Lessons From Katrina and Rita

What Major Disasters Can Teach Transportation Planners

Todd Litman
Victoria Transport Policy Institute

13 April, 2006

Abstract

This paper examines failures in hurricane Katrina and Rita emergency response and their lessons for transportation planning in other communities. Katrina's evacuation plan functioned relatively well for motorists but failed to serve people who depend on public transit. Rita's evacuation plan failed because of excessive reliance on automobiles, resulting in traffic congestion and fuel shortages. Equitable and compassionate emergency response requires special efforts to address the needs of vulnerable residents. Improved emergency response planning can result in more efficient use of available resources. This paper identifies various policy and planning strategies that can help create a more efficient, equitable and resilient transport system.

Preface

I recently purchased a fascinating book, *The San Francisco Calamity by Earthquake and Fire*, published in 1906, just a few months after that disaster occurred. There are interesting similarities between the problems described in that book and those reported 99 years later from the Katrina and Rita disasters: general panic and confusion, uncontrolled fires, reports of lawlessness that justified martial law (police and soldiers were instructed to shoot looters on sight) leading to accusations of brutality, severe thirst although fresh water was available nearby, overwhelmed medical services, homelessness and inadequate shelter, hunger and fear of starvation, overwhelmed transportation services, failing communication systems, and stories of racism and excessive suffering by poor people. Society's ability to respond to major disasters seems to have progressed little in a century.

Intelligence is reflected in our ability to learn from past events and apply general concepts to specific situations. We cannot predict the exact type of disaster that will occur in the future and the specific problems it will create, but we can develop general principles and guidance for better emergency response. It is my hope that this paper will help planners do a better job of preparing for the next major disaster, thereby reducing damage and suffering.

1906 San Francisco Earthquake and Fire Evacuation (Carleton Emmons Watkins)

1

Introduction

A good planning principle is to "hope for the best but prepare for the worst." We often have trouble imagining the worst scenario until the terrible event occurs. Only then can we evaluate our emergency response preparations. This paper examines lessons transportation planners can learn from two recent disasters: hurricanes Katrina and Rita. Planners can use this information to improve the quality of services they provide under emergency conditions and avoid repeating past mistakes.

Every disaster presents a unique combination of problems. Katrina, which hit the Gulf Coast August 29, 2005, began with a hurricane, which lead to infrastructure damage, flooding, civil disorder, fires, toxic chemical dispersion, disease risk, and thousands of people isolated for days without water, food or medical care. Rita, which hit the Coast September 24, 2005, created huge traffic congestion and fuel supply problems. There is much such disasters can teach us.

This analysis is not intended to fault individuals. Rather, it is intended to honestly examine planning failures. We can assume that nearly everybody involved in emergency response sincerely wants to do their best; after all, they and their loved ones may also require emergency services. Many emergency responders make significant personal sacrifices. If we are to make any judgments, it would be against anybody who hides, denies or understates mistakes and so prevents society from learning to avoid such errors in the future. This paper attempts to identify ways to better allow individuals to help people in emergencies.

Various long-term planning errors contributed to these disasters: the concentration of poverty in New Orleans neighborhoods vulnerable to flooding, allowing shoreline development that eliminated protective barrier islands and wetlands, and underfunding levee maintenance (Bourne, 2004; Begley, 2005). There is also evidence that global warming exacerbated hurricane impacts by increasing ocean surface temperatures. Federal security planning may have focused excessively on terrorist risks at the expense of natural risks. These are all important issues to explore, and where appropriate, correct. However, this paper focuses only on transport policy and planning issues.

It is worth noting that these disasters could have been worse. Hurricanes follow a predictable path and provide considerable warning. These cities have well-established hurricane response plans and there was ample warning. Travel conditions were good during the evacuation periods. The hurricanes did not follow the most damaging possible course, and much infrastructure survived. Although delayed, extensive emergency response and relief was provided. Actual deaths were a fraction of what could have occurred. Other conditions could result in far more deadly and damaging events.

What Failed

Katrina

It would be wrong to claim that this disaster was an unavoidable "act of god." Katrina began as a hurricane but only became a disaster because of significant, preventable planning and management failures. By most accounts, automobile evacuation functioned adequately. The plan, which involved using all lanes on major highways to accommodate outbound vehicle traffic, was well engineered and publicized (Wolshon, 2002). Motorists were able to flee the city, although congestion resulted in very slow traffic speeds and problems when vehicles ran out of fuel or had other mechanical problems.

However, there was no effective plan to evacuate transit dependent residents. In an article titled "Planning for the Evacuation of New Orleans" published in the *Institute of Transportation Engineers Journal* (Wolshon, 2002, p. 45) the author explains,

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

This indicates that public officials were aware of and willing to accept significant risk to hundreds of thousands of residents unable to evacuate because they lacked transportation. The little effort that was made to assist non-drivers was careless and incompetent. Public officials provided little guidance or assistance to people who lacked automobiles (Renne, 2005). The city established ten pickup locations where city buses were to take people to emergency shelters, but the service was unreliable. Transit dependent people were directed to the Superdome, although it had insufficient water, food, medical care and security. This lead to a medical and humanitarian crisis.

