified Command System (UCS). Under a UCS structure, all agencies with a jurisdictional duty in the response essentially become players in the resource-allocating and decision-making process (Mignone & Davidson, 2003). By bringing together all relevant government agencies from all levels of government with medical and emergency professionals, an EOC addresses the crucial need for emergency response operations to use the most reliable, up-to-date information when collaboratively making decisions (Mignone & Davidson, 2003).[20]

[20] In describing the intent of EOCs, it should also be noted that scholars, in observing EOC emergency training exercises, have categorized a list of obstacles inherent in attempting to optimize EOC operations. While observing two separate county EOC exercises in Ohio, Militello, *et al.* (2007) identified several key limitations in the implementation of an EOC. Firstly, EOC members have separate areas of expertise and only a few members have this expertise in emergency management. While not having a marked impact on outgoing communications, this can cause barriers to communicating within the EOC itself, perhaps slowing collective decision-making (Militello *et al.*, 2007). Secondly, strained lines of communication, crowded and noisy EOCs with limited technical capacity can prohibit knowledge of the situation being disseminated adequately to all EOC workers (Militello *et al.*, 2007). Perhaps most significantly, it was realized through these observations that EOC participants with an emergency services background (the EOC director and representatives from police and fire departments) assumed greater workloads than

E.3 The American Red Cross

For over 130 years, the American Red Cross (ARC) has been the preeminent organization in the U.S. for emergency response. Assisting in relief for all types of disasters throughout the world, the ARC operates through a network of over 35,000 employees and over 500,000 volunteers (ARC, 2012a). The organization works closely with the U.S. federal government (ARC, 2012b) and other related organizations such as the Medical Reserve Corps (American Red Cross Greater Buffalo Chapter interview, 2012) making it a critical resource in the response effort for any emergency incident (Hoetmer, 1991). The work of the ARC network can be seen locally to globally (ARC Greater Buffalo Chapter interview, 2012; ARC, 2012a). The central role of this institution during disaster response is to shelter and care for individuals affected by a disaster; the ARC has no role in transporting people to safe havens (American Red Cross Greater Buffalo Chapter interview, 2012). The New York Red Cross confirms its primary concern during disasters is the sheltering of people displaced by disasters (NY Red Cross interview, 2012).

other EOC members. This led to a lack of awareness among some EOC members as those with the most information were often too busy to share it with others (Militello *et al.*, 2007). This shortcoming was corroborated by the authors' observation of an EOC exercise in Erie County, NY (Stormwest exercise, 2012). In the event that an EOC location itself is destroyed by a disaster, as was the case in the terrorist attacks of September 11, 2001, the administrative relationships developed from its establishment help to preserve a relatively effective handling of a disaster (Mignone & Davidson, 2003).

Appendix F: Community-Based Disaster Volunteerism

This appendix describes various volunteer efforts related to disasters and emergency planning. The information is useful in helping to generate a new volunteer-based community-driven corps for assisting with evacuation if needed during a disaster.

F.1 Spontaneous Volunteerism

One seemingly underutilized human resource in the universe of disaster response is the considerable number of people without an affiliation to any emergency response organization, who, acting on a natural human impulse, offer assistance in disaster response efforts; these individuals have come to be known as spontaneous volunteers (Lichterman, 2000); Orloff, 2011). As proven by numerous devastating emergency events, most notably the events of September 11, 2001 which motivated an estimated 40,000 unaffiliated community volunteers, disaster response from such spontaneous volunteerism is resilient, supportive and impossible to suppress (Orloff, 2011). To stress this point further, disaster volunteering could be considered crucial for communities and the individuals within them to recover after an incident. Likewise, this inevitable response must be coordinated and incorporated fully into emergency management operations through comprehensive public education and clearly defined responsibilities (Points of Light Foundation & Volunteer Center National Network [PLFVCNN], 2002).

Spontaneous community volunteers present a cost-effective and necessary resource which should be empowered in disaster relief efforts (Orloff, 2011; PLFVCNN, 2002). Most often however, without acknowledgement or proper management of volunteers by professional first responders, disorder may ensue, giving rise to dissatisfaction between the parties (Orloff, 2011). At times emergency managers discourage people from getting involved in disaster relief in any way whatsoever (Orloff, 2011). Such discouragement opposes a natural human response to rebuild, reconnect and revitalize neighborhoods after they are damaged or destroyed. In this light, the prevailing institutional disaster-response climate may need to be wholly reformed to accommodate spontaneous volunteers (Orloff, 2011). In lieu of this, community-based, non-government organizations may be in the best position to support volunteer involvement in disaster response, considering that these organizations would naturally hold strong ties to the community (Orloff, 2011). Likewise, volunteers could be involved in every phase of disaster cycles, which will in turn make them better prepared to respond when a disaster strikes (PLFVCNN, 2002).

The purpose of embracing spontaneous volunteerism is to transform communities from "victims" to "resources" (Lichterman, 2000, p. 262). Citizens and emergency managers at all levels of government and society at large are now recognizing this model as the

most effective way to promote security and resiliency within U.S. cities (Lichterman, 2000). Moreover, through the effective management of disaster response volunteers, first responders are actually able to better carry out their responsibilities and do not have to allocate additional time to oversee volunteers (PLFVCNN, 2002). Despite this recognition however, eager volunteers who are unaffiliated are often not meaningfully incorporated in disaster response efforts (Orloff, 2011). This gives urgency to the argument to either better prepare this resource in an unaffiliated individual-based manner, or, to increase participation in new and expanding community-based disaster response groups which make these individuals more credible, allowing for a much greater chance of inclusion in disaster relief efforts by official first responders.

F.2 The Citizen Corps

Brief Overview

In the aftermath of the terrorist attacks of September 11, 2001, emergency responders, public officials and the general public became acutely aware of how unforeseen devastating events can overwhelm local emergency operations (CCC, 2009). As a consequence, the Citizen Corps was established by a presidential declaration in January 2002 to embrace the irrepressible community spirit that invariably arises when a disaster strikes. In the period since, this organization has grown to a national network of 1,175 locally-based Citizen Corps Councils (CCC, 2012). By all accounts, its membership has proven to uphold the organization's mission of coordinating community volunteers in order to build more resilient and secure communities (CCC, 2009).

The Citizen Corps asserts itself as a forum where all individuals and organizations are invited to educate themselves on disaster preparedness and logistics in efforts to safeguard communities from harm (Citizen Corps Council [CCC], 2011). Complementing the over 1,100 Councils operating through counties, tribes or other localities are 56 State/Territory Citizen Corps Councils (CCC, 2012). Figure F-1 shows how the councils are organized in New York State. The Citizen Corps lists five partner programs[21], an association which includes: (1) Volunteers in Police Service (VIPS), (2) Neighborhood Watch/ U.S.AonWatch, (3) the Community Emergency Response Team (CERT), (4) the Medical Reserve Corps and (5) Fire Corps. Supplementing these five partners are 27 Affiliates to the Citizen Corps. These entities, which range from the American Red Cross to Meals on Wheels, support Citizen Corps through public

[21] The number of Citizen Corps Partner Programs totals to 6,353 organizations servicing 63 percent of the national population. This figure includes 1,098 Fire Corps, 2,248 VIPS groups and 2,027 CERT teams in addition to the 980 MRC groups nationwide (CCC, 2012). In New York state, there are 24 county/tribal/local Citizen Corps Councils serving approximately 64 percent of the state's population. Supplementing these groups are a total of 145 Partner Programs within the state (36 Fire Corps, 54 VIPS groups, 24 CERT teams and 31 MRC units) (CCC, 2012). Bearing in mind the listed requisites for consideration as a Citizen Corps Affiliate, a **TRC** could likely be considered a prospective candidate for inclusion in this group (CCC, 2009).

education, and volunteer support coordination and management. One particularly significant Citizen Corps affiliate in terms of this discussion is the National Voluntary Organizations Active in Disaster (NVOAD).[22] Figure F-2 depicts this organizational structure.

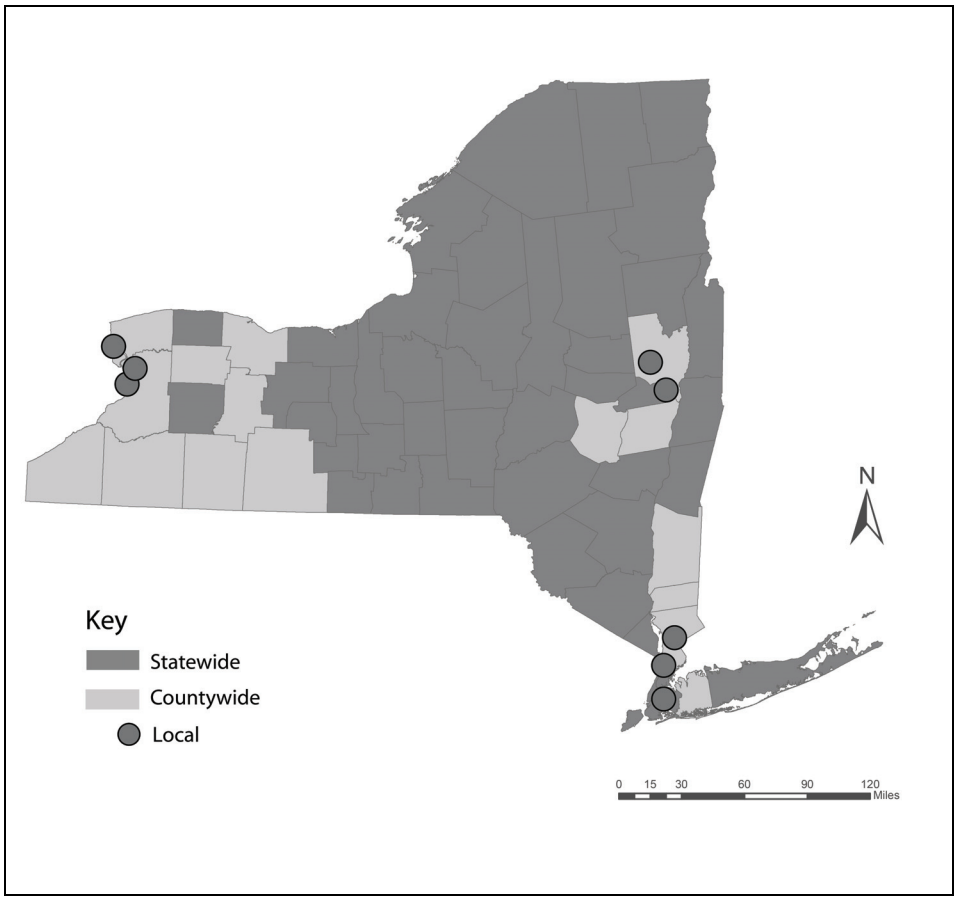


Figure F-1. New York State Citizen Corps Councils

[22] NVOAD, a 38-year old cooperative coalition of 49 national nonprofit organizations, provides disaster related services to people impacted across the nation every year (CCC, 2012). The services provided by this group, including the transportation of water and other supplies and volunteer management, may be a model for similar services of, as well as a great assistance to the proposed **TRC**. The NVOAD has satellite organizations employing its model in 5 territories and every state in the U.S. (NVOADb, 2012a). This organization is also a potential arm for a **TRC** to operate through, bearing in mind their criteria for admission (NVOAD, 2012a).

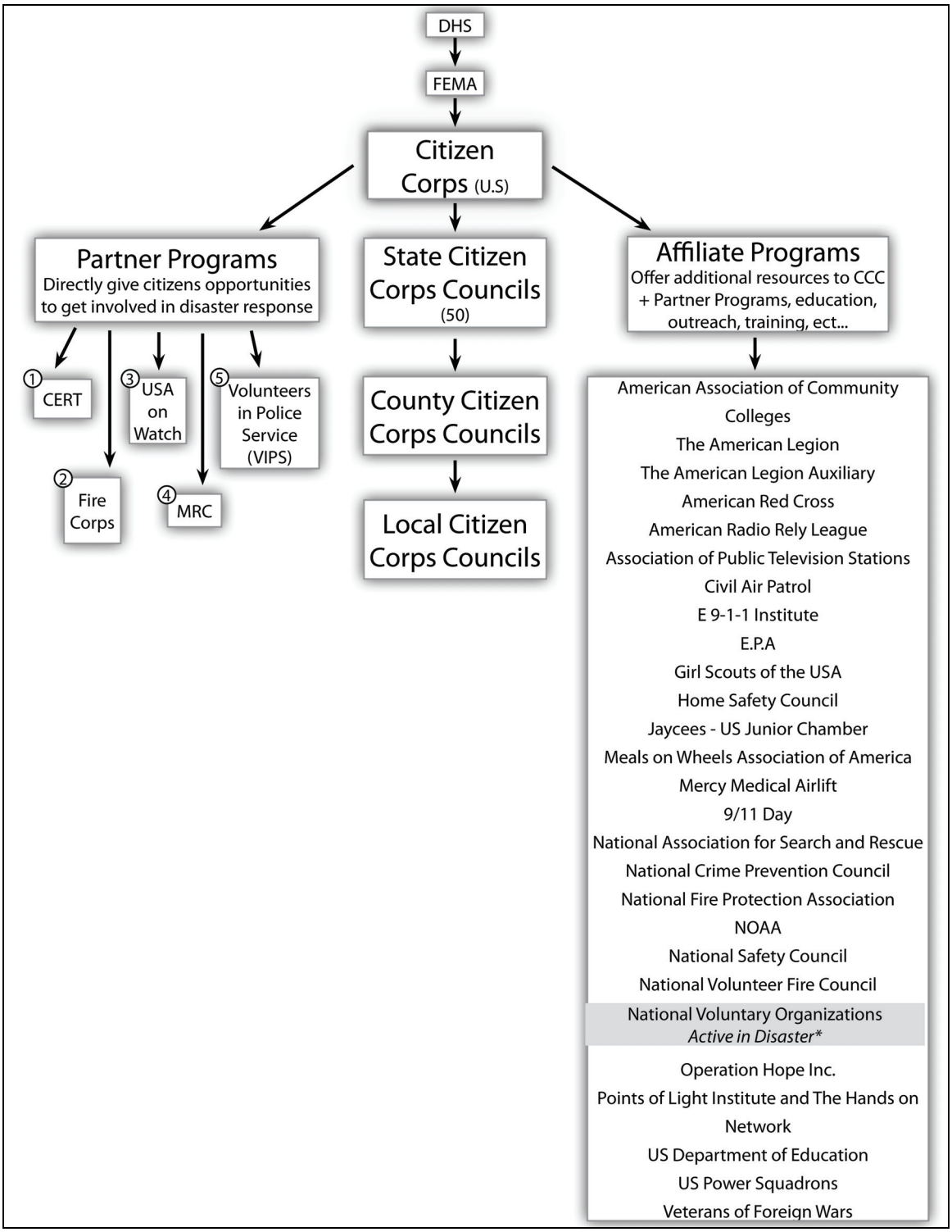


Figure F-2. Citizen Corps Organizational Structure

F.3 The Medical Reserve Corps

An Overview

Following a wide range of catastrophic events over the past decade, a network of nearly 1,000 community-based civilian groups operated by over 200,000 registered medical volunteers, known as the Medical Reserve Corps (MRC), has proven time after time the remarkably valuable potential of such volunteer organizations in emergency response (Division of the Civilian Volunteer Medical Reserve Corps [DCVMRC], 2011). As the MRC exemplifies the administrative and procedural framework required for the effective management of any volunteer emergency response organization, this organization becomes a key inspiration for a **TRC**. Thus, an overview of the MRC, its history, structure and operations, is provided here prior to outlining the future structure and procedures of a **TRC**.

History

A particularly vital piece of insight realized after the events of September 11, 2001 is the crucial need for supplemental, synchronized medical personnel during emergency response. It is also understood that generous numbers of medical professionals wished to support emergency response. In response to these realizations, the Medical Reserve Corps (MRC), a partner of the Citizen Corps program, was established under President George W. Bush in July 2002 (DCVMRC, 2011). Through this structured organization, willing medical and public health professionals may now be deployed more effectively during emergency response.

Administrative Structure of the Medical Reserve Corps

The Division of the Civilian Volunteer Medical Reserve Corps (DCVMRC)

Housed in the Office of the Surgeon General (OSG), the DCVMRC serves as the national facilitator of local MRC groups. Functioning as a clearinghouse of best practices and other resources, the DCVMRC assists in the establishment, implementation and preservation of MRC units nationwide with an objective to serve, promote, support and strengthen its network through amplified participation and improved internal capacity. Here, the hierarchical administrative framework which links the DCVMRC to broader governmental bodies as well as the internal framework that enables it to coordinate its 980 local branches are discussed. This overview, illustrated in Figure F-3, should clarify ways in which a **TRC** could mobilize its services or potentially integrate itself into an established administrative hierarchy or institution.

There is an intricate web of organizations which sponsor, oversee, assist or are otherwise affiliated with the DCVMRC. Along with the OSG which is listed as the housing organization, the DCVMRC aligns its concerns and operations with those of the Office of the Assistant Secretary for Health (OASH), the Office of the Assistant Secretary for Preparedness and Response (ASPR), and the more general Department of Health and Human Services (HHS). The DCVMRC aims to integrate with these 'customers' (defined as the central beneficiaries of DCVMRC services) to improve the effectiveness

of MRC operations. Along with these customers, the DCVMRC collaborates with numerous stakeholder organizations; including the Department of Homeland Security, public health agencies of states and localities, non-profits, faith-based organizations and academic institutions (DCVMRC, 2011).