New Orleans officials were aware of the risks facing transit-dependent residents. These had been described in recent articles in *Scientific American* (Fischett, 2001) and *National Geographic* (Bourne, 2004) magazines, and from previous experience (see box on the next page). A July 2004 simulation of a Category 3 "Hurricane Pam" on the southern Louisiana coast by the Federal Emergency Management Agency (FEMA), projected 61,290 dead and 384,257 injured or sick in a catastrophic flood of New Orleans. City and regional emergency plans describe likely problems in detail (Louisiana, 2000; New Orleans, 2005).

Coastal communities flooded by Hurricane Katrina.

The *City of New Orleans Comprehensive Emergency Management Plan* (New Orleans, 2005) states:

> The city of New Orleans will utilize all available resources to quickly and safely evacuate threatened areas. ...Special arrangements will be made to evacuate persons unable to transport themselves or who require specific life-saving assistance. Additional personnel will be recruited to assist in evacuation procedure as needed. ...Approximately 100,000 citizens of New Orleans do not have means of personal transportation.

The *Southeast Louisiana Hurricane Evacuation and Sheltering Plan* specifies that school and municipal buses should be used to evacuate people who lack access to private transportation (Louisiana, 2000, p. 13):

> The primary means of hurricane evacuation will be personal vehicles. School and municipal buses, government-owned vehicles and vehicles provided by volunteer agencies may be used to provide transportation for individuals who lack transportation and require assistance in evacuating.

Some Can't Evacuate New Orleans for Ivan (A Year Before Katrina)
Free Republic (www.freerepublic.com/focus/f-news/1477282/posts), by Mary Foster, Sept. 2004.

NEW ORLEANS - Fleeing to safety was not an option for some people as 140-mph Hurricane Ivan churned toward the Gulf Coast, threatening to submerge the below-sea-level city in what could be the most disastrous storm to hit in nearly 40 years.

Latonya Hill, who waited out the dangerous storm sitting on her stoop Tuesday, said the official pleas for residents to pack up and leave meant little to her. "Got no place to go and no way to get there," said the 57-year-old grandmother, who lives on a disability check and money she picks up cleaning houses or baby sitting. "They say evacuate, but they don't say how I'm supposed to do that," Hill said. "If I can't walk it or get there on the bus, I don't go. I don't got a car. My daughter don't either."

Hill is among the estimated 100,000 people in New Orleans who rely on city transportation to get around, making evacuation impossible for them. Yet, no shelters were open in the city as of Tuesday night and there were no plans to open any. The city was working on setting up a shelter of "last resort," Mayor Ray Nagin said. No shelters had been set up yet because of concerns about flooding and capacity, Nagin added.

At 5 a.m. Wednesday, Ivan was about 220 miles from the city and moving at 12 mph. Forecasters said Ivan could bring a coastal storm surge of 10 to 16 feet, topped by large, battering waves. More than 1.2 million people in metropolitan New Orleans were warned to get out as Ivan approached, and those who could streamed inland in bumper-to-bumper traffic in an agonizingly slow exodus, spurred by dire warnings that the hurricane could overwhelm New Orleans with up to 20 feet of water.

The New Orleans Regional Transit Authority (RTA) had a hurricane evacuation policy: Drivers should evacuate buses and other agency vehicles with their families and transit-dependent residents, thereby protecting people and vehicles. There are unconfirmed stories that Amtrak offered use of a train for evacuation that was not accepted by local officials. But neither public buses nor trains were deployed to evacuate people out of the city (Murdock, 2005). Residents who wanted to leave the area by public transport were expected to pay for commercial services, a major barrier to many low-income residents. New Orleans Mayor Ray Nagin later explained that, in his interpretation, using buses to transport residents to the Superdome reflected the emergency plans' intent, and there were insufficient buses to evacuate everybody who needed assistance.

The city had approximately 500 transit and school buses, a quarter of the estimated 2,000 buses needed to evacuate residents who wanted transport (even more buses would have been needed to carry *all* residents who needed transport, since under emergency conditions it is unrealistic for a bus to carry 50 passengers). However, if given priority in traffic buses could have made multiple trips out of the city during the 48-hour evacuation period, and even evacuating 10,000 to 30,000 people would have reduced emergency shelter overcrowding. Many public buses were subsequently ruined by the flooding (Preston, 2005).

Flooded New Orleans School Buses

Federal emergency officials also failed to deploy buses for evacuation as planned. A top FEMA staff described his surprise and frustration at the agency's inadequate preparation before Katrina struck, despite his urgent warnings to agency executives (Bosner, 2005). He says that at the time he wondered, "Where are the buses to get people out of there?"

The importance of buses for evacuation of the city became clear soon after the hurricane hit. On September 1 Mayor Nagin said on a local radio station, "I need 500 buses…This is a national disaster. Get every doggone Greyhound bus line in the country and get their asses moving to New Orleans." Two weeks after the hurricane he explained on NBC's *Meet the Press* (www.msnbc.msn.com/id/9240461):

> "Sure, there was [sic] lots of buses out there, but guess what? You can't find drivers that would stay behind with a Category 5 hurricane, you know, pending down on New Orleans. We barely got enough drivers to move people on Sunday, or Saturday and Sunday, to move them to the Superdome. We barely had enough drivers for that. So sure, we had the assets, but the drivers just weren't available."

This indicates that bus deployment was ad hoc, implemented by officials during the emergency without a detailed action plan. Such a plan would include the designation of certain staff as *essential*, meaning that they are expected to work during emergency situations. Transit agency staff would have an incentive to volunteer for such a role because they would be allowed to evacuate their own families.