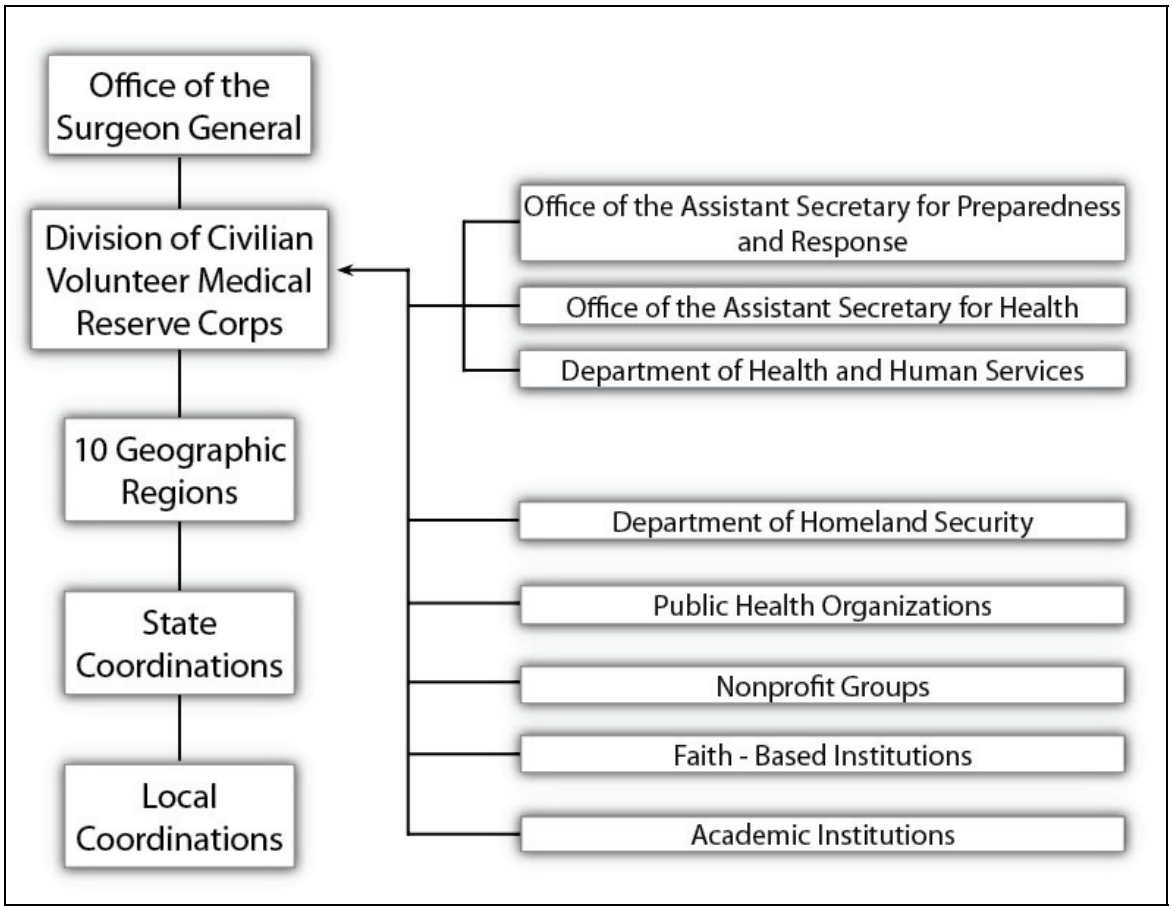


Figure F-3. Medical Reserve Corps Administrative Hierarchy

Internally, the DCVMRC is operated by a group of coordinators serving ten geographical regions that all answer to an MRC Program Director, who also holds a rank of Captain in the U.S. Public Health Service (PHS). These appointees, also Commanders in the PHS, coordinate resources and activities through enhanced communication with local and state MRC coordinators. All states staff MRC coordinators, who typically hold additional supporting positions with state departments of public health, offices of emergency services or emergency preparedness programs. These officials serve in roles ranging from volunteer coordinators or coordinators of emergency medical response to disaster planning analysts or hospital preparedness managers. The state of New York falls into the DCVMRC's Region 2 along with New Jersey, Vermont and Puerto Rico (DCVMRC, 2012).

MRC Units

MRC units are community-based organizations which enlist properly credentialed, trained medical personnel to support emergency response and promote public health year-round. While all MRC units hold the same mission of engaging volunteers in community resiliency, disaster response and public health (DCVMRC, 2011), there is no archetypal MRC unit as each caters to the community it serves. For instance, the MRC unit in Erie County, NY serves its community through two separate functions; (1) day-to-day operations and (2) large disaster response (NYSOHEP interview 2012). Enlisted volunteers consist of public health and medical professionals of all varieties as well as support staff including office workers, legal workers and interpreters. Of the 980 MRC units nationwide, 31 are in New York state (3 in the Buffalo/WNY area, and 7 in New York City region). The OSG directs MRC units to target areas where community public health infrastructure and health literacy are especially frail; in places where MRC units work towards broader goals of dissolving health disparities and increasing disease prevention (DCVMRC, 2012). Individual MRC units are housed or sponsored by separate organizations, most often locally-based (DCVMRC, 2011). MRC units often form local partnerships with related organizations, typically, emergency services, departments of health or the American Red Cross (DCVMRC, 2012).

Funding and Training of MRC Responders

To supplement government sources of funding typically provided through the Department of Homeland Security, the DCVMRC lists 59 organizations considered as potential funding sources for start-up or sustained MRC units (DCVMRC, 2012). In 2008, the National Response Framework (NRF) established the National Incident Management System (NIMS) which set standards for both online and classroom training courses required for emergency officials and certified responders. All emergency responders, regardless of position, are mandated to complete these training standards (Office of the Surgeon General, 2008). This proactive training provides all interested agencies, including the MRC, with tools for improving coordinated disaster response. Training courses are grouped based on volunteers' role (entry level, first line responders, emergency operations staff members or emergency operations managers). Often MRC units work with CERT teams for emergency response training, which also follow the NIMS framework (County of Erie Emergency Medical Services interview, 2012).

A Case Example of an MRC Unit: The Erie County SMART Team

Though it is an MRC unit and operates as such since its formation in 2001, the origin of the Erie County Specialized Medical Assistance Response Team (SMART) actually predates that of the MRC at large (County of Erie Emergence Medical Services interview, 2012). This fact coupled with the team's service area makes SMART a relative example to illustrate the inner-workings of an MRC unit.

Administrative Structure of SMART

Erie County's SMART is sponsored by two organizations; (1) the Erie County Department of Health and (2) the Department of Emergency Medicine housed at the Erie County Medical Center. Assisting a medical director, the team operates through nine sectors each having a representative on SMART's executive steering committee; (1) Communications, (2) Fatality Management, (3) Logistics, (4) Mental Health, (5) Pharmacy, (6) Spiritual Care, (7) Tactical Medicine, (8) Veterinary and (9) Treatment. Numerous affiliations of the team's representatives include the Erie County Department of Emergency Services, Erie County Department of Mental Health, the Catholic Health System, the Niagara Frontier Veterinary Society and the Dental Association of Western New York, among others. SMART also receives an endorsement from the Western New York Public Health Alliance (ECDH interview 2012).

SMART Volunteers

In total, around 450 volunteers are currently enrolled in at least one of Erie County SMART's nine operational sectors. Of these, about 100 are considered active members attending training, meetings, outreach and other events (County of Erie Emergency Medical Services interview, 2012). These volunteers may or may not be medically-trained, as logistical and support staff is in a sense just as critical to the operations of an MRC as its medical personnel. These volunteers are often recruited through university medical programs, at events (such as the county fair), or through the Western New York CERT team. Once recruited, SMART provides a simple process for both non-medical and medical volunteers to enlist their services. Volunteering medical personnel must provide the additional credential of a valid medical license in order to enroll (ECDH interview, 2012). SMART staffs a manager of volunteers to keep the records of enlisted assistants up to date and ensure they meet proper credentialing and training requirements (County of Erie Emergency Medical Services interview, 2012).

SMART Operations

There are two main functions of SMART which are devised to support public health; (1) day-to-day operations and (2) disaster medicine. SMART is self-tasked with preparation for and response to disasters large and small. Likewise, SMART has the ability to mobilize equipment, personnel and medical sites (emergency tents, etc…) when they are needed. Over the past decade, the SMART team has been deployed for events ranging from a hepatitis outbreak, the crash of Continental Airlines flight #3407 (January, 2009) and the surprise winter storm of October, 2006. During an emergency incident, if deemed necessary, SMART will be activated and instructed by the ECDH to deploy to the scene of the incident. There, SMART (which maintains a sports-utility vehicle equipped with emergency and medical supplies) will support local responders. Possibly the most valuable means of assistance SMART provides in such a situation is triage. In other words, SMART medical personnel at the scene can conduct preliminary screening of injured persons and thereby relieve hospital emergency rooms and emergency medical services who may be overwhelmed during such events. Another

task for SMART teams is to provide standby for SWAT operations (County of Erie Emergency Medical Services interview, 2012).

SMART's Volunteer Communications

SMART uses standard methods of communication, mainly email messages and phone calls but also pagers and Facebook, to keep in touch with its registered volunteers regarding day-to-day operations. In order to summon SMART volunteers to duty at times of need, the team utilizes a state-run telephone notification system, *Serve New York*, used by all medical volunteers statewide. During an emergency, volunteers log into this system via telephone and are instructed where and how to respond.

Recently, New York State modified the system to assist those who staff phones and schedule volunteers during emergencies by initiating responder profiles which can be reviewed by these phone operators. These profiles include information such as general contact info and the locations to which they have agreed to respond (County of Erie Emergency Medical Services interview, 2012).

SMART Training

In addition to member orientation and general information sessions, SMART offers several specialized training courses including: CPR, pediatric care, disaster psychology, first aid, geriatric care and radiological and chemical treatment (with online registration required to attend). At least one from this variety of courses is offered each month. Accompanying classroom courses, SMART also provides links to NIMS online training courses on its website (ECDH interview, 2012). One especially notable training program offered through SMART is afforded through an Emergency Medical Fellowship through the University at Buffalo. Here, students in their second or third year of medical school submit to a four-week rotating residency program assisting SMART. These residents provide the aforementioned crucial triage procedures which alleviate oft-stressed emergency medical services. In this way, this emergency medical fellowship is mutually beneficial, providing training for resident doctors and support for emergency medical services and SMART (County of Erie Emergency Medical Services interview, 2012).

SMART and CERT Cooperation

The relationship between county-run SMART teams and municipal CERT teams is a uniquely productive partnership. These two volunteer coalitions have been known to partner during emergency response where SMART assumes responsibility for assisting in medical care and CERT offers assistance in related tasks such as crowd control or traffic direction. As mentioned earlier, non-medical volunteers are often members of both SMART and CERT. This produces both a positive and negative effect on volunteer emergency response operations as it increases the number of volunteers overall but also leaves many volunteers with conflicted responsibilities when presented with an actual emergency (County of Erie Emergency Medical Services interview, 2012).

Funding SMART

The Erie County SMART program pursues two avenues of funding to carry out its operations; (1) grant funding and (2) donations. Grant funds are used to train volunteers and administer exercises while donations provided through outreach pay for other events such as appreciation dinners and volunteer tee-shirts. Donations are deemed to be more suitable for these purposes as they are less scrutinized than grant funds (County of Erie Emergency Medical Services interview, 2012). SMART may be a unique MRC unit in regards to funding its disaster response operations as the county has granted SMART liability coverage, making operations much more financially feasible than MRC units in other counties without such coverage. As a result, SMART is more focused on disaster response than other MRC units which likely center more of their focus on the public health side of the MRC mission (County of Erie Emergency Medical Services interview, 2012).

MCEER Technical Reports

MCEER publishes technical reports on a variety of subjects written by authors funded through MCEER. These reports are available from both MCEER Publications and the National Technical Information Service (NTIS). Requests for reports should be directed to MCEER Publications, MCEER, University at Buffalo, State University of New York, 133A Ketter Hall, Buffalo, New York 14260. Reports can also be requested through NTIS, P.O. Box 1425, Springfield, Virginia 22151. NTIS accession numbers are shown in parenthesis, if available.

NCEER-87-0001 "First-Year Program in Research, Education and Technology Transfer," 3/5/87, (PB88-134275, A04, MF-A01).

NCEER-87-0002 "Experimental Evaluation of Instantaneous Optimal Algorithms for Structural Control," by R.C. Lin, T.T. Soong and A.M. Reinhorn, 4/20/87, (PB88-134341, A04, MF-A01).

NCEER-87-0003 "Experimentation Using the Earthquake Simulation Facilities at University at Buffalo," by A.M. Reinhorn and R.L. Ketter, not available.

NCEER-87-0004 "The System Characteristics and Performance of a Shaking Table," by J.S. Hwang, K.C. Chang and G.C. Lee, 6/1/87, (PB88-134259, A03, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0005 "A Finite Element Formulation for Nonlinear Viscoplastic Material Using a Q Model," by O. Gyebi and G. Dasgupta, 11/2/87, (PB88-213764, A08, MF-A01).

NCEER-87-0006 "Symbolic Manipulation Program (SMP) - Algebraic Codes for Two and Three Dimensional Finite Element Formulations," by X. Lee and G. Dasgupta, 11/9/87, (PB88-218522, A05, MF-A01).

NCEER-87-0007 "Instantaneous Optimal Control Laws for Tall Buildings Under Seismic Excitations," by J.N. Yang, A. Akbarpour and P. Ghaemmaghami, 6/10/87, (PB88-134333, A06, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0008 "IDARC: Inelastic Damage Analysis of Reinforced Concrete Frame - Shear-Wall Structures," by Y.J. Park, A.M. Reinhorn and S.K. Kunnath, 7/20/87, (PB88-134325, A09, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0009 "Liquefaction Potential for New York State: A Preliminary Report on Sites in Manhattan and Buffalo," by M. Budhu, V. Vijayakumar, R.F. Giese and L. Baumgras, 8/31/87, (PB88-163704, A03, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0010 "Vertical and Torsional Vibration of Foundations in Inhomogeneous Media," by A.S. Veletsos and K.W. Dotson, 6/1/87, (PB88-134291, A03, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0011 "Seismic Probabilistic Risk Assessment and Seismic Margins Studies for Nuclear Power Plants," by Howard H.M. Hwang, 6/15/87, (PB88-134267, A03, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0012 "Parametric Studies of Frequency Response of Secondary Systems Under Ground-Acceleration Excitations," by Y. Yong and Y.K. Lin, 6/10/87, (PB88-134309, A03, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0013 "Frequency Response of Secondary Systems Under Seismic Excitation," by J.A. HoLung, J. Cai and Y.K. Lin, 7/31/87, (PB88-134317, A05, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0014 "Modelling Earthquake Ground Motions in Seismically Active Regions Using Parametric Time Series Methods," by G.W. Ellis and A.S. Cakmak, 8/25/87, (PB88-134283, A08, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0015 "Detection and Assessment of Seismic Structural Damage," by E. DiPasquale and A.S. Cakmak, 8/25/87, (PB88-163712, A05, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0016 "Pipeline Experiment at Parkfield, California," by J. Isenberg and E. Richardson, 9/15/87, (PB88-163720, A03, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0017 "Digital Simulation of Seismic Ground Motion," by M. Shinozuka, G. Deodatis and T. Harada, 8/31/87, (PB88-155197, A04, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0018 "Practical Considerations for Structural Control: System Uncertainty, System Time Delay and Truncation of Small Control Forces," J.N. Yang and A. Akbarpour, 8/10/87, (PB88-163738, A08, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0019 "Modal Analysis of Nonclassically Damped Structural Systems Using Canonical Transformation," by J.N. Yang, S. Sarkani and F.X. Long, 9/27/87, (PB88-187851, A04, MF-A01).

NCEER-87-0020 "A Nonstationary Solution in Random Vibration Theory," by J.R. Red-Horse and P.D. Spanos, 11/3/87, (PB88-163746, A03, MF-A01).

NCEER-87-0021 "Horizontal Impedances for Radially Inhomogeneous Viscoelastic Soil Layers," by A.S. Veletsos and K.W. Dotson, 10/15/87, (PB88-150859, A04, MF-A01).

NCEER-87-0022 "Seismic Damage Assessment of Reinforced Concrete Members," by Y.S. Chung, C. Meyer and M. Shinozuka, 10/9/87, (PB88-150867, A05, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0023 "Active Structural Control in Civil Engineering," by T.T. Soong, 11/11/87, (PB88-187778, A03, MF-A01).

NCEER-87-0024 "Vertical and Torsional Impedances for Radially Inhomogeneous Viscoelastic Soil Layers," by K.W. Dotson and A.S. Veletsos, 12/87, (PB88-187786, A03, MF-A01).

NCEER-87-0025 "Proceedings from the Symposium on Seismic Hazards, Ground Motions, Soil-Liquefaction and Engineering Practice in Eastern North America," October 20-22, 1987, edited by K.H. Jacob, 12/87, (PB88-188115, A23, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0026 "Report on the Whittier-Narrows, California, Earthquake of October 1, 1987," by J. Pantelic and A. Reinhorn, 11/87, (PB88-187752, A03, MF-A01). This report is available only through NTIS (see address given above).

NCEER-87-0027 "Design of a Modular Program for Transient Nonlinear Analysis of Large 3-D Building Structures," by S. Srivastav and J.F. Abel, 12/30/87, (PB88-187950, A05, MF-A01). This report is only available through NTIS (see address given above).

NCEER-87-0028 "Second-Year Program in Research, Education and Technology Transfer," 3/8/88, (PB88-219480, A04, MF-A01).

NCEER-88-0001 "Workshop on Seismic Computer Analysis and Design of Buildings With Interactive Graphics," by W. McGuire, J.F. Abel and C.H. Conley, 1/18/88, (PB88-187760, A03, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0002 "Optimal Control of Nonlinear Flexible Structures," by J.N. Yang, F.X. Long and D. Wong, 1/22/88, (PB88-213772, A06, MF-A01).

NCEER-88-0003 "Substructuring Techniques in the Time Domain for Primary-Secondary Structural Systems," by G.D. Manolis and G. Juhn, 2/10/88, (PB88-213780, A04, MF-A01).

NCEER-88-0004 "Iterative Seismic Analysis of Primary-Secondary Systems," by A. Singhal, L.D. Lutes and P.D. Spanos, 2/23/88, (PB88-213798, A04, MF-A01).

NCEER-88-0005 "Stochastic Finite Element Expansion for Random Media," by P.D. Spanos and R. Ghanem, 3/14/88, (PB88-213806, A03, MF-A01).

NCEER-88-0006 "Combining Structural Optimization and Structural Control," by F.Y. Cheng and C.P. Pantelides, 1/10/88, (PB88-213814, A05, MF-A01).

NCEER-88-0007 "Seismic Performance Assessment of Code-Designed Structures," by H.H-M. Hwang, J-W. Jaw and H-J. Shau, 3/20/88, (PB88-219423, A04, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0008 "Reliability Analysis of Code-Designed Structures Under Natural Hazards," by H.H-M. Hwang, H. Ushiba and M. Shinozuka, 2/29/88, (PB88-229471, A07, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0009 "Seismic Fragility Analysis of Shear Wall Structures," by J-W Jaw and H.H-M. Hwang, 4/30/88, (PB89-102867, A04, MF-A01).

NCEER-88-0010 "Base Isolation of a Multi-Story Building Under a Harmonic Ground Motion - A Comparison of Performances of Various Systems," by F-G Fan, G. Ahmadi and I.G. Tadjbakhsh, 5/18/88, (PB89-122238, A06, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0011 "Seismic Floor Response Spectra for a Combined System by Green's Functions," by F.M. Lavelle, L.A. Bergman and P.D. Spanos, 5/1/88, (PB89-102875, A03, MF-A01).

NCEER-88-0012 "A New Solution Technique for Randomly Excited Hysteretic Structures," by G.Q. Cai and Y.K. Lin, 5/16/88, (PB89-102883, A03, MF-A01).

NCEER-88-0013 "A Study of Radiation Damping and Soil-Structure Interaction Effects in the Centrifuge," by K. Weissman, supervised by J.H. Prevost, 5/24/88, (PB89-144703, A06, MF-A01).

NCEER-88-0014 "Parameter Identification and Implementation of a Kinematic Plasticity Model for Frictional Soils," by J.H. Prevost and D.V. Griffiths, not available.

NCEER-88-0015 "Two- and Three- Dimensional Dynamic Finite Element Analyses of the Long Valley Dam," by D.V. Griffiths and J.H. Prevost, 6/17/88, (PB89-144711, A04, MF-A01).

NCEER-88-0016 "Damage Assessment of Reinforced Concrete Structures in Eastern United States," by A.M. Reinhorn, M.J. Seidel, S.K. Kunnath and Y.J. Park, 6/15/88, (PB89-122220, A04, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0017 "Dynamic Compliance of Vertically Loaded Strip Foundations in Multilayered Viscoelastic Soils," by S. Ahmad and A.S.M. Israil, 6/17/88, (PB89-102891, A04, MF-A01).

NCEER-88-0018 "An Experimental Study of Seismic Structural Response With Added Viscoelastic Dampers," by R.C. Lin, Z. Liang, T.T. Soong and R.H. Zhang, 6/30/88, (PB89-122212, A05, MF-A01). This report is available only through NTIS (see address given above).

NCEER-88-0019 "Experimental Investigation of Primary - Secondary System Interaction," by G.D. Manolis, G. Juhn and A.M. Reinhorn, 5/27/88, (PB89-122204, A04, MF-A01).

NCEER-88-0020 "A Response Spectrum Approach For Analysis of Nonclassically Damped Structures," by J.N. Yang, S. Sarkani and F.X. Long, 4/22/88, (PB89-102909, A04, MF-A01).

NCEER-88-0021 "Seismic Interaction of Structures and Soils: Stochastic Approach," by A.S. Veletsos and A.M. Prasad, 7/21/88, (PB89-122196, A04, MF-A01). This report is only available through NTIS (see address given above).

NCEER-88-0022 "Identification of the Serviceability Limit State and Detection of Seismic Structural Damage," by E. DiPasquale and A.S. Cakmak, 6/15/88, (PB89-122188, A05, MF-A01). This report is available only through NTIS (see address given above).

NCEER-88-0023 "Multi-Hazard Risk Analysis: Case of a Simple Offshore Structure," by B.K. Bhartia and E.H. Vanmarcke, 7/21/88, (PB89-145213, A05, MF-A01).

NCEER-88-0024 "Automated Seismic Design of Reinforced Concrete Buildings," by Y.S. Chung, C. Meyer and M. Shinozuka, 7/5/88, (PB89-122170, A06, MF-A01). This report is available only through NTIS (see address given above).

NCEER-88-0025 "Experimental Study of Active Control of MDOF Structures Under Seismic Excitations," by L.L. Chung, R.C. Lin, T.T. Soong and A.M. Reinhorn, 7/10/88, (PB89-122600, A04, MF-A01).

NCEER-88-0026 "Earthquake Simulation Tests of a Low-Rise Metal Structure," by J.S. Hwang, K.C. Chang, G.C. Lee and R.L. Ketter, 8/1/88, (PB89-102917, A04, MF-A01).

NCEER-88-0027 "Systems Study of Urban Response and Reconstruction Due to Catastrophic Earthquakes," by F. Kozin and H.K. Zhou, 9/22/88, (PB90-162348, A04, MF-A01).

NCEER-88-0028 "Seismic Fragility Analysis of Plane Frame Structures," by H.H-M. Hwang and Y.K. Low, 7/31/88, (PB89-131445, A06, MF-A01).

NCEER-88-0029 "Response Analysis of Stochastic Structures," by A. Kardara, C. Bucher and M. Shinozuka, 9/22/88, (PB89-174429, A04, MF-A01).

NCEER-88-0030 "Nonnormal Accelerations Due to Yielding in a Primary Structure," by D.C.K. Chen and L.D. Lutes, 9/19/88, (PB89-131437, A04, MF-A01).

NCEER-88-0031 "Design Approaches for Soil-Structure Interaction," by A.S. Veletsos, A.M. Prasad and Y. Tang, 12/30/88, (PB89-174437, A03, MF-A01). This report is available only through NTIS (see address given above).

NCEER-88-0032 "A Re-evaluation of Design Spectra for Seismic Damage Control," by C.J. Turkstra and A.G. Tallin, 11/7/88, (PB89-145221, A05, MF-A01).

NCEER-88-0033 "The Behavior and Design of Noncontact Lap Splices Subjected to Repeated Inelastic Tensile Loading," by V.E. Sagan, P. Gergely and R.N. White, 12/8/88, (PB89-163737, A08, MF-A01).

NCEER-88-0034 "Seismic Response of Pile Foundations," by S.M. Mamoon, P.K. Banerjee and S. Ahmad, 11/1/88, (PB89-145239, A04, MF-A01).

NCEER-88-0035 "Modeling of R/C Building Structures With Flexible Floor Diaphragms (IDARC2)," by A.M. Reinhorn, S.K. Kunnath and N. Panahshahi, 9/7/88, (PB89-207153, A07, MF-A01).

NCEER-88-0036 "Solution of the Dam-Reservoir Interaction Problem Using a Combination of FEM, BEM with Particular Integrals, Modal Analysis, and Substructuring," by C-S. Tsai, G.C. Lee and R.L. Ketter, 12/31/88, (PB89-207146, A04, MF-A01).

NCEER-88-0037 "Optimal Placement of Actuators for Structural Control," by F.Y. Cheng and C.P. Pantelides, 8/15/88, (PB89-162846, A05, MF-A01).

NCEER-88-0038 "Teflon Bearings in Aseismic Base Isolation: Experimental Studies and Mathematical Modeling," by A. Mokha, M.C. Constantinou and A.M. Reinhorn, 12/5/88, (PB89-218457, A10, MF-A01). This report is available only through NTIS (see address given above).

NCEER-88-0039 "Seismic Behavior of Flat Slab High-Rise Buildings in the New York City Area," by P. Weidlinger and M. Ettouney, 10/15/88, (PB90-145681, A04, MF-A01).

NCEER-88-0040 "Evaluation of the Earthquake Resistance of Existing Buildings in New York City," by P. Weidlinger and M. Ettouney, 10/15/88, not available.

NCEER-88-0041 "Small-Scale Modeling Techniques for Reinforced Concrete Structures Subjected to Seismic Loads," by W. Kim, A. El-Attar and R.N. White, 11/22/88, (PB89-189625, A05, MF-A01).

NCEER-88-0042 "Modeling Strong Ground Motion from Multiple Event Earthquakes," by G.W. Ellis and A.S. Cakmak, 10/15/88, (PB89-174445, A03, MF-A01).

NCEER-88-0043 "Nonstationary Models of Seismic Ground Acceleration," by M. Grigoriu, S.E. Ruiz and E. Rosenblueth, 7/15/88, (PB89-189617, A04, MF-A01).

NCEER-88-0044 "SARCF User's Guide: Seismic Analysis of Reinforced Concrete Frames," by Y.S. Chung, C. Meyer and M. Shinozuka, 11/9/88, (PB89-174452, A08, MF-A01).

NCEER-88-0045 "First Expert Panel Meeting on Disaster Research and Planning," edited by J. Pantelic and J. Stoyle, 9/15/88, (PB89-174460, A05, MF-A01).

NCEER-88-0046 "Preliminary Studies of the Effect of Degrading Infill Walls on the Nonlinear Seismic Response of Steel Frames," by C.Z. Chrysostomou, P. Gergely and J.F. Abel, 12/19/88, (PB89-208383, A05, MF-A01).

NCEER-88-0047 "Reinforced Concrete Frame Component Testing Facility - Design, Construction, Instrumentation and Operation," by S.P. Pessiki, C. Conley, T. Bond, P. Gergely and R.N. White, 12/16/88, (PB89-174478, A04, MF-A01).

NCEER-89-0001 "Effects of Protective Cushion and Soil Compliancy on the Response of Equipment Within a Seismically Excited Building," by J.A. HoLung, 2/16/89, (PB89-207179, A04, MF-A01).

NCEER-89-0002 "Statistical Evaluation of Response Modification Factors for Reinforced Concrete Structures," by H.H-M. Hwang and J-W. Jaw, 2/17/89, (PB89-207187, A05, MF-A01).

NCEER-89-0003 "Hysteretic Columns Under Random Excitation," by G-Q. Cai and Y.K. Lin, 1/9/89, (PB89-196513, A03, MF-A01).

NCEER-89-0004 "Experimental Study of `Elephant Foot Bulge' Instability of Thin-Walled Metal Tanks," by Z-H. Jia and R.L. Ketter, 2/22/89, (PB89-207195, A03, MF-A01).

NCEER-89-0005 "Experiment on Performance of Buried Pipelines Across San Andreas Fault," by J. Isenberg, E. Richardson and T.D. O'Rourke, 3/10/89, (PB89-218440, A04, MF-A01). This report is available only through NTIS (see address given above).

NCEER-89-0006 "A Knowledge-Based Approach to Structural Design of Earthquake-Resistant Buildings," by M. Subramani, P. Gergely, C.H. Conley, J.F. Abel and A.H. Zaghw, 1/15/89, (PB89-218465, A06, MF-A01).

NCEER-89-0007 "Liquefaction Hazards and Their Effects on Buried Pipelines," by T.D. O'Rourke and P.A. Lane, 2/1/89, (PB89-218481, A09, MF-A01).

NCEER-89-0008 "Fundamentals of System Identification in Structural Dynamics," by H. Imai, C-B. Yun, O. Maruyama and M. Shinozuka, 1/26/89, (PB89-207211, A04, MF-A01).

NCEER-89-0009 "Effects of the 1985 Michoacan Earthquake on Water Systems and Other Buried Lifelines in Mexico," by A.G. Ayala and M.J. O'Rourke, 3/8/89, (PB89-207229, A06, MF-A01).

NCEER-89-R010 "NCEER Bibliography of Earthquake Education Materials," by K.E.K. Ross, Second Revision, 9/1/89, (PB90-125352, A05, MF-A01). This report is replaced by NCEER-92-0018.

NCEER-89-0011 "Inelastic Three-Dimensional Response Analysis of Reinforced Concrete Building Structures (IDARC-3D), Part I - Modeling," by S.K. Kunnath and A.M. Reinhorn, 4/17/89, (PB90-114612, A07, MF-A01). This report is available only through NTIS (see address given above).

NCEER-89-0012 "Recommended Modifications to ATC-14," by C.D. Poland and J.O. Malley, 4/12/89, (PB90-108648, A15, MF-A01).

NCEER-89-0013 "Repair and Strengthening of Beam-to-Column Connections Subjected to Earthquake Loading," by M. Corazao and A.J. Durrani, 2/28/89, (PB90-109885, A06, MF-A01).

NCEER-89-0014 "Program EXKAL2 for Identification of Structural Dynamic Systems," by O. Maruyama, C-B. Yun, M. Hoshiya and M. Shinozuka, 5/19/89, (PB90-109877, A09, MF-A01).

NCEER-89-0015 "Response of Frames With Bolted Semi-Rigid Connections, Part I - Experimental Study and Analytical Predictions," by P.J. DiCorso, A.M. Reinhorn, J.R. Dickerson, J.B. Radziminski and W.L. Harper, 6/1/89, not available.

NCEER-89-0016 "ARMA Monte Carlo Simulation in Probabilistic Structural Analysis," by P.D. Spanos and M.P. Mignolet, 7/10/89, (PB90-109893, A03, MF-A01).

NCEER-89-P017 "Preliminary Proceedings from the Conference on Disaster Preparedness - The Place of Earthquake Education in Our Schools," Edited by K.E.K. Ross, 6/23/89, (PB90-108606, A03, MF-A01).

NCEER-89-0017 "Proceedings from the Conference on Disaster Preparedness - The Place of Earthquake Education in Our Schools," Edited by K.E.K. Ross, 12/31/89, (PB90-207895, A012, MF-A02). This report is available only through NTIS (see address given above).

NCEER-89-0018 "Multidimensional Models of Hysteretic Material Behavior for Vibration Analysis of Shape Memory Energy Absorbing Devices, by E.J. Graesser and F.A. Cozzarelli, 6/7/89, (PB90-164146, A04, MF-A01).

NCEER-89-0019 "Nonlinear Dynamic Analysis of Three-Dimensional Base Isolated Structures (3D-BASIS)," by S. Nagarajaiah, A.M. Reinhorn and M.C. Constantinou, 8/3/89, (PB90-161936, A06, MF-A01). This report has been replaced by NCEER-93-0011.

NCEER-89-0020 "Structural Control Considering Time-Rate of Control Forces and Control Rate Constraints," by F.Y. Cheng and C.P. Pantelides, 8/3/89, (PB90-120445, A04, MF-A01).

NCEER-89-0021 "Subsurface Conditions of Memphis and Shelby County," by K.W. Ng, T-S. Chang and H-H.M. Hwang, 7/26/89, (PB90-120437, A03, MF-A01).

NCEER-89-0022 "Seismic Wave Propagation Effects on Straight Jointed Buried Pipelines," by K. Elhmadi and M.J. O'Rourke, 8/24/89, (PB90-162322, A10, MF-A02).

NCEER-89-0023 "Workshop on Serviceability Analysis of Water Delivery Systems," edited by M. Grigoriu, 3/6/89, (PB90-127424, A03, MF-A01).

NCEER-89-0024 "Shaking Table Study of a 1/5 Scale Steel Frame Composed of Tapered Members," by K.C. Chang, J.S. Hwang and G.C. Lee, 9/18/89, (PB90-160169, A04, MF-A01).

NCEER-89-0025 "DYNA1D: A Computer Program for Nonlinear Seismic Site Response Analysis - Technical Documentation," by Jean H. Prevost, 9/14/89, (PB90-161944, A07, MF-A01). This report is available only through NTIS (see address given above).

NCEER-89-0026 "1:4 Scale Model Studies of Active Tendon Systems and Active Mass Dampers for Aseismic Protection," by A.M. Reinhorn, T.T. Soong, R.C. Lin, Y.P. Yang, Y. Fukao, H. Abe and M. Nakai, 9/15/89, (PB90-173246, A10, MF-A02). This report is available only through NTIS (see address given above).

NCEER-89-0027 "Scattering of Waves by Inclusions in a Nonhomogeneous Elastic Half Space Solved by Boundary Element Methods," by P.K. Hadley, A. Askar and A.S. Cakmak, 6/15/89, (PB90-145699, A07, MF-A01).

NCEER-89-0028 "Statistical Evaluation of Deflection Amplification Factors for Reinforced Concrete Structures," by H.H.M. Hwang, J-W. Jaw and A.L. Ch'ng, 8/31/89, (PB90-164633, A05, MF-A01).

NCEER-89-0029 "Bedrock Accelerations in Memphis Area Due to Large New Madrid Earthquakes," by H.H.M. Hwang, C.H.S. Chen and G. Yu, 11/7/89, (PB90-162330, A04, MF-A01).

NCEER-89-0030 "Seismic Behavior and Response Sensitivity of Secondary Structural Systems," by Y.Q. Chen and T.T. Soong, 10/23/89, (PB90-164658, A08, MF-A01).

NCEER-89-0031 "Random Vibration and Reliability Analysis of Primary-Secondary Structural Systems," by Y. Ibrahim, M. Grigoriu and T.T. Soong, 11/10/89, (PB90-161951, A04, MF-A01).

NCEER-89-0032 "Proceedings from the Second U.S. - Japan Workshop on Liquefaction, Large Ground Deformation and Their Effects on Lifelines, September 26-29, 1989," Edited by T.D. O'Rourke and M. Hamada, 12/1/89, (PB90-209388, A22, MF-A03).

NCEER-89-0033 "Deterministic Model for Seismic Damage Evaluation of Reinforced Concrete Structures," by J.M. Bracci, A.M. Reinhorn, J.B. Mander and S.K. Kunnath, 9/27/89, (PB91-108803, A06, MF-A01).

NCEER-89-0034 "On the Relation Between Local and Global Damage Indices," by E. DiPasquale and A.S. Cakmak, 8/15/89, (PB90-173865, A05, MF-A01).

NCEER-89-0035 "Cyclic Undrained Behavior of Nonplastic and Low Plasticity Silts," by A.J. Walker and H.E. Stewart, 7/26/89, (PB90-183518, A10, MF-A01).

NCEER-89-0036 "Liquefaction Potential of Surficial Deposits in the City of Buffalo, New York," by M. Budhu, R. Giese and L. Baumgrass, 1/17/89, (PB90-208455, A04, MF-A01).

NCEER-89-0037 "A Deterministic Assessment of Effects of Ground Motion Incoherence," by A.S. Veletsos and Y. Tang, 7/15/89, (PB90-164294, A03, MF-A01).

NCEER-89-0038 "Workshop on Ground Motion Parameters for Seismic Hazard Mapping," July 17-18, 1989, edited by R.V. Whitman, 12/1/89, (PB90-173923, A04, MF-A01).

NCEER-89-0039 "Seismic Effects on Elevated Transit Lines of the New York City Transit Authority," by C.J. Costantino, C.A. Miller and E. Heymsfield, 12/26/89, (PB90-207887, A06, MF-A01).

NCEER-89-0040 "Centrifugal Modeling of Dynamic Soil-Structure Interaction," by K. Weissman, Supervised by J.H. Prevost, 5/10/89, (PB90-207879, A07, MF-A01).

NCEER-89-0041 "Linearized Identification of Buildings With Cores for Seismic Vulnerability Assessment," by I-K. Ho and A.E. Aktan, 11/1/89, (PB90-251943, A07, MF-A01).

NCEER-90-0001 "Geotechnical and Lifeline Aspects of the October 17, 1989 Loma Prieta Earthquake in San Francisco," by T.D. O'Rourke, H.E. Stewart, F.T. Blackburn and T.S. Dickerman, 1/90, (PB90-208596, A05, MF-A01).

NCEER-90-0002 "Nonnormal Secondary Response Due to Yielding in a Primary Structure," by D.C.K. Chen and L.D. Lutes, 2/28/90, (PB90-251976, A07, MF-A01).

NCEER-90-0003 "Earthquake Education Materials for Grades K-12," by K.E.K. Ross, 4/16/90, (PB91-251984, A05, MF-A05). This report has been replaced by NCEER-92-0018.

NCEER-90-0004 "Catalog of Strong Motion Stations in Eastern North America," by R.W. Busby, 4/3/90, (PB90-251984, A05, MF-A01).

NCEER-90-0005 "NCEER Strong-Motion Data Base: A User Manual for the GeoBase Release (Version 1.0 for the Sun3)," by P. Friberg and K. Jacob, 3/31/90 (PB90-258062, A04, MF-A01).