It is unsurprising that public officials directed transit-dependent residents to local emergency shelters, since that strategy had worked successfully during previous hurricanes. They appeared to be unaware of Katrina's greater severity, and insensitive to the risks and discomfort shelter occupants faced. A more cautious and compassionate plan would have offered all residents the option of free transport out of the city.

This situation is simply an extreme example of the problems non-drivers face every day. In most North American cities, New Orleans included, public transit is considered a mode of last resort or a novelty for tourists. Service quality is minimal, and poorly integrated into the overall transport system. The result is a huge difference in convenience, comfort and safety between motorists and non-motorists (and therefore between wealthy and poor, white and black, able and disabled), which is degrading and inequitable ("Evaluating Transportation Equity," VTPI, 2005). It is also inefficient and leads to additional problems, such as costly and dangerous rescue efforts, health problems, and distrust of authority.

After the hurricane there was no lack of material or human resources ready for deployment. Water, food, state-of-the-art equipment, and skilled rescuers were available and waiting, but were turned back, misdirected or misused (Murdock, 2005). Civil organizations were not allowed into the city to provide assistance. The American Red Cross explained soon after the hurricane struck (2005),

> Access to New Orleans is controlled by the National Guard and local authorities and while we are in constant contact with them, we simply cannot enter New Orleans against their orders. The state Homeland Security Department had requested--and continues to request--that the American Red Cross not come back into New Orleans following the hurricane. Our presence would keep people from evacuating and encourage others to come into the city.

The official response, when it came, was slow and confused, leaving tens of thousands of people without food, water, medical treatment or public services. Civil disorder developed, with reports of looting and violence, and poor coordination among public officials (Bradshaw and Slonsky, 2005).

With better planning, hundreds of deaths could have been avoided and billions of dollars in property and productivity could have been preserved. Better planning could also have greatly reduced the fear, discomfort, frustration and violence experienced by residents.

Rita

Hurricane Rita hit the Louisiana and Texas coasts September 24. Public officials ordered evacuations of coastal cities, and provided free bus transportation for non-drivers. More residents responded to evacuation instructions. This resulted in significant problems automobile traffic problems (Blumenthal, 2005).

An estimated three million people evacuated the Texas coast, creating colossal 100-mile-long traffic jams that left many stranded and out of fuel. Drivers heeding the call to evacuate Galveston Island and other low-lying areas took 4 and 5 hours to cover the 50 miles to Houston, and from there roadway conditions were even worse, with traffic crawling at just a few miles per hour.

Many fuel stations ran out of gasoline, because fuel truck drivers did not report to work. Some evacuees spent hours searching for fuel. Despite high heat and humidity, many evacuees did not use their vehicle air conditioning to save fuel. Vehicles failed along the way due to overheating and running out of fuel, further increasing congestion. There were inadequate washrooms and emergency services. After crawling only 10 or 20 miles in nine hours, some drivers turned around to take their chances at home rather than risk being caught in the open when the hurricane struck.

Timothy Adcock, 48, a Houston landscaper in the 15th hour of inching to north a companion's truck after his car broke down under the grueling conditions, said, "I never saw anything so disorganized. We did everything we were supposed to do; secure our house, left early, checked routes, checked on our neighbors, but when we got out there we were totally on our own." A high-occupancy vehicle lane went unused, he said, and they saw no police officers. At one point, Mr. Adcock said, he called the Texas DOT for an alternate route, but the woman who answered could not find a map.

Many stranded drivers said they had responded to official pleas to flee made by Mayor White and Judge Eckels, who often invoked the specter of Hurricane Katrina. "Don't wait, the time for waiting is over," Mr. White urged Wednesday. "Don't follow the example of New Orleans and think someone's going to get you." But Thursday as the traffic chaos worsened, he and Judge Eckels appeared to back off their dire warnings, saying that the only mandatory evacuation order concerned those in flood-prone areas along the coast. "The biggest flaw in this plan was communications," Judge Eckels said. "They didn't understand what could happen. We did not do a good enough job of telling people that you get on the road, it may take 20 hours."

County officials admitted that their plans had not anticipated the volume of traffic. They maintained that they had not urged such a widespread evacuation, although only a day earlier they invoked the specter of Hurricane Katrina to urge all residents to leave. Officials also made matters worse by announcing at one point that they would use inbound lanes on one highway to ease the outbound crush, only to abort the plan later, saying it was impractical, because the route was still needed to get resources into the city.

Educated by Rita – Editorial
New York Times (www.nytimes.com), 24 Sept. 2005.

Three weeks after the nation was shocked to realize how little the government knew about emergency management in New Orleans, another hurricane has hit the South and made it clear that the learning curve is still daunting.

There was little danger that Rita would fail to get the authorities' full attention, or that people in the potential path of danger would not heed warnings to evacuate. But when Houston residents were told to leave, they found themselves stranded and sweltering in 90-degree heat in colossal traffic jams.

High-occupancy-vehicle lanes went unused, as did many inbound lanes of highways, because authorities inexplicably waited until late Thursday to open some up. Some motorists discovered, in terror, that they were stuck in what could be the hurricane's path. Tragically, one bus carrying elderly nursing home residents caught fire, killing 24.