NCEER-90-0006 "Seismic Hazard Along a Crude Oil Pipeline in the Event of an 1811-1812 Type New Madrid Earthquake," by H.H.M. Hwang and C-H.S. Chen, 4/16/90, (PB90-258054, A04, MF-A01).

NCEER-90-0007 "Site-Specific Response Spectra for Memphis Sheahan Pumping Station," by H.H.M. Hwang and C.S. Lee, 5/15/90, (PB91-108811, A05, MF-A01).

NCEER-90-0008 "Pilot Study on Seismic Vulnerability of Crude Oil Transmission Systems," by T. Ariman, R. Dobry, M. Grigoriu, F. Kozin, M. O'Rourke, T. O'Rourke and M. Shinozuka, 5/25/90, (PB91-108837, A06, MF-A01).

NCEER-90-0009 "A Program to Generate Site Dependent Time Histories: EQGEN," by G.W. Ellis, M. Srinivasan and A.S. Cakmak, 1/30/90, (PB91-108829, A04, MF-A01).

NCEER-90-0010 "Active Isolation for Seismic Protection of Operating Rooms," by M.E. Talbott, Supervised by M. Shinozuka, 6/8/9, (PB91-110205, A05, MF-A01).

NCEER-90-0011 "Program LINEARID for Identification of Linear Structural Dynamic Systems," by C-B. Yun and M. Shinozuka, 6/25/90, (PB91-110312, A08, MF-A01).

NCEER-90-0012 "Two-Dimensional Two-Phase Elasto-Plastic Seismic Response of Earth Dams," by A.N. Yiagos, Supervised by J.H. Prevost, 6/20/90, (PB91-110197, A13, MF-A02).

NCEER-90-0013 "Secondary Systems in Base-Isolated Structures: Experimental Investigation, Stochastic Response and Stochastic Sensitivity," by G.D. Manolis, G. Juhn, M.C. Constantinou and A.M. Reinhorn, 7/1/90, (PB91-110320, A08, MF-A01).

NCEER-90-0014 "Seismic Behavior of Lightly-Reinforced Concrete Column and Beam-Column Joint Details," by S.P. Pessiki, C.H. Conley, P. Gergely and R.N. White, 8/22/90, (PB91-108795, A11, MF-A02).

NCEER-90-0015 "Two Hybrid Control Systems for Building Structures Under Strong Earthquakes," by J.N. Yang and A. Danielians, 6/29/90, (PB91-125393, A04, MF-A01).

NCEER-90-0016 "Instantaneous Optimal Control with Acceleration and Velocity Feedback," by J.N. Yang and Z. Li, 6/29/90, (PB91-125401, A03, MF-A01).

NCEER-90-0017 "Reconnaissance Report on the Northern Iran Earthquake of June 21, 1990," by M. Mehrain, 10/4/90, (PB91-125377, A03, MF-A01).

NCEER-90-0018 "Evaluation of Liquefaction Potential in Memphis and Shelby County," by T.S. Chang, P.S. Tang, C.S. Lee and H. Hwang, 8/10/90, (PB91-125427, A09, MF-A01).

NCEER-90-0019 "Experimental and Analytical Study of a Combined Sliding Disc Bearing and Helical Steel Spring Isolation System," by M.C. Constantinou, A.S. Mokha and A.M. Reinhorn, 10/4/90, (PB91-125385, A06, MF-A01). This report is available only through NTIS (see address given above).

NCEER-90-0020 "Experimental Study and Analytical Prediction of Earthquake Response of a Sliding Isolation System with a Spherical Surface," by A.S. Mokha, M.C. Constantinou and A.M. Reinhorn, 10/11/90, (PB91-125419, A05, MF-A01).

NCEER-90-0021 "Dynamic Interaction Factors for Floating Pile Groups," by G. Gazetas, K. Fan, A. Kaynia and E. Kausel, 9/10/90, (PB91-170381, A05, MF-A01).

NCEER-90-0022 "Evaluation of Seismic Damage Indices for Reinforced Concrete Structures," by S. Rodriguez-Gomez and A.S. Cakmak, 9/30/90, PB91-171322, A06, MF-A01).

NCEER-90-0023 "Study of Site Response at a Selected Memphis Site," by H. Desai, S. Ahmad, E.S. Gazetas and M.R. Oh, 10/11/90, (PB91-196857, A03, MF-A01).

NCEER-90-0024 "A User's Guide to Strongmo: Version 1.0 of NCEER's Strong-Motion Data Access Tool for PCs and Terminals," by P.A. Friberg and C.A.T. Susch, 11/15/90, (PB91-171272, A03, MF-A01).

NCEER-90-0025 "A Three-Dimensional Analytical Study of Spatial Variability of Seismic Ground Motions," by L-L. Hong and A.H.-S. Ang, 10/30/90, (PB91-170399, A09, MF-A01).

NCEER-90-0026 "MUMOID User's Guide - A Program for the Identification of Modal Parameters," by S. Rodriguez-Gomez and E. DiPasquale, 9/30/90, (PB91-171298, A04, MF-A01).

NCEER-90-0027 "SARCF-II User's Guide - Seismic Analysis of Reinforced Concrete Frames," by S. Rodriguez-Gomez, Y.S. Chung and C. Meyer, 9/30/90, (PB91-171280, A05, MF-A01).

NCEER-90-0028 "Viscous Dampers: Testing, Modeling and Application in Vibration and Seismic Isolation," by N. Makris and M.C. Constantinou, 12/20/90 (PB91-190561, A06, MF-A01).

NCEER-90-0029 "Soil Effects on Earthquake Ground Motions in the Memphis Area," by H. Hwang, C.S. Lee, K.W. Ng and T.S. Chang, 8/2/90, (PB91-190751, A05, MF-A01).

NCEER-91-0001 "Proceedings from the Third Japan-U.S. Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures for Soil Liquefaction, December 17-19, 1990," edited by T.D. O'Rourke and M. Hamada, 2/1/91, (PB91-179259, A99, MF-A04).

NCEER-91-0002 "Physical Space Solutions of Non-Proportionally Damped Systems," by M. Tong, Z. Liang and G.C. Lee, 1/15/91, (PB91-179242, A04, MF-A01).

NCEER-91-0003 "Seismic Response of Single Piles and Pile Groups," by K. Fan and G. Gazetas, 1/10/91, (PB92-174994, A04, MF-A01).

NCEER-91-0004 "Damping of Structures: Part 1 - Theory of Complex Damping," by Z. Liang and G. Lee, 10/10/91, (PB92-197235, A12, MF-A03).

NCEER-91-0005 "3D-BASIS - Nonlinear Dynamic Analysis of Three Dimensional Base Isolated Structures: Part II," by S. Nagarajaiah, A.M. Reinhorn and M.C. Constantinou, 2/28/91, (PB91-190553, A07, MF-A01). This report has been replaced by NCEER-93-0011.

NCEER-91-0006 "A Multidimensional Hysteretic Model for Plasticity Deforming Metals in Energy Absorbing Devices," by E.J. Graesser and F.A. Cozzarelli, 4/9/91, (PB92-108364, A04, MF-A01).

NCEER-91-0007 "A Framework for Customizable Knowledge-Based Expert Systems with an Application to a KBES for Evaluating the Seismic Resistance of Existing Buildings," by E.G. Ibarra-Anaya and S.J. Fenves, 4/9/91, (PB91-210930, A08, MF-A01).

NCEER-91-0008 "Nonlinear Analysis of Steel Frames with Semi-Rigid Connections Using the Capacity Spectrum Method," by G.G. Deierlein, S-H. Hsieh, Y-J. Shen and J.F. Abel, 7/2/91, (PB92-113828, A05, MF-A01).

NCEER-91-0009 "Earthquake Education Materials for Grades K-12," by K.E.K. Ross, 4/30/91, (PB91-212142, A06, MF-A01). This report has been replaced by NCEER-92-0018.

NCEER-91-0010 "Phase Wave Velocities and Displacement Phase Differences in a Harmonically Oscillating Pile," by N. Makris and G. Gazetas, 7/8/91, (PB92-108356, A04, MF-A01).

NCEER-91-0011 "Dynamic Characteristics of a Full-Size Five-Story Steel Structure and a 2/5 Scale Model," by K.C. Chang, G.C. Yao, G.C. Lee, D.S. Hao and Y.C. Yeh," 7/2/91, (PB93-116648, A06, MF-A02).

NCEER-91-0012 "Seismic Response of a 2/5 Scale Steel Structure with Added Viscoelastic Dampers," by K.C. Chang, T.T. Soong, S-T. Oh and M.L. Lai, 5/17/91, (PB92-110816, A05, MF-A01).

NCEER-91-0013 "Earthquake Response of Retaining Walls; Full-Scale Testing and Computational Modeling," by S. Alampalli and A-W.M. Elgamal, 6/20/91, not available.

NCEER-91-0014 "3D-BASIS-M: Nonlinear Dynamic Analysis of Multiple Building Base Isolated Structures," by P.C. Tsopelas, S. Nagarajaiah, M.C. Constantinou and A.M. Reinhorn, 5/28/91, (PB92-113885, A09, MF-A02).

NCEER-91-0015 "Evaluation of SEAOC Design Requirements for Sliding Isolated Structures," by D. Theodossiou and M.C. Constantinou, 6/10/91, (PB92-114602, A11, MF-A03).

NCEER-91-0016 "Closed-Loop Modal Testing of a 27-Story Reinforced Concrete Flat Plate-Core Building," by H.R. Somaprasad, T. Toksoy, H. Yoshiyuki and A.E. Aktan, 7/15/91, (PB92-129980, A07, MF-A02).

NCEER-91-0017 "Shake Table Test of a 1/6 Scale Two-Story Lightly Reinforced Concrete Building," by A.G. El-Attar, R.N. White and P. Gergely, 2/28/91, (PB92-222447, A06, MF-A02).

NCEER-91-0018 "Shake Table Test of a 1/8 Scale Three-Story Lightly Reinforced Concrete Building," by A.G. El-Attar, R.N. White and P. Gergely, 2/28/91, (PB93-116630, A08, MF-A02).

NCEER-91-0019 "Transfer Functions for Rigid Rectangular Foundations," by A.S. Veletsos, A.M. Prasad and W.H. Wu, 7/31/91, not available.

NCEER-91-0020 "Hybrid Control of Seismic-Excited Nonlinear and Inelastic Structural Systems," by J.N. Yang, Z. Li and A. Danielians, 8/1/91, (PB92-143171, A06, MF-A02).

NCEER-91-0021 "The NCEER-91 Earthquake Catalog: Improved Intensity-Based Magnitudes and Recurrence Relations for U.S. Earthquakes East of New Madrid," by L. Seeber and J.G. Armbruster, 8/28/91, (PB92-176742, A06, MF-A02).

NCEER-91-0022 "Proceedings from the Implementation of Earthquake Planning and Education in Schools: The Need for Change - The Roles of the Changemakers," by K.E.K. Ross and F. Winslow, 7/23/91, (PB92-129998, A12, MF-A03).

NCEER-91-0023 "A Study of Reliability-Based Criteria for Seismic Design of Reinforced Concrete Frame Buildings," by H.H.M. Hwang and H-M. Hsu, 8/10/91, (PB92-140235, A09, MF-A02).

NCEER-91-0024 "Experimental Verification of a Number of Structural System Identification Algorithms," by R.G. Ghanem, H. Gavin and M. Shinozuka, 9/18/91, (PB92-176577, A18, MF-A04).

NCEER-91-0025 "Probabilistic Evaluation of Liquefaction Potential," by H.H.M. Hwang and C.S. Lee," 11/25/91, (PB92-143429, A05, MF-A01).

NCEER-91-0026 "Instantaneous Optimal Control for Linear, Nonlinear and Hysteretic Structures - Stable Controllers," by J.N. Yang and Z. Li, 11/15/91, (PB92-163807, A04, MF-A01).

NCEER-91-0027 "Experimental and Theoretical Study of a Sliding Isolation System for Bridges," by M.C. Constantinou, A. Kartoum, A.M. Reinhorn and P. Bradford, 11/15/91, (PB92-176973, A10, MF-A03).

NCEER-92-0001 "Case Studies of Liquefaction and Lifeline Performance During Past Earthquakes, Volume 1: Japanese Case Studies," Edited by M. Hamada and T. O'Rourke, 2/17/92, (PB92-197243, A18, MF-A04).

NCEER-92-0002 "Case Studies of Liquefaction and Lifeline Performance During Past Earthquakes, Volume 2: United States Case Studies," Edited by T. O'Rourke and M. Hamada, 2/17/92, (PB92-197250, A20, MF-A04).

NCEER-92-0003 "Issues in Earthquake Education," Edited by K. Ross, 2/3/92, (PB92-222389, A07, MF-A02).

NCEER-92-0004 "Proceedings from the First U.S. - Japan Workshop on Earthquake Protective Systems for Bridges," Edited by I.G. Buckle, 2/4/92, (PB94-142239, A99, MF-A06).

NCEER-92-0005 "Seismic Ground Motion from a Haskell-Type Source in a Multiple-Layered Half-Space," A.P. Theoharis, G. Deodatis and M. Shinozuka, 1/2/92, not available.

NCEER-92-0006 "Proceedings from the Site Effects Workshop," Edited by R. Whitman, 2/29/92, (PB92-197201, A04, MF-A01).

NCEER-92-0007 "Engineering Evaluation of Permanent Ground Deformations Due to Seismically-Induced Liquefaction," by M.H. Baziar, R. Dobry and A-W.M. Elgamal, 3/24/92, (PB92-222421, A13, MF-A03).

NCEER-92-0008 "A Procedure for the Seismic Evaluation of Buildings in the Central and Eastern United States," by C.D. Poland and J.O. Malley, 4/2/92, (PB92-222439, A20, MF-A04).

NCEER-92-0009 "Experimental and Analytical Study of a Hybrid Isolation System Using Friction Controllable Sliding Bearings," by M.Q. Feng, S. Fujii and M. Shinozuka, 5/15/92, (PB93-150282, A06, MF-A02).

NCEER-92-0010 "Seismic Resistance of Slab-Column Connections in Existing Non-Ductile Flat-Plate Buildings," by A.J. Durrani and Y. Du, 5/18/92, (PB93-116812, A06, MF-A02).

NCEER-92-0011 "The Hysteretic and Dynamic Behavior of Brick Masonry Walls Upgraded by Ferrocement Coatings Under Cyclic Loading and Strong Simulated Ground Motion," by H. Lee and S.P. Prawel, 5/11/92, not available.

NCEER-92-0012 "Study of Wire Rope Systems for Seismic Protection of Equipment in Buildings," by G.F. Demetriades, M.C. Constantinou and A.M. Reinhorn, 5/20/92, (PB93-116655, A08, MF-A02).

NCEER-92-0013 "Shape Memory Structural Dampers: Material Properties, Design and Seismic Testing," by P.R. Witting and F.A. Cozzarelli, 5/26/92, (PB93-116663, A05, MF-A01).

NCEER-92-0014 "Longitudinal Permanent Ground Deformation Effects on Buried Continuous Pipelines," by M.J. O'Rourke, and C. Nordberg, 6/15/92, (PB93-116671, A08, MF-A02).

NCEER-92-0015 "A Simulation Method for Stationary Gaussian Random Functions Based on the Sampling Theorem," by M. Grigoriu and S. Balopoulou, 6/11/92, (PB93-127496, A05, MF-A01).

NCEER-92-0016 "Gravity-Load-Designed Reinforced Concrete Buildings: Seismic Evaluation of Existing Construction and Detailing Strategies for Improved Seismic Resistance," by G.W. Hoffmann, S.K. Kunnath, A.M. Reinhorn and J.B. Mander, 7/15/92, (PB94-142007, A08, MF-A02).

NCEER-92-0017 "Observations on Water System and Pipeline Performance in the Limón Area of Costa Rica Due to the April 22, 1991 Earthquake," by M. O'Rourke and D. Ballantyne, 6/30/92, (PB93-126811, A06, MF-A02).

NCEER-92-0018 "Fourth Edition of Earthquake Education Materials for Grades K-12," Edited by K.E.K. Ross, 8/10/92, (PB93-114023, A07, MF-A02).

NCEER-92-0019 "Proceedings from the Fourth Japan-U.S. Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures for Soil Liquefaction," Edited by M. Hamada and T.D. O'Rourke, 8/12/92, (PB93-163939, A99, MF-E11).

NCEER-92-0020 "Active Bracing System: A Full Scale Implementation of Active Control," by A.M. Reinhorn, T.T. Soong, R.C. Lin, M.A. Riley, Y.P. Wang, S. Aizawa and M. Higashino, 8/14/92, (PB93-127512, A06, MF-A02).

NCEER-92-0021 "Empirical Analysis of Horizontal Ground Displacement Generated by Liquefaction-Induced Lateral Spreads," by S.F. Bartlett and T.L. Youd, 8/17/92, (PB93-188241, A06, MF-A02).

NCEER-92-0022 "IDARC Version 3.0: Inelastic Damage Analysis of Reinforced Concrete Structures," by S.K. Kunnath, A.M. Reinhorn and R.F. Lobo, 8/31/92, (PB93-227502, A07, MF-A02).

NCEER-92-0023 "A Semi-Empirical Analysis of Strong-Motion Peaks in Terms of Seismic Source, Propagation Path and Local Site Conditions, by M. Kamiyama, M.J. O'Rourke and R. Flores-Berrones, 9/9/92, (PB93-150266, A08, MF-A02).

NCEER-92-0024 "Seismic Behavior of Reinforced Concrete Frame Structures with Nonductile Details, Part I: Summary of Experimental Findings of Full Scale Beam-Column Joint Tests," by A. Beres, R.N. White and P. Gergely, 9/30/92, (PB93-227783, A05, MF-A01).

NCEER-92-0025 "Experimental Results of Repaired and Retrofitted Beam-Column Joint Tests in Lightly Reinforced Concrete Frame Buildings," by A. Beres, S. El-Borgi, R.N. White and P. Gergely, 10/29/92, (PB93-227791, A05, MF-A01).

NCEER-92-0026 "A Generalization of Optimal Control Theory: Linear and Nonlinear Structures," by J.N. Yang, Z. Li and S. Vongchavalitkul, 11/2/92, (PB93-188621, A05, MF-A01).

NCEER-92-0027 "Seismic Resistance of Reinforced Concrete Frame Structures Designed Only for Gravity Loads: Part I - Design and Properties of a One-Third Scale Model Structure," by J.M. Bracci, A.M. Reinhorn and J.B. Mander, 12/1/92, (PB94-104502, A08, MF-A02).

NCEER-92-0028 "Seismic Resistance of Reinforced Concrete Frame Structures Designed Only for Gravity Loads: Part II - Experimental Performance of Subassemblages," by L.E. Aycardi, J.B. Mander and A.M. Reinhorn, 12/1/92, (PB94-104510, A08, MF-A02).

NCEER-92-0029 "Seismic Resistance of Reinforced Concrete Frame Structures Designed Only for Gravity Loads: Part III - Experimental Performance and Analytical Study of a Structural Model," by J.M. Bracci, A.M. Reinhorn and J.B. Mander, 12/1/92, (PB93-227528, A09, MF-A01).

NCEER-92-0030 "Evaluation of Seismic Retrofit of Reinforced Concrete Frame Structures: Part I - Experimental Performance of Retrofitted Subassemblages," by D. Choudhuri, J.B. Mander and A.M. Reinhorn, 12/8/92, (PB93-198307, A07, MF-A02).

NCEER-92-0031 "Evaluation of Seismic Retrofit of Reinforced Concrete Frame Structures: Part II - Experimental Performance and Analytical Study of a Retrofitted Structural Model," by J.M. Bracci, A.M. Reinhorn and J.B. Mander, 12/8/92, (PB93-198315, A09, MF-A03).

NCEER-92-0032 "Experimental and Analytical Investigation of Seismic Response of Structures with Supplemental Fluid Viscous Dampers," by M.C. Constantinou and M.D. Symans, 12/21/92, (PB93-191435, A10, MF-A03). This report is available only through NTIS (see address given above).

NCEER-92-0033 "Reconnaissance Report on the Cairo, Egypt Earthquake of October 12, 1992," by M. Khater, 12/23/92, (PB93-188621, A03, MF-A01).

NCEER-92-0034 "Low-Level Dynamic Characteristics of Four Tall Flat-Plate Buildings in New York City," by H. Gavin, S. Yuan, J. Grossman, E. Pekelis and K. Jacob, 12/28/92, (PB93-188217, A07, MF-A02).

NCEER-93-0001 "An Experimental Study on the Seismic Performance of Brick-Infilled Steel Frames With and Without Retrofit," by J.B. Mander, B. Nair, K. Wojtkowski and J. Ma, 1/29/93, (PB93-227510, A07, MF-A02).

NCEER-93-0002 "Social Accounting for Disaster Preparedness and Recovery Planning," by S. Cole, E. Pantoja and V. Razak, 2/22/93, (PB94-142114, A12, MF-A03).

NCEER-93-0003 "Assessment of 1991 NEHRP Provisions for Nonstructural Components and Recommended Revisions," by T.T. Soong, G. Chen, Z. Wu, R-H. Zhang and M. Grigoriu, 3/1/93, (PB93-188639, A06, MF-A02).

NCEER-93-0004 "Evaluation of Static and Response Spectrum Analysis Procedures of SEAOC/UBC for Seismic Isolated Structures," by C.W. Winters and M.C. Constantinou, 3/23/93, (PB93-198299, A10, MF-A03).

NCEER-93-0005 "Earthquakes in the Northeast - Are We Ignoring the Hazard? A Workshop on Earthquake Science and Safety for Educators," edited by K.E.K. Ross, 4/2/93, (PB94-103066, A09, MF-A02).

NCEER-93-0006 "Inelastic Response of Reinforced Concrete Structures with Viscoelastic Braces," by R.F. Lobo, J.M. Bracci, K.L. Shen, A.M. Reinhorn and T.T. Soong, 4/5/93, (PB93-227486, A05, MF-A02).

NCEER-93-0007 "Seismic Testing of Installation Methods for Computers and Data Processing Equipment," by K. Kosar, T.T. Soong, K.L. Shen, J.A. HoLung and Y.K. Lin, 4/12/93, (PB93-198299, A07, MF-A02).

NCEER-93-0008 "Retrofit of Reinforced Concrete Frames Using Added Dampers," by A. Reinhorn, M. Constantinou and C. Li, not available.

NCEER-93-0009 "Seismic Behavior and Design Guidelines for Steel Frame Structures with Added Viscoelastic Dampers," by K.C. Chang, M.L. Lai, T.T. Soong, D.S. Hao and Y.C. Yeh, 5/1/93, (PB94-141959, A07, MF-A02).

NCEER-93-0010 "Seismic Performance of Shear-Critical Reinforced Concrete Bridge Piers," by J.B. Mander, S.M. Waheed, M.T.A. Chaudhary and S.S. Chen, 5/12/93, (PB93-227494, A08, MF-A02).

NCEER-93-0011 "3D-BASIS-TABS: Computer Program for Nonlinear Dynamic Analysis of Three Dimensional Base Isolated Structures," by S. Nagarajaiah, C. Li, A.M. Reinhorn and M.C. Constantinou, 8/2/93, (PB94-141819, A09, MF-A02).

NCEER-93-0012 "Effects of Hydrocarbon Spills from an Oil Pipeline Break on Ground Water," by O.J. Helweg and H.H.M. Hwang, 8/3/93, (PB94-141942, A06, MF-A02).

NCEER-93-0013 "Simplified Procedures for Seismic Design of Nonstructural Components and Assessment of Current Code Provisions," by M.P. Singh, L.E. Suarez, E.E. Matheu and G.O. Maldonado, 8/4/93, (PB94-141827, A09, MF-A02).

NCEER-93-0014 "An Energy Approach to Seismic Analysis and Design of Secondary Systems," by G. Chen and T.T. Soong, 8/6/93, (PB94-142767, A11, MF-A03).

NCEER-93-0015 "Proceedings from School Sites: Becoming Prepared for Earthquakes - Commemorating the Third Anniversary of the Loma Prieta Earthquake," Edited by F.E. Winslow and K.E.K. Ross, 8/16/93, (PB94-154275, A16, MF-A02).

NCEER-93-0016 "Reconnaissance Report of Damage to Historic Monuments in Cairo, Egypt Following the October 12, 1992 Dahshur Earthquake," by D. Sykora, D. Look, G. Croci, E. Karaesmen and E. Karaesmen, 8/19/93, (PB94-142221, A08, MF-A02).

NCEER-93-0017 "The Island of Guam Earthquake of August 8, 1993," by S.W. Swan and S.K. Harris, 9/30/93, (PB94-141843, A04, MF-A01).

NCEER-93-0018 "Engineering Aspects of the October 12, 1992 Egyptian Earthquake," by A.W. Elgamal, M. Amer, K. Adalier and A. Abul-Fadl, 10/7/93, (PB94-141983, A05, MF-A01).

NCEER-93-0019 "Development of an Earthquake Motion Simulator and its Application in Dynamic Centrifuge Testing," by I. Krstelj, Supervised by J.H. Prevost, 10/23/93, (PB94-181773, A-10, MF-A03).

NCEER-93-0020 "NCEER-Taisei Corporation Research Program on Sliding Seismic Isolation Systems for Bridges: Experimental and Analytical Study of a Friction Pendulum System (FPS)," by M.C. Constantinou, P. Tsopelas, Y-S. Kim and S. Okamoto, 11/1/93, (PB94-142775, A08, MF-A02).

NCEER-93-0021 "Finite Element Modeling of Elastomeric Seismic Isolation Bearings," by L.J. Billings, Supervised by R. Shepherd, 11/8/93, not available.

NCEER-93-0022 "Seismic Vulnerability of Equipment in Critical Facilities: Life-Safety and Operational Consequences," by K. Porter, G.S. Johnson, M.M. Zadeh, C. Scawthorn and S. Eder, 11/24/93, (PB94-181765, A16, MF-A03).

NCEER-93-0023 "Hokkaido Nansei-oki, Japan Earthquake of July 12, 1993, by P.I. Yanev and C.R. Scawthorn, 12/23/93, (PB94-181500, A07, MF-A01).

NCEER-94-0001 "An Evaluation of Seismic Serviceability of Water Supply Networks with Application to the San Francisco Auxiliary Water Supply System," by I. Markov, Supervised by M. Grigoriu and T. O'Rourke, 1/21/94, (PB94-204013, A07, MF-A02).

NCEER-94-0002 "NCEER-Taisei Corporation Research Program on Sliding Seismic Isolation Systems for Bridges: Experimental and Analytical Study of Systems Consisting of Sliding Bearings, Rubber Restoring Force Devices and Fluid Dampers," Volumes I and II, by P. Tsopelas, S. Okamoto, M.C. Constantinou, D. Ozaki and S. Fujii, 2/4/94, (PB94-181740, A09, MF-A02 and PB94-181757, A12, MF-A03).

NCEER-94-0003 "A Markov Model for Local and Global Damage Indices in Seismic Analysis," by S. Rahman and M. Grigoriu, 2/18/94, (PB94-206000, A12, MF-A03).

NCEER-94-0004 "Proceedings from the NCEER Workshop on Seismic Response of Masonry Infills," edited by D.P. Abrams, 3/1/94, (PB94-180783, A07, MF-A02).

NCEER-94-0005 "The Northridge, California Earthquake of January 17, 1994: General Reconnaissance Report," edited by J.D. Goltz, 3/11/94, (PB94-193943, A10, MF-A03).

NCEER-94-0006 "Seismic Energy Based Fatigue Damage Analysis of Bridge Columns: Part I - Evaluation of Seismic Capacity," by G.A. Chang and J.B. Mander, 3/14/94, (PB94-219185, A11, MF-A03).

NCEER-94-0007 "Seismic Isolation of Multi-Story Frame Structures Using Spherical Sliding Isolation Systems," by T.M. Al-Hussaini, V.A. Zayas and M.C. Constantinou, 3/17/94, (PB94-193745, A09, MF-A02).

NCEER-94-0008 "The Northridge, California Earthquake of January 17, 1994: Performance of Highway Bridges," edited by I.G. Buckle, 3/24/94, (PB94-193851, A06, MF-A02).

NCEER-94-0009 "Proceedings of the Third U.S.-Japan Workshop on Earthquake Protective Systems for Bridges," edited by I.G. Buckle and I. Friedland, 3/31/94, (PB94-195815, A99, MF-A06).

NCEER-94-0010 "3D-BASIS-ME: Computer Program for Nonlinear Dynamic Analysis of Seismically Isolated Single and Multiple Structures and Liquid Storage Tanks," by P.C. Tsopelas, M.C. Constantinou and A.M. Reinhorn, 4/12/94, (PB94-204922, A09, MF-A02).

NCEER-94-0011 "The Northridge, California Earthquake of January 17, 1994: Performance of Gas Transmission Pipelines," by T.D. O'Rourke and M.C. Palmer, 5/16/94, (PB94-204989, A05, MF-A01).

NCEER-94-0012 "Feasibility Study of Replacement Procedures and Earthquake Performance Related to Gas Transmission Pipelines," by T.D. O'Rourke and M.C. Palmer, 5/25/94, (PB94-206638, A09, MF-A02).

NCEER-94-0013 "Seismic Energy Based Fatigue Damage Analysis of Bridge Columns: Part II - Evaluation of Seismic Demand," by G.A. Chang and J.B. Mander, 6/1/94, (PB95-18106, A08, MF-A02).

NCEER-94-0014 "NCEER-Taisei Corporation Research Program on Sliding Seismic Isolation Systems for Bridges: Experimental and Analytical Study of a System Consisting of Sliding Bearings and Fluid Restoring Force/Damping Devices," by P. Tsopelas and M.C. Constantinou, 6/13/94, (PB94-219144, A10, MF-A03).

NCEER-94-0015 "Generation of Hazard-Consistent Fragility Curves for Seismic Loss Estimation Studies," by H. Hwang and J-R. Huo, 6/14/94, (PB95-181996, A09, MF-A02).

NCEER-94-0016 "Seismic Study of Building Frames with Added Energy-Absorbing Devices," by W.S. Pong, C.S. Tsai and G.C. Lee, 6/20/94, (PB94-219136, A10, A03).

NCEER-94-0017 "Sliding Mode Control for Seismic-Excited Linear and Nonlinear Civil Engineering Structures," by J. Yang, J. Wu, A. Agrawal and Z. Li, 6/21/94, (PB95-138483, A06, MF-A02).

NCEER-94-0018 "3D-BASIS-TABS Version 2.0: Computer Program for Nonlinear Dynamic Analysis of Three Dimensional Base Isolated Structures," by A.M. Reinhorn, S. Nagarajaiah, M.C. Constantinou, P. Tsopelas and R. Li, 6/22/94, (PB95-182176, A08, MF-A02).

NCEER-94-0019 "Proceedings of the International Workshop on Civil Infrastructure Systems: Application of Intelligent Systems and Advanced Materials on Bridge Systems," Edited by G.C. Lee and K.C. Chang, 7/18/94, (PB95-252474, A20, MF-A04).

NCEER-94-0020 "Study of Seismic Isolation Systems for Computer Floors," by V. Lambrou and M.C. Constantinou, 7/19/94, (PB95-138533, A10, MF-A03).

NCEER-94-0021 "Proceedings of the U.S.-Italian Workshop on Guidelines for Seismic Evaluation and Rehabilitation of Unreinforced Masonry Buildings," Edited by D.P. Abrams and G.M. Calvi, 7/20/94, (PB95-138749, A13, MF-A03).

NCEER-94-0022 "NCEER-Taisei Corporation Research Program on Sliding Seismic Isolation Systems for Bridges: Experimental and Analytical Study of a System Consisting of Lubricated PTFE Sliding Bearings and Mild Steel Dampers," by P. Tsopelas and M.C. Constantinou, 7/22/94, (PB95-182184, A08, MF-A02).

NCEER-94-0023 “Development of Reliability-Based Design Criteria for Buildings Under Seismic Load,” by Y.K. Wen, H. Hwang and M. Shinozuka, 8/1/94, (PB95-211934, A08, MF-A02).

NCEER-94-0024 “Experimental Verification of Acceleration Feedback Control Strategies for an Active Tendon System,” by S.J. Dyke, B.F. Spencer, Jr., P. Quast, M.K. Sain, D.C. Kaspari, Jr. and T.T. Soong, 8/29/94, (PB95-212320, A05, MF-A01).

NCEER-94-0025 “Seismic Retrofitting Manual for Highway Bridges,” Edited by I.G. Buckle and I.F. Friedland, published by the Federal Highway Administration (PB95-212676, A15, MF-A03).

NCEER-94-0026 “Proceedings from the Fifth U.S.-Japan Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures Against Soil Liquefaction,” Edited by T.D. O’Rourke and M. Hamada, 11/7/94, (PB95-220802, A99, MF-E08).

NCEER-95-0001 "Experimental and Analytical Investigation of Seismic Retrofit of Structures with Supplemental Damping: Part 1 - Fluid Viscous Damping Devices," by A.M. Reinhorn, C. Li and M.C. Constantinou, 1/3/95, (PB95-266599, A09, MF-A02).

NCEER-95-0002 "Experimental and Analytical Study of Low-Cycle Fatigue Behavior of Semi-Rigid Top-And-Seat Angle Connections," by G. Pekcan, J.B. Mander and S.S. Chen, 1/5/95, (PB95-220042, A07, MF-A02).

NCEER-95-0003 "NCEER-ATC Joint Study on Fragility of Buildings," by T. Anagnos, C. Rojahn and A.S. Kiremidjian, 1/20/95, (PB95-220026, A06, MF-A02).

NCEER-95-0004 "Nonlinear Control Algorithms for Peak Response Reduction," by Z. Wu, T.T. Soong, V. Gattulli and R.C. Lin, 2/16/95, (PB95-220349, A05, MF-A01).

NCEER-95-0005 "Pipeline Replacement Feasibility Study: A Methodology for Minimizing Seismic and Corrosion Risks to Underground Natural Gas Pipelines," by R.T. Eguchi, H.A. Seligson and D.G. Honegger, 3/2/95, (PB95-252326, A06, MF-A02).

NCEER-95-0006 "Evaluation of Seismic Performance of an 11-Story Frame Building During the 1994 Northridge Earthquake," by F. Naeim, R. DiSulio, K. Benuska, A. Reinhorn and C. Li, not available.

NCEER-95-0007 "Prioritization of Bridges for Seismic Retrofitting," by N. Basöz and A.S. Kiremidjian, 4/24/95, (PB95-252300, A08, MF-A02).

NCEER-95-0008 "Method for Developing Motion Damage Relationships for Reinforced Concrete Frames," by A. Singhal and A.S. Kiremidjian, 5/11/95, (PB95-266607, A06, MF-A02).

NCEER-95-0009 "Experimental and Analytical Investigation of Seismic Retrofit of Structures with Supplemental Damping: Part II - Friction Devices," by C. Li and A.M. Reinhorn, 7/6/95, (PB96-128087, A11, MF-A03).

NCEER-95-0010 "Experimental Performance and Analytical Study of a Non-Ductile Reinforced Concrete Frame Structure Retrofitted with Elastomeric Spring Dampers," by G. Pekcan, J.B. Mander and S.S. Chen, 7/14/95, (PB96-137161, A08, MF-A02).

NCEER-95-0011 "Development and Experimental Study of Semi-Active Fluid Damping Devices for Seismic Protection of Structures," by M.D. Symans and M.C. Constantinou, 8/3/95, (PB96-136940, A23, MF-A04).

NCEER-95-0012 "Real-Time Structural Parameter Modification (RSPM): Development of Innervated Structures," by Z. Liang, M. Tong and G.C. Lee, 4/11/95, (PB96-137153, A06, MF-A01).

NCEER-95-0013 "Experimental and Analytical Investigation of Seismic Retrofit of Structures with Supplemental Damping: Part III - Viscous Damping Walls," by A.M. Reinhorn and C. Li, 10/1/95, (PB96-176409, A11, MF-A03).

NCEER-95-0014 "Seismic Fragility Analysis of Equipment and Structures in a Memphis Electric Substation," by J-R. Huo and H.H.M. Hwang, 8/10/95, (PB96-128087, A09, MF-A02).

NCEER-95-0015 "The Hanshin-Awaji Earthquake of January 17, 1995: Performance of Lifelines," Edited by M. Shinozuka, 11/3/95, (PB96-176383, A15, MF-A03).

NCEER-95-0016 "Highway Culvert Performance During Earthquakes," by T.L. Youd and C.J. Beckman, available as NCEER-96-0015.

NCEER-95-0017 "The Hanshin-Awaji Earthquake of January 17, 1995: Performance of Highway Bridges," Edited by I.G. Buckle, 12/1/95, not available.

NCEER-95-0018 "Modeling of Masonry Infill Panels for Structural Analysis," by A.M. Reinhorn, A. Madan, R.E. Valles, Y. Reichmann and J.B. Mander, 12/8/95, (PB97-110886, MF-A01, A06).

NCEER-95-0019 "Optimal Polynomial Control for Linear and Nonlinear Structures," by A.K. Agrawal and J.N. Yang, 12/11/95, (PB96-168737, A07, MF-A02).

NCEER-95-0020 "Retrofit of Non-Ductile Reinforced Concrete Frames Using Friction Dampers," by R.S. Rao, P. Gergely and R.N. White, 12/22/95, (PB97-133508, A10, MF-A02).

NCEER-95-0021 "Parametric Results for Seismic Response of Pile-Supported Bridge Bents," by G. Mylonakis, A. Nikolaou and G. Gazetas, 12/22/95, (PB97-100242, A12, MF-A03).