If Katrina exposed what happens when many people have no cars to escape danger, Rita seemed to show the other side of the coin. The authorities are going to have to become much more sophisticated about developing evacuation plans that do not put every family on the highway in its own vehicle. But the car-obsessed American public is going to require a lot of education before many will accept the idea that they should flee disaster via mass transit.

Some Rita-related failures seemed inexplicable. A dearth of federal security screeners at Houston's airports led to long lines for passengers trying get out of the city. The Homeland Security Department should have anticipated that problem. Houston's shortage of emergency shelters and the local officials' apparent reluctance to let the public know where space was available were hard to comprehend.

Traffic congestion leaving Houston during Rita evacuation.

Police maintain order at gas stations.

Fuel was difficult to find.

Harris County emergency management coordinator Frank E. Gutierrez, explained that their evacuation models envisioned 0.8 to 1.2 million people but more than 2.5 million fled Rita. State officials promised to send gas trucks to relieve fuel shortages but their mobilization was slow. Gutierrez said the city intended to send out vans and buses with water for stranded people, and to evacuate people by buses, as needed. City officials put out a call for volunteers to help load vans and buses with water.

As congestion worsened state officials announced that contraflow lanes would be established on I-45, 290 and I-10. But by mid-afternoon, with traffic immobile on 290, the plan was dropped, stranding many and prompting other to reverse course. "We need that route so resources can still get into the city," explained an agency spokeswoman.

The Houston area's two major air gateways, Hobby Airport and Bush Intercontinental, suffered major delays when more than 150 screeners from the Transportation Security Administration, facing their own evacuation concerns, did not show up for work. The agency later rushed in replacements, but passengers, already burdening the system with extra luggage for their trips to safety, waited for hours to go through security.

Evacuation Picked Apart In Houston: Task Force Zeroes In On Traffic Flow, Fuel Supplies, Communication And Special Needs, by Rad Sallee, *Houston Chronicle* (www.chron.com), 27 Oct. 2005

Who should evacuate, when should they go, and how can their safety be guaranteed along the way were among the issues discussed at the governor's evacuation task force meeting Wednesday. Jack Little, chairman of the Task Force on Evacuation Transportation and Logistics, said the group will focus on "four very large, overarching needs":
  • Traffic flow, from the surge zones to shelter destinations.
  • Fuel availability along the evacuation routes.
  • Evacuation of those with special needs such as hospital and nursing home patients.
  • Communication and coordination among governmental bodies and with the public.

The public meeting in Houston is the first of several statewide. The task force will probably report its findings before June 1, when next year's hurricane season begins, said Kathy Walt, spokeswoman for Gov. Rick Perry. Mayor Bill White said the most urgent needs that local governments cannot provide are "fuel ... and incident management along the highways."

County Judge Robert Eckels said "communication was probably the biggest failure." During Hurricane Rita, he said, many evacuees hit the road without knowing how long the trip would take or how much fuel, food and water they would need.

Task force member Bill King, former mayor of Kemah, noted that centralizing authority for evacuation had been "resisted" by local governments and asked Galveston City Manager Steve LeBlanc if some might welcome such centralization now. Le- Blanc said he thought they would. "We have to get out first," LeBlanc said. He noted that the plan called for a sequenced evacuation, but "it just didn't get followed."

Shoreacres Mayor Nancy Edmonson echoed LeBlanc in saying the critical problem was "to keep people off the road who don't need to be there." She said west Houston and other inland areas are unlikely to be flooded, and their residents should shelter in place. Instead of controlling the lights, she said, police in some towns seemed focused on keeping evacuees from leaving the roadway. She said some people need to pick up relatives along the way.

Mayor Bill Jackson of Bayou Vista recommended posting National Guard troops to help police at barricades, which would free law officers to patrol the routes. Houston did not need to evacuate, Jackson said, "but my city would be totally and completely destroyed."

Bellaire Mayor Cindy Siegel disagreed. Although her city is not in a storm-surge zone, 80% of its homes flooded during Tropical Storm Allison, she said. And it has two large nursing homes with patients who would die if power were cut off for a long time, as in New Orleans after Hurricane Katrina, she said.

Galveston Mayor Lyda Ann Thomas said finding shelters was as big a problem as transportation. She said Galveston residents spent 18 hours getting to Huntsville, their initial destination, only to be "shuffled off" to Buffalo, Centerville and other towns. "What I'm looking for is specific shelters for Galveston and Galveston County," she said.

Houston METRO's described his agency's response to Hurricane Rita (Wilson, 2005).

> Public transit is an extremely versatile and flexible asset that can provide on-demand, custom services tailored to the unplanned needs of tens of thousands of people. We became, in effect, the means by which thousands of people, who had no way out, actually got out or got to safety in area shelters. METRO deployed multi-purpose services, including round trip transit, rescue of evacuees, humanitarian lifeline services, and demand response emergency relief.
>
> Specifically, during Hurricane Rita, METRO used over 1,000 vehicles to transport more than 20,000 people during 4,500 trips. We also used 18 METRO buses, plus operators and police – along with 350 wonderful volunteers – to load and dispense 45,000 bottles of water to stranded motorists along area freeways. METRO conducted last minute "sweeps" of the freeways to rescue motorists and residents seeking shelter. We suspended bus service at 2 pm on Thursday, Sept. 22, the day before Rita landed, to use as many vehicles as necessary for the evacuation.

Summary of Planning Problems

Table 1 summarizes various problems encountered during Katrina and Rita.