NCEER-95-0022 "Kinematic Bending Moments in Seismically Stressed Piles," by A. Nikolaou, G. Mylonakis and G. Gazetas, 12/23/95, (PB97-113914, MF-A03, A13).

NCEER-96-0001 "Dynamic Response of Unreinforced Masonry Buildings with Flexible Diaphragms," by A.C. Costley and D.P. Abrams," 10/10/96, (PB97-133573, MF-A03, A15).

NCEER-96-0002 "State of the Art Review: Foundations and Retaining Structures," by I. Po Lam, not available.

NCEER-96-0003 "Ductility of Rectangular Reinforced Concrete Bridge Columns with Moderate Confinement," by N. Wehbe, M. Saiidi, D. Sanders and B. Douglas, 11/7/96, (PB97-133557, A06, MF-A02).

NCEER-96-0004 "Proceedings of the Long-Span Bridge Seismic Research Workshop," edited by I.G. Buckle and I.M. Friedland, not available.

NCEER-96-0005 "Establish Representative Pier Types for Comprehensive Study: Eastern United States," by J. Kulicki and Z. Prucz, 5/28/96, (PB98-119217, A07, MF-A02).

NCEER-96-0006 "Establish Representative Pier Types for Comprehensive Study: Western United States," by R. Imbsen, R.A. Schamber and T.A. Osterkamp, 5/28/96, (PB98-118607, A07, MF-A02).

NCEER-96-0007 "Nonlinear Control Techniques for Dynamical Systems with Uncertain Parameters," by R.G. Ghanem and M.I. Bujakov, 5/27/96, (PB97-100259, A17, MF-A03).

NCEER-96-0008 "Seismic Evaluation of a 30-Year Old Non-Ductile Highway Bridge Pier and Its Retrofit," by J.B. Mander, B. Mahmoodzadegan, S. Bhadra and S.S. Chen, 5/31/96, (PB97-110902, MF-A03, A10).

NCEER-96-0009 "Seismic Performance of a Model Reinforced Concrete Bridge Pier Before and After Retrofit," by J.B. Mander, J.H. Kim and C.A. Ligozio, 5/31/96, (PB97-110910, MF-A02, A10).

NCEER-96-0010 "IDARC2D Version 4.0: A Computer Program for the Inelastic Damage Analysis of Buildings," by R.E. Valles, A.M. Reinhorn, S.K. Kunnath, C. Li and A. Madan, 6/3/96, (PB97-100234, A17, MF-A03).

NCEER-96-0011 "Estimation of the Economic Impact of Multiple Lifeline Disruption: Memphis Light, Gas and Water Division Case Study," by S.E. Chang, H.A. Seligson and R.T. Eguchi, 8/16/96, (PB97-133490, A11, MF-A03).

NCEER-96-0012 "Proceedings from the Sixth Japan-U.S. Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures Against Soil Liquefaction, Edited by M. Hamada and T. O'Rourke, 9/11/96, (PB97-133581, A99, MF-A06).

NCEER-96-0013 "Chemical Hazards, Mitigation and Preparedness in Areas of High Seismic Risk: A Methodology for Estimating the Risk of Post-Earthquake Hazardous Materials Release," by H.A. Seligson, R.T. Eguchi, K.J. Tierney and K. Richmond, 11/7/96, (PB97-133565, MF-A02, A08).

NCEER-96-0014 "Response of Steel Bridge Bearings to Reversed Cyclic Loading," by J.B. Mander, D-K. Kim, S.S. Chen and G.J. Premus, 11/13/96, (PB97-140735, A12, MF-A03).

NCEER-96-0015 "Highway Culvert Performance During Past Earthquakes," by T.L. Youd and C.J. Beckman, 11/25/96, (PB97-133532, A06, MF-A01).

NCEER-97-0001 "Evaluation, Prevention and Mitigation of Pounding Effects in Building Structures," by R.E. Valles and A.M. Reinhorn, 2/20/97, (PB97-159552, A14, MF-A03).

NCEER-97-0002 "Seismic Design Criteria for Bridges and Other Highway Structures," by C. Rojahn, R. Mayes, D.G. Anderson, J. Clark, J.H. Hom, R.V. Nutt and M.J. O'Rourke, 4/30/97, (PB97-194658, A06, MF-A03).

NCEER-97-0003 “Proceedings of the U.S.-Italian Workshop on Seismic Evaluation and Retrofit,” Edited by D.P. Abrams and G.M. Calvi, 3/19/97, (PB97-194666, A13, MF-A03).

NCEER-97-0004 "Investigation of Seismic Response of Buildings with Linear and Nonlinear Fluid Viscous Dampers," by A.A. Seleemah and M.C. Constantinou, 5/21/97, (PB98-109002, A15, MF-A03).

NCEER-97-0005 "Proceedings of the Workshop on Earthquake Engineering Frontiers in Transportation Facilities," edited by G.C. Lee and I.M. Friedland, 8/29/97, (PB98-128911, A25, MR-A04).

NCEER-97-0006 "Cumulative Seismic Damage of Reinforced Concrete Bridge Piers," by S.K. Kunnath, A. El-Bahy, A. Taylor and W. Stone, 9/2/97, (PB98-108814, A11, MF-A03).

NCEER-97-0007 "Structural Details to Accommodate Seismic Movements of Highway Bridges and Retaining Walls," by R.A. Imbsen, R.A. Schamber, E. Thorkildsen, A. Kartoum, B.T. Martin, T.N. Rosser and J.M. Kulicki, 9/3/97, (PB98-108996, A09, MF-A02).

NCEER-97-0008 "A Method for Earthquake Motion-Damage Relationships with Application to Reinforced Concrete Frames," by A. Singhal and A.S. Kiremidjian, 9/10/97, (PB98-108988, A13, MF-A03).

NCEER-97-0009 "Seismic Analysis and Design of Bridge Abutments Considering Sliding and Rotation," by K. Fishman and R. Richards, Jr., 9/15/97, (PB98-108897, A06, MF-A02).

NCEER-97-0010 "Proceedings of the FHWA/NCEER Workshop on the National Representation of Seismic Ground Motion for New and Existing Highway Facilities," edited by I.M. Friedland, M.S. Power and R.L. Mayes, 9/22/97, (PB98-128903, A21, MF-A04).

NCEER-97-0011 "Seismic Analysis for Design or Retrofit of Gravity Bridge Abutments," by K.L. Fishman, R. Richards, Jr. and R.C. Divito, 10/2/97, (PB98-128937, A08, MF-A02).

NCEER-97-0012 "Evaluation of Simplified Methods of Analysis for Yielding Structures," by P. Tsopelas, M.C. Constantinou, C.A. Kircher and A.S. Whittaker, 10/31/97, (PB98-128929, A10, MF-A03).

NCEER-97-0013 "Seismic Design of Bridge Columns Based on Control and Repairability of Damage," by C-T. Cheng and J.B. Mander, 12/8/97, (PB98-144249, A11, MF-A03).

NCEER-97-0014 "Seismic Resistance of Bridge Piers Based on Damage Avoidance Design," by J.B. Mander and C-T. Cheng, 12/10/97, (PB98-144223, A09, MF-A02).

NCEER-97-0015 “Seismic Response of Nominally Symmetric Systems with Strength Uncertainty,” by S. Balopoulou and M. Grigoriu, 12/23/97, (PB98-153422, A11, MF-A03).

NCEER-97-0016 “Evaluation of Seismic Retrofit Methods for Reinforced Concrete Bridge Columns,” by T.J. Wipf, F.W. Klaiber and F.M. Russo, 12/28/97, (PB98-144215, A12, MF-A03).

NCEER-97-0017 “Seismic Fragility of Existing Conventional Reinforced Concrete Highway Bridges,” by C.L. Mullen and A.S. Cakmak, 12/30/97, (PB98-153406, A08, MF-A02).

NCEER-97-0018 “Loss Asssessment of Memphis Buildings,” edited by D.P. Abrams and M. Shinozuka, 12/31/97, (PB98-144231, A13, MF-A03).

NCEER-97-0019 “Seismic Evaluation of Frames with Infill Walls Using Quasi-static Experiments,” by K.M. Mosalam, R.N. White and P. Gergely, 12/31/97, (PB98-153455, A07, MF-A02).

NCEER-97-0020 “Seismic Evaluation of Frames with Infill Walls Using Pseudo-dynamic Experiments,” by K.M. Mosalam, R.N. White and P. Gergely, 12/31/97, (PB98-153430, A07, MF-A02).

NCEER-97-0021 “Computational Strategies for Frames with Infill Walls: Discrete and Smeared Crack Analyses and Seismic Fragility,” by K.M. Mosalam, R.N. White and P. Gergely, 12/31/97, (PB98-153414, A10, MF-A02).

NCEER-97-0022 "Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils," edited by T.L. Youd and I.M. Idriss, 12/31/97, (PB98-155617, A15, MF-A03).

MCEER-98-0001 "Extraction of Nonlinear Hysteretic Properties of Seismically Isolated Bridges from Quick-Release Field Tests," by Q. Chen, B.M. Douglas, E.M. Maragakis and I.G. Buckle, 5/26/98, (PB99-118838, A06, MF-A01).

MCEER-98-0002 "Methodologies for Evaluating the Importance of Highway Bridges," by A. Thomas, S. Eshenaur and J. Kulicki, 5/29/98, (PB99-118846, A10, MF-A02).

MCEER-98-0003 "Capacity Design of Bridge Piers and the Analysis of Overstrength," by J.B. Mander, A. Dutta and P. Goel, 6/1/98, (PB99-118853, A09, MF-A02).

MCEER-98-0004 "Evaluation of Bridge Damage Data from the Loma Prieta and Northridge, California Earthquakes," by N. Basoz and A. Kiremidjian, 6/2/98, (PB99-118861, A15, MF-A03).

MCEER-98-0005 "Screening Guide for Rapid Assessment of Liquefaction Hazard at Highway Bridge Sites," by T. L. Youd, 6/16/98, (PB99-118879, A06, not available on microfiche).

MCEER-98-0006 "Structural Steel and Steel/Concrete Interface Details for Bridges," by P. Ritchie, N. Kauhl and J. Kulicki, 7/13/98, (PB99-118945, A06, MF-A01).

MCEER-98-0007 "Capacity Design and Fatigue Analysis of Confined Concrete Columns," by A. Dutta and J.B. Mander, 7/14/98, (PB99-118960, A14, MF-A03).

MCEER-98-0008 "Proceedings of the Workshop on Performance Criteria for Telecommunication Services Under Earthquake Conditions," edited by A.J. Schiff, 7/15/98, (PB99-118952, A08, MF-A02).

MCEER-98-0009 "Fatigue Analysis of Unconfined Concrete Columns," by J.B. Mander, A. Dutta and J.H. Kim, 9/12/98, (PB99-123655, A10, MF-A02).

MCEER-98-0010 "Centrifuge Modeling of Cyclic Lateral Response of Pile-Cap Systems and Seat-Type Abutments in Dry Sands," by A.D. Gadre and R. Dobry, 10/2/98, (PB99-123606, A13, MF-A03).

MCEER-98-0011 "IDARC-BRIDGE: A Computational Platform for Seismic Damage Assessment of Bridge Structures," by A.M. Reinhorn, V. Simeonov, G. Mylonakis and Y. Reichman, 10/2/98, (PB99-162919, A15, MF-A03).

MCEER-98-0012 "Experimental Investigation of the Dynamic Response of Two Bridges Before and After Retrofitting with Elastomeric Bearings," by D.A. Wendichansky, S.S. Chen and J.B. Mander, 10/2/98, (PB99-162927, A15, MF-A03).

MCEER-98-0013 "Design Procedures for Hinge Restrainers and Hinge Sear Width for Multiple-Frame Bridges," by R. Des Roches and G.L. Fenves, 11/3/98, (PB99-140477, A13, MF-A03).

MCEER-98-0014 "Response Modification Factors for Seismically Isolated Bridges," by M.C. Constantinou and J.K. Quarshie, 11/3/98, (PB99-140485, A14, MF-A03).

MCEER-98-0015 "Proceedings of the U.S.-Italy Workshop on Seismic Protective Systems for Bridges," edited by I.M. Friedland and M.C. Constantinou, 11/3/98, (PB2000-101711, A22, MF-A04).

MCEER-98-0016 "Appropriate Seismic Reliability for Critical Equipment Systems: Recommendations Based on Regional Analysis of Financial and Life Loss," by K. Porter, C. Scawthorn, C. Taylor and N. Blais, 11/10/98, (PB99-157265, A08, MF-A02).

MCEER-98-0017 "Proceedings of the U.S. Japan Joint Seminar on Civil Infrastructure Systems Research," edited by M. Shinozuka and A. Rose, 11/12/98, (PB99-156713, A16, MF-A03).

MCEER-98-0018 "Modeling of Pile Footings and Drilled Shafts for Seismic Design," by I. PoLam, M. Kapuskar and D. Chaudhuri, 12/21/98, (PB99-157257, A09, MF-A02).

MCEER-99-0001 "Seismic Evaluation of a Masonry Infilled Reinforced Concrete Frame by Pseudodynamic Testing," by S.G. Buonopane and R.N. White, 2/16/99, (PB99-162851, A09, MF-A02).

MCEER-99-0002 "Response History Analysis of Structures with Seismic Isolation and Energy Dissipation Systems: Verification Examples for Program SAP2000," by J. Scheller and M.C. Constantinou, 2/22/99, (PB99-162869, A08, MF-A02).

MCEER-99-0003 "Experimental Study on the Seismic Design and Retrofit of Bridge Columns Including Axial Load Effects," by A. Dutta, T. Kokorina and J.B. Mander, 2/22/99, (PB99-162877, A09, MF-A02).

MCEER-99-0004 "Experimental Study of Bridge Elastomeric and Other Isolation and Energy Dissipation Systems with Emphasis on Uplift Prevention and High Velocity Near-source Seismic Excitation," by A. Kasalanati and M. C. Constantinou, 2/26/99, (PB99-162885, A12, MF-A03).

MCEER-99-0005 "Truss Modeling of Reinforced Concrete Shear-flexure Behavior," by J.H. Kim and J.B. Mander, 3/8/99, (PB99-163693, A12, MF-A03).

MCEER-99-0006 "Experimental Investigation and Computational Modeling of Seismic Response of a 1:4 Scale Model Steel Structure with a Load Balancing Supplemental Damping System," by G. Pekcan, J.B. Mander and S.S. Chen, 4/2/99, (PB99-162893, A11, MF-A03).

MCEER-99-0007 "Effect of Vertical Ground Motions on the Structural Response of Highway Bridges," by M.R. Button, C.J. Cronin and R.L. Mayes, 4/10/99, (PB2000-101411, A10, MF-A03).

MCEER-99-0008 "Seismic Reliability Assessment of Critical Facilities: A Handbook, Supporting Documentation, and Model Code Provisions," by G.S. Johnson, R.E. Sheppard, M.D. Quilici, S.J. Eder and C.R. Scawthorn, 4/12/99, (PB2000-101701, A18, MF-A04).

MCEER-99-0009 "Impact Assessment of Selected MCEER Highway Project Research on the Seismic Design of Highway Structures," by C. Rojahn, R. Mayes, D.G. Anderson, J.H. Clark, D'Appolonia Engineering, S. Gloyd and R.V. Nutt, 4/14/99, (PB99-162901, A10, MF-A02).

MCEER-99-0010 "Site Factors and Site Categories in Seismic Codes," by R. Dobry, R. Ramos and M.S. Power, 7/19/99, (PB2000-101705, A08, MF-A02).

MCEER-99-0011 "Restrainer Design Procedures for Multi-Span Simply-Supported Bridges," by M.J. Randall, M. Saiidi, E. Maragakis and T. Isakovic, 7/20/99, (PB2000-101702, A10, MF-A02).

MCEER-99-0012 "Property Modification Factors for Seismic Isolation Bearings," by M.C. Constantinou, P. Tsopelas, A. Kasalanati and E. Wolff, 7/20/99, (PB2000-103387, A11, MF-A03).

MCEER-99-0013 "Critical Seismic Issues for Existing Steel Bridges," by P. Ritchie, N. Kauhl and J. Kulicki, 7/20/99, (PB2000-101697, A09, MF-A02).

MCEER-99-0014 "Nonstructural Damage Database," by A. Kao, T.T. Soong and A. Vender, 7/24/99, (PB2000-101407, A06, MF-A01).

MCEER-99-0015 "Guide to Remedial Measures for Liquefaction Mitigation at Existing Highway Bridge Sites," by H.G. Cooke and J. K. Mitchell, 7/26/99, (PB2000-101703, A11, MF-A03).

MCEER-99-0016 "Proceedings of the MCEER Workshop on Ground Motion Methodologies for the Eastern United States," edited by N. Abrahamson and A. Becker, 8/11/99, (PB2000-103385, A07, MF-A02).

MCEER-99-0017 "Quindío, Colombia Earthquake of January 25, 1999: Reconnaissance Report," by A.P. Asfura and P.J. Flores, 10/4/99, (PB2000-106893, A06, MF-A01).

MCEER-99-0018 "Hysteretic Models for Cyclic Behavior of Deteriorating Inelastic Structures," by M.V. Sivaselvan and A.M. Reinhorn, 11/5/99, (PB2000-103386, A08, MF-A02).

MCEER-99-0019 "Proceedings of the 7th U.S.- Japan Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures Against Soil Liquefaction," edited by T.D. O'Rourke, J.P. Bardet and M. Hamada, 11/19/99, (PB2000-103354, A99, MF-A06).

MCEER-99-0020 "Development of Measurement Capability for Micro-Vibration Evaluations with Application to Chip Fabrication Facilities," by G.C. Lee, Z. Liang, J.W. Song, J.D. Shen and W.C. Liu, 12/1/99, (PB2000-105993, A08, MF-A02).

MCEER-99-0021 "Design and Retrofit Methodology for Building Structures with Supplemental Energy Dissipating Systems," by G. Pekcan, J.B. Mander and S.S. Chen, 12/31/99, (PB2000-105994, A11, MF-A03).

MCEER-00-0001 "The Marmara, Turkey Earthquake of August 17, 1999: Reconnaissance Report," edited by C. Scawthorn; with major contributions by M. Bruneau, R. Eguchi, T. Holzer, G. Johnson, J. Mander, J. Mitchell, W. Mitchell, A. Papageorgiou, C. Scaethorn, and G. Webb, 3/23/00, (PB2000-106200, A11, MF-A03).

MCEER-00-0002 "Proceedings of the MCEER Workshop for Seismic Hazard Mitigation of Health Care Facilities," edited by G.C. Lee, M. Ettouney, M. Grigoriu, J. Hauer and J. Nigg, 3/29/00, (PB2000-106892, A08, MF-A02).

MCEER-00-0003 "The Chi-Chi, Taiwan Earthquake of September 21, 1999: Reconnaissance Report," edited by G.C. Lee and C.H. Loh, with major contributions by G.C. Lee, M. Bruneau, I.G. Buckle, S.E. Chang, P.J. Flores, T.D. O'Rourke, M. Shinozuka, T.T. Soong, C-H. Loh, K-C. Chang, Z-J. Chen, J-S. Hwang, M-L. Lin, G-Y. Liu, K-C. Tsai, G.C. Yao and C-L. Yen, 4/30/00, (PB2001-100980, A10, MF-A02).

MCEER-00-0004 "Seismic Retrofit of End-Sway Frames of Steel Deck-Truss Bridges with a Supplemental Tendon System: Experimental and Analytical Investigation," by G. Pekcan, J.B. Mander and S.S. Chen, 7/1/00, (PB2001-100982, A10, MF-A02).

MCEER-00-0005 "Sliding Fragility of Unrestrained Equipment in Critical Facilities," by W.H. Chong and T.T. Soong, 7/5/00, (PB2001-100983, A08, MF-A02).

MCEER-00-0006 "Seismic Response of Reinforced Concrete Bridge Pier Walls in the Weak Direction," by N. Abo-Shadi, M. Saiidi and D. Sanders, 7/17/00, (PB2001-100981, A17, MF-A03).

MCEER-00-0007 "Low-Cycle Fatigue Behavior of Longitudinal Reinforcement in Reinforced Concrete Bridge Columns," by J. Brown and S.K. Kunnath, 7/23/00, (PB2001-104392, A08, MF-A02).

MCEER-00-0008 "Soil Structure Interaction of Bridges for Seismic Analysis," I. PoLam and H. Law, 9/25/00, (PB2001-105397, A08, MF-A02).

MCEER-00-0009 "Proceedings of the First MCEER Workshop on Mitigation of Earthquake Disaster by Advanced Technologies (MEDAT-1), edited by M. Shinozuka, D.J. Inman and T.D. O'Rourke, 11/10/00, (PB2001-105399, A14, MF-A03).

MCEER-00-0010 "Development and Evaluation of Simplified Procedures for Analysis and Design of Buildings with Passive Energy Dissipation Systems, Revision 01," by O.M. Ramirez, M.C. Constantinou, C.A. Kircher, A.S. Whittaker, M.W. Johnson, J.D. Gomez and C. Chrysostomou, 11/16/01, (PB2001-105523, A23, MF-A04).

MCEER-00-0011 "Dynamic Soil-Foundation-Structure Interaction Analyses of Large Caissons," by C-Y. Chang, C-M. Mok, Z-L. Wang, R. Settgast, F. Waggoner, M.A. Ketchum, H.M. Gonnermann and C-C. Chin, 12/30/00, (PB2001-104373, A07, MF-A02).

MCEER-00-0012 "Experimental Evaluation of Seismic Performance of Bridge Restrainers," by A.G. Vlassis, E.M. Maragakis and M. Saiid Saiidi, 12/30/00, (PB2001-104354, A09, MF-A02).

MCEER-00-0013 "Effect of Spatial Variation of Ground Motion on Highway Structures," by M. Shinozuka, V. Saxena and G. Deodatis, 12/31/00, (PB2001-108755, A13, MF-A03).

MCEER-00-0014 "A Risk-Based Methodology for Assessing the Seismic Performance of Highway Systems," by S.D. Werner, C.E. Taylor, J.E. Moore, II, J.S. Walton and S. Cho, 12/31/00, (PB2001-108756, A14, MF-A03).

MCEER-01-0001 "Experimental Investigation of P-Delta Effects to Collapse During Earthquakes," by D. Vian and M. Bruneau, 6/25/01, (PB2002-100534, A17, MF-A03).

MCEER-01-0002 "Proceedings of the Second MCEER Workshop on Mitigation of Earthquake Disaster by Advanced Technologies (MEDAT-2)," edited by M. Bruneau and D.J. Inman, 7/23/01, (PB2002-100434, A16, MF-A03).

MCEER-01-0003 "Sensitivity Analysis of Dynamic Systems Subjected to Seismic Loads," by C. Roth and M. Grigoriu, 9/18/01, (PB2003-100884, A12, MF-A03).

MCEER-01-0004 "Overcoming Obstacles to Implementing Earthquake Hazard Mitigation Policies: Stage 1 Report," by D.J. Alesch and W.J. Petak, 12/17/01, (PB2002-107949, A07, MF-A02).

MCEER-01-0005 "Updating Real-Time Earthquake Loss Estimates: Methods, Problems and Insights," by C.E. Taylor, S.E. Chang and R.T. Eguchi, 12/17/01, (PB2002-107948, A05, MF-A01).

MCEER-01-0006 "Experimental Investigation and Retrofit of Steel Pile Foundations and Pile Bents Under Cyclic Lateral Loadings," by A. Shama, J. Mander, B. Blabac and S. Chen, 12/31/01, (PB2002-107950, A13, MF-A03).

MCEER-02-0001 "Assessment of Performance of Bolu Viaduct in the 1999 Duzce Earthquake in Turkey" by P.C. Roussis, M.C. Constantinou, M. Erdik, E. Durukal and M. Dicleli, 5/8/02, (PB2003-100883, A08, MF-A02).

MCEER-02-0002 "Seismic Behavior of Rail Counterweight Systems of Elevators in Buildings," by M.P. Singh, Rildova and L.E. Suarez, 5/27/02. (PB2003-100882, A11, MF-A03).

MCEER-02-0003 "Development of Analysis and Design Procedures for Spread Footings," by G. Mylonakis, G. Gazetas, S. Nikolaou and A. Chauncey, 10/02/02, (PB2004-101636, A13, MF-A03, CD-A13).

MCEER-02-0004 "Bare-Earth Algorithms for Use with SAR and LIDAR Digital Elevation Models," by C.K. Huyck, R.T. Eguchi and B. Houshmand, 10/16/02, (PB2004-101637, A07, CD-A07).

MCEER-02-0005 "Review of Energy Dissipation of Compression Members in Concentrically Braced Frames," by K.Lee and M. Bruneau, 10/18/02, (PB2004-101638, A10, CD-A10).

MCEER-03-0001 "Experimental Investigation of Light-Gauge Steel Plate Shear Walls for the Seismic Retrofit of Buildings" by J. Berman and M. Bruneau, 5/2/03, (PB2004-101622, A10, MF-A03, CD-A10).

MCEER-03-0002 "Statistical Analysis of Fragility Curves," by M. Shinozuka, M.Q. Feng, H. Kim, T. Uzawa and T. Ueda, 6/16/03, (PB2004-101849, A09, CD-A09).

MCEER-03-0003 "Proceedings of the Eighth U.S.-Japan Workshop on Earthquake Resistant Design f Lifeline Facilities and Countermeasures Against Liquefaction," edited by M. Hamada, J.P. Bardet and T.D. O'Rourke, 6/30/03, (PB2004-104386, A99, CD-A99).

MCEER-03-0004 "Proceedings of the PRC-US Workshop on Seismic Analysis and Design of Special Bridges," edited by L.C. Fan and G.C. Lee, 7/15/03, (PB2004-104387, A14, CD-A14).

MCEER-03-0005 "Urban Disaster Recovery: A Framework and Simulation Model," by S.B. Miles and S.E. Chang, 7/25/03, (PB2004-104388, A07, CD-A07).

MCEER-03-0006 "Behavior of Underground Piping Joints Due to Static and Dynamic Loading," by R.D. Meis, M. Maragakis and R. Siddharthan, 11/17/03, (PB2005-102194, A13, MF-A03, CD-A00).

MCEER-04-0001 "Experimental Study of Seismic Isolation Systems with Emphasis on Secondary System Response and Verification of Accuracy of Dynamic Response History Analysis Methods," by E. Wolff and M. Constantinou, 1/16/04 (PB2005-102195, A99, MF-E08, CD-A00).

MCEER-04-0002 "Tension, Compression and Cyclic Testing of Engineered Cementitious Composite Materials," by K. Kesner and S.L. Billington, 3/1/04, (PB2005-102196, A08, CD-A08).

MCEER-04-0003 "Cyclic Testing of Braces Laterally Restrained by Steel Studs to Enhance Performance During Earthquakes," by O.C. Celik, J.W. Berman and M. Bruneau, 3/16/04, (PB2005-102197, A13, MF-A03, CD-A00).

MCEER-04-0004 "Methodologies for Post Earthquake Building Damage Detection Using SAR and Optical Remote Sensing: Application to the August 17, 1999 Marmara, Turkey Earthquake," by C.K. Huyck, B.J. Adams, S. Cho, R.T. Eguchi, B. Mansouri and B. Houshmand, 6/15/04, (PB2005-104888, A10, CD-A00).

MCEER-04-0005 "Nonlinear Structural Analysis Towards Collapse Simulation: A Dynamical Systems Approach," by M.V. Sivaselvan and A.M. Reinhorn, 6/16/04, (PB2005-104889, A11, MF-A03, CD-A00).

MCEER-04-0006 "Proceedings of the Second PRC-US Workshop on Seismic Analysis and Design of Special Bridges," edited by G.C. Lee and L.C. Fan, 6/25/04, (PB2005-104890, A16, CD-A00).

MCEER-04-0007 "Seismic Vulnerability Evaluation of Axially Loaded Steel Built-up Laced Members," by K. Lee and M. Bruneau, 6/30/04, (PB2005-104891, A16, CD-A00).

MCEER-04-0008 "Evaluation of Accuracy of Simplified Methods of Analysis and Design of Buildings with Damping Systems for Near-Fault and for Soft-Soil Seismic Motions," by E.A. Pavlou and M.C. Constantinou, 8/16/04, (PB2005-104892, A08, MF-A02, CD-A00).

MCEER-04-0009 "Assessment of Geotechnical Issues in Acute Care Facilities in California," by M. Lew, T.D. O'Rourke, R. Dobry and M. Koch, 9/15/04, (PB2005-104893, A08, CD-A00).

MCEER-04-0010 "Scissor-Jack-Damper Energy Dissipation System," by A.N. Sigaher-Boyle and M.C. Constantinou, 12/1/04 (PB2005-108221).

MCEER-04-0011 "Seismic Retrofit of Bridge Steel Truss Piers Using a Controlled Rocking Approach," by M. Pollino and M. Bruneau, 12/20/04 (PB2006-105795).

MCEER-05-0001 "Experimental and Analytical Studies of Structures Seismically Isolated with an Uplift-Restraint Isolation System," by P.C. Roussis and M.C. Constantinou, 1/10/05 (PB2005-108222).

MCEER-05-0002 "A Versatile Experimentation Model for Study of Structures Near Collapse Applied to Seismic Evaluation of Irregular Structures," by D. Kusumastuti, A.M. Reinhorn and A. Rutenberg, 3/31/05 (PB2006-101523).

MCEER-05-0003 "Proceedings of the Third PRC-US Workshop on Seismic Analysis and Design of Special Bridges," edited by L.C. Fan and G.C. Lee, 4/20/05, (PB2006-105796).

MCEER-05-0004 "Approaches for the Seismic Retrofit of Braced Steel Bridge Piers and Proof-of-Concept Testing of an Eccentrically Braced Frame with Tubular Link," by J.W. Berman and M. Bruneau, 4/21/05 (PB2006-101524).

MCEER-05-0005 "Simulation of Strong Ground Motions for Seismic Fragility Evaluation of Nonstructural Components in Hospitals," by A. Wanitkorkul and A. Filiatrault, 5/26/05 (PB2006-500027).

MCEER-05-0006 "Seismic Safety in California Hospitals: Assessing an Attempt to Accelerate the Replacement or Seismic Retrofit of Older Hospital Facilities," by D.J. Alesch, L.A. Arendt and W.J. Petak, 6/6/05 (PB2006-105794).

MCEER-05-0007 "Development of Seismic Strengthening and Retrofit Strategies for Critical Facilities Using Engineered Cementitious Composite Materials," by K. Kesner and S.L. Billington, 8/29/05 (PB2006-111701).

MCEER-05-0008 "Experimental and Analytical Studies of Base Isolation Systems for Seismic Protection of Power Transformers," by N. Murota, M.Q. Feng and G-Y. Liu, 9/30/05 (PB2006-111702).

MCEER-05-0009 "3D-BASIS-ME-MB: Computer Program for Nonlinear Dynamic Analysis of Seismically Isolated Structures," by P.C. Tsopelas, P.C. Roussis, M.C. Constantinou, R. Buchanan and A.M. Reinhorn, 10/3/05 (PB2006-111703).

MCEER-05-0010 "Steel Plate Shear Walls for Seismic Design and Retrofit of Building Structures," by D. Vian and M. Bruneau, 12/15/05 (PB2006-111704).

MCEER-05-0011 "The Performance-Based Design Paradigm," by M.J. Astrella and A. Whittaker, 12/15/05 (PB2006-111705).

MCEER-06-0001 "Seismic Fragility of Suspended Ceiling Systems," H. Badillo-Almaraz, A.S. Whittaker, A.M. Reinhorn and G.P. Cimellaro, 2/4/06 (PB2006-111706).

MCEER-06-0002 "Multi-Dimensional Fragility of Structures," by G.P. Cimellaro, A.M. Reinhorn and M. Bruneau, 3/1/06 (PB2007-106974, A09, MF-A02, CD A00).

MCEER-06-0003 "Built-Up Shear Links as Energy Dissipators for Seismic Protection of Bridges," by P. Dusicka, A.M. Itani and I.G. Buckle, 3/15/06 (PB2006-111708).

MCEER-06-0004 "Analytical Investigation of the Structural Fuse Concept," by R.E. Vargas and M. Bruneau, 3/16/06 (PB2006-111709).

MCEER-06-0005 "Experimental Investigation of the Structural Fuse Concept," by R.E. Vargas and M. Bruneau, 3/17/06 (PB2006-111710).

MCEER-06-0006 "Further Development of Tubular Eccentrically Braced Frame Links for the Seismic Retrofit of Braced Steel Truss Bridge Piers," by J.W. Berman and M. Bruneau, 3/27/06 (PB2007-105147).

MCEER-06-0007 "REDARS Validation Report," by S. Cho, C.K. Huyck, S. Ghosh and R.T. Eguchi, 8/8/06 (PB2007-106983).

MCEER-06-0008 "Review of Current NDE Technologies for Post-Earthquake Assessment of Retrofitted Bridge Columns," by J.W. Song, Z. Liang and G.C. Lee, 8/21/06 (PB2007-106984).

MCEER-06-0009 "Liquefaction Remediation in Silty Soils Using Dynamic Compaction and Stone Columns," by S. Thevanayagam, G.R. Martin, R. Nashed, T. Shenthan, T. Kanagalingam and N. Ecemis, 8/28/06 (PB2007-106985).

MCEER-06-0010 "Conceptual Design and Experimental Investigation of Polymer Matrix Composite Infill Panels for Seismic Retrofitting," by W. Jung, M. Chiewanichakorn and A.J. Aref, 9/21/06 (PB2007-106986).

MCEER-06-0011 "A Study of the Coupled Horizontal-Vertical Behavior of Elastomeric and Lead-Rubber Seismic Isolation Bearings," by G.P. Warn and A.S. Whittaker, 9/22/06 (PB2007-108679).

MCEER-06-0012 "Proceedings of the Fourth PRC-US Workshop on Seismic Analysis and Design of Special Bridges: Advancing Bridge Technologies in Research, Design, Construction and Preservation," Edited by L.C. Fan, G.C. Lee and L. Ziang, 10/12/06 (PB2007-109042).

MCEER-06-0013 "Cyclic Response and Low Cycle Fatigue Characteristics of Plate Steels," by P. Dusicka, A.M. Itani and I.G. Buckle, 11/1/06 06 (PB2007-106987).

MCEER-06-0014 "Proceedings of the Second US-Taiwan Bridge Engineering Workshop," edited by W.P. Yen, J. Shen, J-Y. Chen and M. Wang, 11/15/06 (PB2008-500041).

MCEER-06-0015 "User Manual and Technical Documentation for the REDARS^{TM} Import Wizard," by S. Cho, S. Ghosh, C.K. Huyck and S.D. Werner, 11/30/06 (PB2007-114766).

MCEER-06-0016 "Hazard Mitigation Strategy and Monitoring Technologies for Urban and Infrastructure Public Buildings: Proceedings of the China-US Workshops," edited by X.Y. Zhou, A.L. Zhang, G.C. Lee and M. Tong, 12/12/06 (PB2008-500018).

MCEER-07-0001 "Static and Kinetic Coefficients of Friction for Rigid Blocks," by C. Kafali, S. Fathali, M. Grigoriu and A.S. Whittaker, 3/20/07 (PB2007-114767).

MCEER-07-0002 "Hazard Mitigation Investment Decision Making: Organizational Response to Legislative Mandate," by L.A. Arendt, D.J. Alesch and W.J. Petak, 4/9/07 (PB2007-114768).

MCEER-07-0003 "Seismic Behavior of Bidirectional-Resistant Ductile End Diaphragms with Unbonded Braces in Straight or Skewed Steel Bridges," by O. Celik and M. Bruneau, 4/11/07 (PB2008-105141).

MCEER-07-0004 "Modeling Pile Behavior in Large Pile Groups Under Lateral Loading," by A.M. Dodds and G.R. Martin, 4/16/07(PB2008-105142).

MCEER-07-0005 "Experimental Investigation of Blast Performance of Seismically Resistant Concrete-Filled Steel Tube Bridge Piers," by S. Fujikura, M. Bruneau and D. Lopez-Garcia, 4/20/07 (PB2008-105143).

MCEER-07-0006 "Seismic Analysis of Conventional and Isolated Liquefied Natural Gas Tanks Using Mechanical Analogs," by I.P. Christovasilis and A.S. Whittaker, 5/1/07, not available.

MCEER-07-0007 "Experimental Seismic Performance Evaluation of Isolation/Restraint Systems for Mechanical Equipment – Part 1: Heavy Equipment Study," by S. Fathali and A. Filiatrault, 6/6/07 (PB2008-105144).

MCEER-07-0008 "Seismic Vulnerability of Timber Bridges and Timber Substructures," by A.A. Sharma, J.B. Mander, I.M. Friedland and D.R. Allicock, 6/7/07 (PB2008-105145).

MCEER-07-0009 "Experimental and Analytical Study of the XY-Friction Pendulum (XY-FP) Bearing for Bridge Applications," by C.C. Marin-Artieda, A.S. Whittaker and M.C. Constantinou, 6/7/07 (PB2008-105191).

MCEER-07-0010 "Proceedings of the PRC-US Earthquake Engineering Forum for Young Researchers," Edited by G.C. Lee and X.Z. Qi, 6/8/07 (PB2008-500058).