Table 1 **Examples of Poor Decision-Making**

General	Transportation
• Failure to track the number of people at emergency shelters, and provide adequate facilities and resources.	• Failure to have an effective evacuation plan for non-drivers.
• Failure to define who is in charge, conflicts over authority, and inadequate communication among top-level decision-makers.	• Failure to prioritize evacuation to insure that the most vulnerable (residents of the riskiest areas and people with special needs) leave first.
• Failure to distribute food and water immediately after the hurricane.	• Failure to understand and address the reasons that discourage people from evacuating.
• Waiting until the fourth day to deploy the National Guard and supply ships waiting nearby.	• Failure to offer free or subsidized evacuation transport to people who need it.
• Failure to provide security to rescue teams.	• Failure to prioritize evacuation traffic to favor buses, HOVs and service vehicles.
• Failure to help evacuate families of essential staff (police, fire, transit, healthcare, utility, etc.) so they could concentrate on emergency response.	• Failure to implement a transit and school bus "evacuation action plan."
• Failure of communications systems (telephone service stopped) and backup generators at critical facilities.	• Failure to use counterflow lanes and road shoulders for evacuation traffic, in some cases where it was possible.
• Official overreaction to reports of violence, and so failing to provide help or allow evacuation of some people, particularly African-Americans.	• Failure to coordinate vehicle rentals, fuel distribution and services along evacuation route.
• Failure to show respect and compassion to disadvantaged people.	• Failure to use public transit, school buses, charter buses and trains for evacuation. • Failure to accommodate pets.

Other countries have more effective disaster response than the U.S. For example, by all accounts Cuba has an outstanding system to alert residents, organize evacuations, maintain public services during evacuation periods, and repair damages (Cohn, 2005; Martin, 2005). It accommodates special needs, such as medical services for evacuees. Cuba is a socialist dictatorship. Its economic policies are not an attractive model. But it demonstrates that financial or technical resources are not the key to effective emergency response. Rather than dismissing Cuba's disaster response programs because the government is communist, it would be better to learn from them and do even better.

Overcoming Resistance to Evacuation

It is important to understand why some people refused to evacuate when ordered before and after Katrina struck. Interviews indicated various reasons:

- Many lower income people lacked a vehicle and money.

- Many had no place to go and were fearful of conditions in emergency shelters.

- Many had survived previous hurricanes safely in their homes.

- Many did not expect the hurricane to be as bad as it was.

- Some wanted to protect their homes or pets.

- Some were proud of their ability to endure disaster risks and discomfort.

Various strategies could be used to increase evacuation rates, including more information on the risks facing people who stay, subsidized transportation, more comfortable and secure shelters, and better protection of homes. Had residents been offered free transportation out of and back to the city, and assurance of a relatively comfortable and safe refuge, perhaps half of those who stayed would have left. This would have greatly reduced crowding at emergency shelters and subsequent rescue problems. Assuming 200,000 residents had accepted free evacuation transportation at a cost of $100 each, it would have required $20 million in subsidy. This may seem costly for a single city (it represents about 20% of the regional transit agency annual budget), but is tiny compared with the costs it would have avoided.

Pets present a particular challenge. Before a disaster strikes it seems unreasonable to abandon or destroy pets. It is therefore important to try to accommodate pets, by allowing animals to accompany evacuees (perhaps only small animals in a carrying cage) or by having special SPCA services to collect pets and house them in kennels.

Caring For The Most Vulnerable

An important test of a transportation system's effectiveness and fairness is its ability to accommodate the needs of the most vulnerable users under extreme conditions (Litman, 2004). Katrina disaster response failed in those terms. People who had resources were served relatively well because planners are familiar with their abilities and needs. People who were poor, disabled or ill were not well served, apparently because decision-makers were unfamiliar with and insensitive to their needs.

The City of New Orleans does provided a section on "Emergency Guide for Citizens with Disabilities" in its *Comprehensive Emergency Management Plan* posted on the City's website (New Orleans, 2005), but it contains little practical support, placing most of the responsibility for safety and evacuation on individuals. The Guide recommends that people with disabilities develop a "support system" to provide help during disasters. The "General Evacuation Guidelines" advises, "If you need a ride, try to go with a neighbor, friend, or relative," but provides no directions for people who lack neighbors, friends or relatives who have extra capacity in their evacuation vehicles, which is likely to be common in areas were poverty is concentrated.

Non-drivers include a diverse group of people who face various combinations of physical, economic and social disadvantages. A system designed for non-drivers must therefore be able to accommodate a wide range of needs, including poverty, physical and mental disabilities (Access Board, 2005), illnesses, inability to speak or read English, parents with young children, distrust of authority, frustration and anger. Many non-drivers lack convenient access to the Internet, and some lack regular telephone and mail service. Many had nowhere to stay outside of the city and no money to pay for housing, food or return transportation. Understanding and responding to these diverse needs is therefore important for effective disaster management and evacuation planning.

Under emergency conditions public infrastructure may be stressed. For example, a typical bus can normally carry about 50 passengers, but in an emergency, with evacuees carrying baggage, some in wheelchairs, and communication systems overwhelmed, 30-40 passengers is a more realistic load. It will therefore be important to provide a generous amount of overcapacity and redundancy.

Planning For Resilience

A key concept recognized by engineers and planners is the value of *resilience* ("Evaluating Transportation Resilience," VTPI, 2005), which refers to a system's ability to accommodate variable and unexpected conditions without catastrophic failure, or "the capacity to absorb shocks gracefully" (Foster, 1993).

Resilience acknowledges *uncertainty*, our inability to know what combination of conditions will occur in the future. If the future were predictable, resilience would lose its importance: individuals and communities would simply need to plan for a single set of conditions. But since the future is unpredictable, it is necessary to plan for a wide range of possible conditions, including some that may be unlikely but which could result in significant harm if they are not anticipated.

Resilience tends to increase if a system has diversity, redundancy, efficiency, autonomy and strength in its critical components. This allows the system to continue functioning if a link is broken, if a particular resource becomes scarce, if a particular decision-maker is unavailable, etc. Resilience is affected by a system's ability to collect and distribute critical information under extreme conditions. Resilience tends to increase if a system has effective ways to prioritize resources. For example, evacuations could be more efficient if buses and trains were given priority where needed to avoid congestion and bottlenecks, or to use limited fuel resources most efficiently.

A single highway lane can typically accommodate a maximum of about 2,000 vehicles per hour, but less under mass evacuation conditions because of congestion, diverse and overloaded vehicles (many tow heavily loaded trailers), weather (rain and flooding), infrastructure failures (such as earthquake damage), and vehicle mechanical problems, crashes and driver confusion. Assuming that each highway lane accommodates 1,000 vehicles per hour under such conditions and vehicles carry an average of 2.5 passengers, each lane accommodates 2,500 passengers per hour. A four-lane highway can therefore evacuate about 10,000 people per hour, or 20,000 if inbound lanes are reversed. A city with one million residents and two four-lane highways in functional conditions would therefore require about 50 hours to evacuate all residents by automobile.

Assuming that a highway lane can accommodate 600 buses per hour (according to the *Highway Capacity Manual* a bus or truck represents 1.5 Passenger Car Equivalents on level highway conditions, and 2.5 under rolling conditions) and buses carry an average of 25 passengers, each bus lane accommodates 15,000 passengers per hour, the same as six lanes of automobile traffic. Highway capacity can therefore more than double by dedicating one lane to buses and encouraging residents to use buses and other high occupant vehicles such as vans with more than six passengers ("HOV Priority," VTPI, 2005). A city with one million residents and two four-lane highways in functional conditions would therefore require only about 24 hours to evacuate all residents if about half are transported by bus and other high occupancy vehicles. In some situations trains may also be useful for mass evacuations. Urban light rail lines can carry 20,000 passengers per hour, and heavy rail lines even with good management.

Mobility management has other applications in emergency situations. During Oakland, California wildfires in 2004, residents who walked down the hills survived but many who tried to drive were delayed and perished. During disasters, emergency responders are sometimes more mobile using bicycles than motor vehicles. Evacuation congestion is often exacerbated by households that drive multiple vehicles, some towing trailers filled with household goods; traffic would flow more efficiently if evacuees have instructions and incentives to use minimal vehicles and limit the amount of goods they carry.

Resilience is also important for addressing long-term changes, such as traffic problems resulting from roadway damage (Giuliano and Golog, 1998), and increasing fuel prices. For example, the financial burden of increased fuel prices is reduced if a community has good travel alternatives (walking and cycling conditions, rideshare and public transit services, telecommuting, delivery services, etc), and so can reduce vehicle use with minimal problem. This flexibility benefits not only people who shift mode and reduce their automobile travel, but also those who continue driving, due to reduced congestion and reduced fuel demand, which reduces price increases.

Below are examples of specific ways to increase transportation system resilience ("Evaluating Transportation Resilience," VTPI, 2005).

- Value diversity, flexibility and redundancy ("Evaluating Transport Diversity," VTPI, 2005). Develop a multi-modal transportation system that provides a variety of mobility options.

- Design transportation facilities to withstand extreme conditions (earthquakes, storms, etc.).

- Create transportation system networks that provide multiple links to each destination, including multiple rail lines, roads, paths and bridges.

- Plan transportation systems to provide *basic mobility* ("Basic Mobility," VTPI, 2005). Insure that transport planning takes into account people with special needs (physical disabilities, low incomes, inability to speak the local language, etc.). Work with community organizations to identify their needs and maintain effective communications with vulnerable groups.

- Develop effective ways to maintain information and communication systems among transport system managers, staff and users under normal and extreme conditions. Develop ways to communicate with residents and travelers under emergency conditions.

- Develop ways to prioritize transport system resources when necessary. For example, design systems to allow emergency, service and freight vehicles priority over general traffic. Maintain contingency plans to allocate fuel and other resources in emergencies.

- Maintain ongoing transportation systems evaluation to provide early detection of possible problems and inefficiencies.

- Design critical components of the transportation system to be fail-safe, self-correcting, repairable, redundant and autonomous. For example, where possible use roundabouts instead of traffic signals, since they function without electricity.

- Cross-train staff to perform critical management and repair services.

- Encourage efficient use of resources, including traffic management, energy efficiency and accessible land use.

Disaster Transportation Issues

Disasters can present various transportation issues:

- Evacuations before, during or after an event, and adequate accommodation of evacuees at refuge destinations.

- Delivery of emergency supplies and services, including water, food, medical care, utility maintenance, law enforcement, etc.

- Search and rescue operations.