MCEER-07-0011 "Design Recommendations for Perforated Steel Plate Shear Walls," by R. Purba and M. Bruneau, 6/18/07, (PB2008-105192).

MCEER-07-0012 "Performance of Seismic Isolation Hardware Under Service and Seismic Loading," by M.C. Constantinou, A.S. Whittaker, Y. Kalpakidis, D.M. Fenz and G.P. Warn, 8/27/07, (PB2008-105193).

MCEER-07-0013 "Experimental Evaluation of the Seismic Performance of Hospital Piping Subassemblies," by E.R. Goodwin, E. Maragakis and A.M. Itani, 9/4/07, (PB2008-105194).

MCEER-07-0014 "A Simulation Model of Urban Disaster Recovery and Resilience: Implementation for the 1994 Northridge Earthquake," by S. Miles and S.E. Chang, 9/7/07, (PB2008-106426).

MCEER-07-0015 "Statistical and Mechanistic Fragility Analysis of Concrete Bridges," by M. Shinozuka, S. Banerjee and S-H. Kim, 9/10/07, (PB2008-106427).

MCEER-07-0016 "Three-Dimensional Modeling of Inelastic Buckling in Frame Structures," by M. Schachter and AM. Reinhorn, 9/13/07, (PB2008-108125).

MCEER-07-0017 "Modeling of Seismic Wave Scattering on Pile Groups and Caissons," by I. Po Lam, H. Law and C.T. Yang, 9/17/07 (PB2008-108150).

MCEER-07-0018 "Bridge Foundations: Modeling Large Pile Groups and Caissons for Seismic Design," by I. Po Lam, H. Law and G.R. Martin (Coordinating Author), 12/1/07 (PB2008-111190).

MCEER-07-0019 "Principles and Performance of Roller Seismic Isolation Bearings for Highway Bridges," by G.C. Lee, Y.C. Ou, Z. Liang, T.C. Niu and J. Song, 12/10/07 (PB2009-110466).

MCEER-07-0020 "Centrifuge Modeling of Permeability and Pinning Reinforcement Effects on Pile Response to Lateral Spreading," by L.L Gonzalez-Lagos, T. Abdoun and R. Dobry, 12/10/07 (PB2008-111191).

MCEER-07-0021 "Damage to the Highway System from the Pisco, Perú Earthquake of August 15, 2007," by J.S. O'Connor, L. Mesa and M. Nykamp, 12/10/07, (PB2008-108126).

MCEER-07-0022 "Experimental Seismic Performance Evaluation of Isolation/Restraint Systems for Mechanical Equipment – Part 2: Light Equipment Study," by S. Fathali and A. Filiatrault, 12/13/07 (PB2008-111192).

MCEER-07-0023 "Fragility Considerations in Highway Bridge Design," by M. Shinozuka, S. Banerjee and S.H. Kim, 12/14/07 (PB2008-111193).

MCEER-07-0024 "Performance Estimates for Seismically Isolated Bridges," by G.P. Warn and A.S. Whittaker, 12/30/07 (PB2008-112230).

MCEER-08-0001 "Seismic Performance of Steel Girder Bridge Superstructures with Conventional Cross Frames," by L.P. Carden, A.M. Itani and I.G. Buckle, 1/7/08, (PB2008-112231).

MCEER-08-0002 "Seismic Performance of Steel Girder Bridge Superstructures with Ductile End Cross Frames with Seismic Isolators," by L.P. Carden, A.M. Itani and I.G. Buckle, 1/7/08 (PB2008-112232).

MCEER-08-0003 "Analytical and Experimental Investigation of a Controlled Rocking Approach for Seismic Protection of Bridge Steel Truss Piers," by M. Pollino and M. Bruneau, 1/21/08 (PB2008-112233).

MCEER-08-0004 "Linking Lifeline Infrastructure Performance and Community Disaster Resilience: Models and Multi-Stakeholder Processes," by S.E. Chang, C. Pasion, K. Tatebe and R. Ahmad, 3/3/08 (PB2008-112234).

MCEER-08-0005 "Modal Analysis of Generally Damped Linear Structures Subjected to Seismic Excitations," by J. Song, Y-L. Chu, Z. Liang and G.C. Lee, 3/4/08 (PB2009-102311).

MCEER-08-0006 "System Performance Under Multi-Hazard Environments," by C. Kafali and M. Grigoriu, 3/4/08 (PB2008-112235).

MCEER-08-0007 "Mechanical Behavior of Multi-Spherical Sliding Bearings," by D.M. Fenz and M.C. Constantinou, 3/6/08 (PB2008-112236).

MCEER-08-0008 "Post-Earthquake Restoration of the Los Angeles Water Supply System," by T.H.P. Tabucchi and R.A. Davidson, 3/7/08 (PB2008-112237).

MCEER-08-0009 "Fragility Analysis of Water Supply Systems," by A. Jacobson and M. Grigoriu, 3/10/08 (PB2009-105545).

MCEER-08-0010 "Experimental Investigation of Full-Scale Two-Story Steel Plate Shear Walls with Reduced Beam Section Connections," by B. Qu, M. Bruneau, C-H. Lin and K-C. Tsai, 3/17/08 (PB2009-106368).

MCEER-08-0011 "Seismic Evaluation and Rehabilitation of Critical Components of Electrical Power Systems," S. Ersoy, B. Feizi, A. Ashrafi and M. Ala Saadeghvaziri, 3/17/08 (PB2009-105546).

MCEER-08-0012 "Seismic Behavior and Design of Boundary Frame Members of Steel Plate Shear Walls," by B. Qu and M. Bruneau, 4/26/08 . (PB2009-106744).

MCEER-08-0013 "Development and Appraisal of a Numerical Cyclic Loading Protocol for Quantifying Building System Performance," by A. Filiatrault, A. Wanitkorkul and M. Constantinou, 4/27/08 (PB2009-107906).

MCEER-08-0014 "Structural and Nonstructural Earthquake Design: The Challenge of Integrating Specialty Areas in Designing Complex, Critical Facilities," by W.J. Petak and D.J. Alesch, 4/30/08 (PB2009-107907).

MCEER-08-0015 "Seismic Performance Evaluation of Water Systems," by Y. Wang and T.D. O'Rourke, 5/5/08 (PB2009-107908).

MCEER-08-0016 "Seismic Response Modeling of Water Supply Systems," by P. Shi and T.D. O'Rourke, 5/5/08 (PB2009-107910).

MCEER-08-0017 "Numerical and Experimental Studies of Self-Centering Post-Tensioned Steel Frames," by D. Wang and A. Filiatrault, 5/12/08 (PB2009-110479).

MCEER-08-0018 "Development, Implementation and Verification of Dynamic Analysis Models for Multi-Spherical Sliding Bearings," by D.M. Fenz and M.C. Constantinou, 8/15/08 (PB2009-107911).

MCEER-08-0019 "Performance Assessment of Conventional and Base Isolated Nuclear Power Plants for Earthquake Blast Loadings," by Y.N. Huang, A.S. Whittaker and N. Luco, 10/28/08 (PB2009-107912).

MCEER-08-0020 "Remote Sensing for Resilient Multi-Hazard Disaster Response – Volume I: Introduction to Damage Assessment Methodologies," by B.J. Adams and R.T. Eguchi, 11/17/08 (PB2010-102695).

MCEER-08-0021 "Remote Sensing for Resilient Multi-Hazard Disaster Response – Volume II: Counting the Number of Collapsed Buildings Using an Object-Oriented Analysis: Case Study of the 2003 Bam Earthquake," by L. Gusella, C.K. Huyck and B.J. Adams, 11/17/08 (PB2010-100925).

MCEER-08-0022 "Remote Sensing for Resilient Multi-Hazard Disaster Response – Volume III: Multi-Sensor Image Fusion Techniques for Robust Neighborhood-Scale Urban Damage Assessment," by B.J. Adams and A. McMillan, 11/17/08 (PB2010-100926).

MCEER-08-0023 "Remote Sensing for Resilient Multi-Hazard Disaster Response – Volume IV: A Study of Multi-Temporal and Multi-Resolution SAR Imagery for Post-Katrina Flood Monitoring in New Orleans," by A. McMillan, J.G. Morley, B.J. Adams and S. Chesworth, 11/17/08 (PB2010-100927).

MCEER-08-0024 "Remote Sensing for Resilient Multi-Hazard Disaster Response – Volume V: Integration of Remote Sensing Imagery and VIEWS^{TM} Field Data for Post-Hurricane Charley Building Damage Assessment," by J.A. Womble, K. Mehta and B.J. Adams, 11/17/08 (PB2009-115532).

MCEER-08-0025 "Building Inventory Compilation for Disaster Management: Application of Remote Sensing and Statistical Modeling," by P. Sarabandi, A.S. Kiremidjian, R.T. Eguchi and B. J. Adams, 11/20/08 (PB2009-110484).

MCEER-08-0026 "New Experimental Capabilities and Loading Protocols for Seismic Qualification and Fragility Assessment of Nonstructural Systems," by R. Retamales, G. Mosqueda, A. Filiatrault and A. Reinhorn, 11/24/08 (PB2009-110485).

MCEER-08-0027 "Effects of Heating and Load History on the Behavior of Lead-Rubber Bearings," by I.V. Kalpakidis and M.C. Constantinou, 12/1/08 (PB2009-115533).

MCEER-08-0028 "Experimental and Analytical Investigation of Blast Performance of Seismically Resistant Bridge Piers," by S.Fujikura and M. Bruneau, 12/8/08 (PB2009-115534).

MCEER-08-0029 "Evolutionary Methodology for Aseismic Decision Support," by Y. Hu and G. Dargush, 12/15/08.

MCEER-08-0030 "Development of a Steel Plate Shear Wall Bridge Pier System Conceived from a Multi-Hazard Perspective," by D. Keller and M. Bruneau, 12/19/08 (PB2010-102696).

MCEER-09-0001 "Modal Analysis of Arbitrarily Damped Three-Dimensional Linear Structures Subjected to Seismic Excitations," by Y.L. Chu, J. Song and G.C. Lee, 1/31/09 (PB2010-100922).

MCEER-09-0002 "Air-Blast Effects on Structural Shapes," by G. Ballantyne, A.S. Whittaker, A.J. Aref and G.F. Dargush, 2/2/09 (PB2010-102697).

MCEER-09-0003 "Water Supply Performance During Earthquakes and Extreme Events," by A.L. Bonneau and T.D. O'Rourke, 2/16/09 (PB2010-100923).

MCEER-09-0004 "Generalized Linear (Mixed) Models of Post-Earthquake Ignitions," by R.A. Davidson, 7/20/09 (PB2010-102698).

MCEER-09-0005 "Seismic Testing of a Full-Scale Two-Story Light-Frame Wood Building: NEESWood Benchmark Test," by I.P. Christovasilis, A. Filiatrault and A. Wanitkorkul, 7/22/09 (PB2012-102401).

MCEER-09-0006 "IDARC2D Version 7.0: A Program for the Inelastic Damage Analysis of Structures," by A.M. Reinhorn, H. Roh, M. Sivaselvan, S.K. Kunnath, R.E. Valles, A. Madan, C. Li, R. Lobo and Y.J. Park, 7/28/09 (PB2010-103199).

MCEER-09-0007 "Enhancements to Hospital Resiliency: Improving Emergency Planning for and Response to Hurricanes," by D.B. Hess and L.A. Arendt, 7/30/09 (PB2010-100924).

MCEER-09-0008 "Assessment of Base-Isolated Nuclear Structures for Design and Beyond-Design Basis Earthquake Shaking," by Y.N. Huang, A.S. Whittaker, R.P. Kennedy and R.L. Mayes, 8/20/09 (PB2010-102699).

MCEER-09-0009 "Quantification of Disaster Resilience of Health Care Facilities," by G.P. Cimellaro, C. Fumo, A.M Reinhorn and M. Bruneau, 9/14/09 (PB2010-105384).

MCEER-09-0010 "Performance-Based Assessment and Design of Squat Reinforced Concrete Shear Walls," by C.K. Gulec and A.S. Whittaker, 9/15/09 (PB2010-102700).

MCEER-09-0011 "Proceedings of the Fourth US-Taiwan Bridge Engineering Workshop," edited by W.P. Yen, J.J. Shen, T.M. Lee and R.B. Zheng, 10/27/09 (PB2010-500009).

MCEER-09-0012 "Proceedings of the Special International Workshop on Seismic Connection Details for Segmental Bridge Construction," edited by W. Phillip Yen and George C. Lee, 12/21/09 (PB2012-102402).

MCEER-10-0001 "Direct Displacement Procedure for Performance-Based Seismic Design of Multistory Woodframe Structures," by W. Pang and D. Rosowsky, 4/26/10 (PB2012-102403).

MCEER-10-0002 "Simplified Direct Displacement Design of Six-Story NEESWood Capstone Building and Pre-Test Seismic Performance Assessment," by W. Pang, D. Rosowsky, J. van de Lindt and S. Pei, 5/28/10 (PB2012-102404).

MCEER-10-0003 "Integration of Seismic Protection Systems in Performance-Based Seismic Design of Woodframed Structures," by J.K. Shinde and M.D. Symans, 6/18/10 (PB2012-102405).

MCEER-10-0004 "Modeling and Seismic Evaluation of Nonstructural Components: Testing Frame for Experimental Evaluation of Suspended Ceiling Systems," by A.M. Reinhorn, K.P. Ryu and G. Maddaloni, 6/30/10 (PB2012-102406).

MCEER-10-0005 "Analytical Development and Experimental Validation of a Structural-Fuse Bridge Pier Concept," by S. El-Bahey and M. Bruneau, 10/1/10 (PB2012-102407).

MCEER-10-0006 "A Framework for Defining and Measuring Resilience at the Community Scale: The PEOPLES Resilience Framework," by C.S. Renschler, A.E. Frazier, L.A. Arendt, G.P. Cimellaro, A.M. Reinhorn and M. Bruneau, 10/8/10 (PB2012-102408).

MCEER-10-0007 "Impact of Horizontal Boundary Elements Design on Seismic Behavior of Steel Plate Shear Walls," by R. Purba and M. Bruneau, 11/14/10 (PB2012-102409).

MCEER-10-0008 "Seismic Testing of a Full-Scale Mid-Rise Building: The NEESWood Capstone Test," by S. Pei, J.W. van de Lindt, S.E. Pryor, H. Shimizu, H. Isoda and D.R. Rammer, 12/1/10 (PB2012-102410).

MCEER-10-0009 "Modeling the Effects of Detonations of High Explosives to Inform Blast-Resistant Design," by P. Sherkar, A.S. Whittaker and A.J. Aref, 12/1/10 (PB2012-102411).

MCEER-10-0010 "L'Aquila Earthquake of April 6, 2009 in Italy: Rebuilding a Resilient City to Withstand Multiple Hazards," by G.P. Cimellaro, I.P. Christovasilis, A.M. Reinhorn, A. De Stefano and T. Kirova, 12/29/10.

MCEER-11-0001 "Numerical and Experimental Investigation of the Seismic Response of Light-Frame Wood Structures," by I.P. Christovasilis and A. Filiatrault, 8/8/11 (PB2012-102412).

MCEER-11-0002 "Seismic Design and Analysis of a Precast Segmental Concrete Bridge Model," by M. Anagnostopoulou, A. Filiatrault and A. Aref, 9/15/11.

MCEER-11-0003 'Proceedings of the Workshop on Improving Earthquake Response of Substation Equipment," Edited by A.M. Reinhorn, 9/19/11 (PB2012-102413).

MCEER-11-0004 "LRFD-Based Analysis and Design Procedures for Bridge Bearings and Seismic Isolators," by M.C. Constantinou, I. Kalpakidis, A. Filiatrault and R.A. Ecker Lay, 9/26/11.

MCEER-11-0005 "Experimental Seismic Evaluation, Model Parameterization, and Effects of Cold-Formed Steel-Framed Gypsum Partition Walls on the Seismic Performance of an Essential Facility," by R. Davies, R. Retamales, G. Mosqueda and A. Filiatrault, 10/12/11.

MCEER-11-0006 "Modeling and Seismic Performance Evaluation of High Voltage Transformers and Bushings," by A.M. Reinhorn, K. Oikonomou, H. Roh, A. Schiff and L. Kempner, Jr., 10/3/11.

MCEER-11-0007 "Extreme Load Combinations: A Survey of State Bridge Engineers," by G.C. Lee, Z. Liang, J.J. Shen and J.S. O'Connor, 10/14/11.

MCEER-12-0001 "Simplified Analysis Procedures in Support of Performance Based Seismic Design," by Y.N. Huang and A.S. Whittaker.

MCEER-12-0002 "Seismic Protection of Electrical Transformer Bushing Systems by Stiffening Techniques," by M. Koliou, A. Filiatrault, A.M. Reinhorn and N. Oliveto, 6/1/12.

MCEER-12-0003 "Post-Earthquake Bridge Inspection Guidelines," by J.S. O'Connor and S. Alampalli, 6/8/12.

MCEER-12-0004 "Integrated Design Methodology for Isolated Floor Systems in Single-Degree-of-Freedom Structural Fuse Systems," by S. Cui, M. Bruneau and M.C. Constantinou, 6/13/12.

MCEER-12-0005 "Characterizing the Rotational Components of Earthquake Ground Motion," by D. Basu, A.S. Whittaker and M.C. Constantinou, 6/15/12.

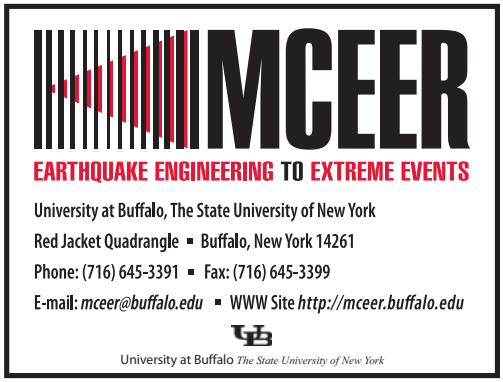
MCEER-12-0006 "Bayesian Fragility for Nonstructural Systems," by C.H. Lee and M.D. Grigoriu, 9/12/12.

MCEER-12-0007 "A Numerical Model for Capturing the In-Plane Seismic Response of Interior Metal Stud Partition Walls," by R.L. Wood and T.C. Hutchinson, 9/12/12.

MCEER-12-0008 "Assessment of Floor Accelerations in Yielding Buildings," by J.D. Wieser, G. Pekcan, A.E. Zaghi, A.M. Itani and E. Maragakis, 10/5/12.

MCEER-13-0001 "Experimental Seismic Study of Pressurized Fire Sprinkler Piping Systems," by Y. Tian, A. Filiatrault and G. Mosqueda, 4/8/13.

MCEER-13-0002 "Enhancing Resource Coordination for Multi-Modal Evacuation Planning," by D.B. Hess, B.W. Conley and C.M. Farrell, 2/8/13.



ISSN 1520-295X