- Quarantine.

- Transportation infrastructure repair.

Many disasters involve a variety of catastrophes, such as an earthquake that causes fires and toxic chemical release. Specific transport issues vary depending on the type and scale of disaster, as summarized below. Major emergencies require regional planning and coordination, since disasters do not recognize jurisdictional boundaries.

Table 2   **Major Transportation Issues**

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

Different types of disasters present different types of transportation issues.

Evacuation activities can vary depending on the type and scale of disaster. Some disasters require mass evacuations. Others, such as earthquakes and fires, require evacuation from collapsed structures to local hospitals and shelters. Even a small building fire, such as an apartment building, might require evacuation of residents to hospitals and temporarily shelters. Emergency transportation and public transit services are therefore an important component of all emergency preparedness efforts.

Role of Automobile Transportation

Some critics argue that the best way to improve emergency transportation is to increase automobile ownership and roadway capacity. In a message distributed after Katrina but before Rita, O'Toole (2005) pointed out most New Orleans residents with automobiles could evacuate with relative convenience and comfort, and so argues that the best evacuation strategy is to subsidize car ownership for households that lack vehicles. But such arguments ignore several important points (Litman, 2005).

- Many people cannot drive due to disabilities, age, addictions, legal restrictions, or other problems. Encouraging such people to drive is impractical and dangerous.

- Many vehicles, particularly the older vehicles typically owned by lower-income people, tend to be unreliable and unsafe. Even people who own a car need backup transport options.

- Automobiles cannot be used in some disaster situations. Earthquakes, storms and floods often damage vehicles, highways and bridges (Giuliano and Golog, 1998).

- Increased automobile ownership would exacerbate traffic congestion. Hurricane Rita evacuation failed due to too many private vehicles.

- The reduction in hurricane deaths cited by O'Toole has been offset many times over by increased automobile traffic deaths.

O'Toole argues that it would be cheaper to purchase cars for nonmotorists than to build New Orleans' streetcar system, but his accounting ignores many costs (operating expenses, parking, road capacity, crash damages, etc.), and the used vehicles he proposes purchasing would require frequent repairs and only last a few more years, compared with the 20-40 year operating life of a train and 50+ years of a rail line. The gift of a "free" car can be a curse to financially struggling families since it adds hundreds of dollars in annual expenses for insurance, fuel, tires and repairs. At $3,500 annually ($1,000 in capital and $2,500 in operating expenses), providing cars to 100,000 New Orleans households that lack vehicles would cost $350 million, more than three times the regional transit budget, plus large additional costs to expand road and parking capacity.

Cox (2005) argues that urban national highways should be expanded to facilitate automobile evacuations, but the costs would be immense since expanding urban highways is particularly costly. Current roadway funding is hardly adequate to maintain the current system and there appears to be little public support for tax increases. It would be inefficient to size all roadways for evacuations that only occur once a century at any particular location, if other strategies can accommodate such needs at lower cost.

Described differently, emergency response requires *mobility*. Automobiles provide mobility, but have high total costs and constraints that limit their use in some situations and for some people, particularly those most vulnerable. Although it makes sense to increase automobile affordability through true cost-saving strategies such as carsharing and Pay-As-You-Drive insurance ("Affordability," VTPI, 2005), it is wrong to assume that automobile solutions are most appropriate or cost effective in every situation.

Best Practices

Many jurisdictions and agencies have emergency response plans, but they often lack details. Emergency action plans are needed that specify exactly who will do what, when. Such plans must be tested occasional with multi-agency practice sessions. Below are recommendations for effective emergency transportation plans (TRB, 2005):

- Include disaster response as part of all transportation planning (local, regional, national, transit, etc.). Consider the widest possible range of possible disasters and stresses on the transport system, and consider the widest possible range of possible solutions.

- Identify exactly who will do what during disasters.

- Update emergency response plans regularly, particularly after a disaster tests its effectiveness.

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

- Use counterflow and highway shoulders for evacuation routes, and apply other traffic management strategies where appropriate.

- Coordinate vehicle rentals and fuel supplies, provide special services (information, water, food, washrooms, medical services, vehicle repairs, etc.) along evacuation routes,

- Create communication and support networks that serve the most vulnerable people. Establish a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation, and establish a chain of responsibility for caregivers. Provide instructions on pickup locations and what evacuees should bring. This information should be distributed regularly, not just when major emergencies occur.

- Give buses and other high occupancy vehicles priority where critical resources (road space, ferry capacity, fuel, repair services, etc.) are limited.

- Be ready to quickly deploy buses, vans and trains. This requires an inventory of such vehicles and their drivers, and clearly established instructions for their use.

- Coordinate fuel, emergency repair and other support services.

Developing communication and support networks that serve vulnerable people requires effective community outreach. Each neighborhood should have an inventory of people who may need assistance, ways to contact them, directions for their evacuation, and a list of their friends and family who can provide emergency support. If possible, social service agency staff or volunteer community leaders should travel with vulnerable evacuees to provide information and reassurance to people who may be frustrated and frightened. Implementing such a system requires that planning professionals work with a broad range of community groups, professionals and social service organizations.

There are often years or even decades between major disasters, so it is important to preserve institutional memory by documenting successes and failures, and updating emergency plans while the experience is still fresh.

Conclusions

This paper identifies ways to improve emergency response transportation services based on experience gained during two recent hurricanes. Katrina and Rita provide important and different lessons. Katrina's evacuation was relatively effective for people with automobiles but failed transit-dependent residents. Non-drivers received better services during Rita's evacuation, but excessive vehicle traffic created problems for motorists. Counterflow lanes were not implemented, fuel was poorly distributed, basic services (such as washrooms) were not provided along the evacuation route, and traffic was poorly managed.

This experience indicates that the best way to quickly evacuate a large city is to give buses, and perhaps private high occupancy vehicles, priority in traffic and fuel access, and then accommodate as many low-occupancy vehicles as resources allow. Individuals can choose between accepting a free and fast bus ride, or driving a private vehicle and facing congestion delays.

Planners can help prevent future disasters by demanding that emergency response plans devote at least as much attention to non-automobile evacuation as to automobile-based evacuation, and by developing ways to prioritize use of critical transportation resources, such as road capacity and fuel, during emergencies. Planners need to anticipate the needs of non-drivers, who include many people with various physical, economic and social problems. This may require community outreach to build understanding and trust among public officials and the people they serve before an emergency occurs. Extra effort should be made to offer comfort to evacuees, for example, by providing washrooms and information stations along evacuation routes, and having public officials and community volunteers accompany evacuation buses to provide physical and emotional support.

It is important to understand why many people ignore evacuation orders. Some face logistical or financial barriers obtaining transportation. Some had nowhere to go and are fearful of emergency shelter conditions. Some stay to protect their property or pets, or out of bravado. Addressing these objections can increase evacuation rates.

Katrina evacuation problems are simply extreme examples of the day-to-day problems facing non-drivers due to inadequate and poorly integrated transportation services. Rita evacuation problems are simply extreme examples of the day-to-day traffic problems that result from excessive reliance on automobile transport without efficient management. Transportation professionals can play an important role in creating a more equitable and efficient transportation system. It would be helpful for all transportation professionals to spend at least two weeks each year without driving so they can directly experience the non-automobile transportation system that they help create.

A variety of planning policies and programs can help create a more resilient transport system. These increase system diversity and integration, improve user information, prioritize resource use, and provide coordinated services during special events and emergencies. Such policies can save lives, reduce suffering, and provide substantial savings and benefits to society.

References and Information Resources

Access Board (2005), *Resources on Emergency Evacuation and Disaster Preparedness*, Access Board (www.access-board.gov/evac.htm). Discusses evacuating people with disabilities.

American Red Cross (2005), "Hurricane Katrina: Why is the Red Cross not in New Orleans?" *Frequently Asked Questions*, (www.redcross.org/faq/0,1096,0_682_4524,00.html)

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

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

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

Ralph Blumenthal, "Miles of Traffic as Texans Heed Order to Leave," *New York Times*, (www.nytimes.com/2005/09/23/national/nationalspecial/23storm.html), September 23, 2005

Leo Bosner (2005), Radio Interview, *National Public Radio*, 16 September 2005.

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

Larry Bradshaw and Lorrie Beth Slonsky (2005), *Hurricane Katrina - Our Experiences*, EMSNetwork.org (www.emsnetwork.org/artman/publish/article_18427.shtml), 6 Sept. 2005.

Bring New Orleans Back (www.bringneworleansback.org) is a committee of local and national leaders that developed recommendations for rebuilding the city, which included emphasis on public transit and smart growth.

Marjorie Cohn (2005), "Cuba's hurricane response far superior to America's," *La Prensa San Diego* (www.laprensa-sandiego.org/archieve/september09-05/superior.htm), 9 September 2005.

Wendell Cox (2005), "Highways to Hell: Investing In Our Safety," *National Review* (www.nationalreview.com/comment/cox200509270811.asp).

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

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

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

Mary Foster (2004), "Some Can't Evacuate New Orleans for Ivan," *Free Republic* (www.freerepublic.com/focus/f-news/1477282/posts), from Associated Press.

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

Todd Litman (2004), *Evaluating Transportation Equity*, VTPI (www.vtpi.org).

Todd Litman (2005), *Evaluating Rail Transit Criticism*, VTPI (www.vtpi.org).

Louisiana (2000), *Southeast Louisiana Hurricane Evacuation and Sheltering Plan*, State Of Louisiana (www.ohsep.louisiana.gov/plans/EOPSupplement1a.pdf).

Susan Taylor Martin (2005), "Can we learn from Cuba's lesson?" *St. Petersburg Times* (www.sptimes.com/2005/09/09/Worldandnation/Can_we_learn_from_Cub.shtml), 9 Sept. 2005.

Cash Michaels (2005), "What Really Happened? Week of Sept. 8-14," *Wilmington Journal* (http://wilmingtonjournal.blackpressusa.com/news/Article/Article.asp?NewsID=61378&sID=12), 11 Sept. 2005.

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

Deroy Murdock (2005), "Multi-Layered Failures: Government Responses To Katrina," *National Review* (www.nationalreview.com/murdock/murdock200509130839.asp), 13 September 2005.

New Orleans (2005), *City of New Orleans Comprehensive Emergency Management Plan*, City of New Orleans (www.cityofno.com).

Randal O'Toole (2005), *Lack of Automobility Key To New Orleans Tragedy,"* The Thoreau Institute (www.ti.org). Also published as "Mobility Counted Most in Fleeing New Orleans," *Seattle Times* (http://seattletimes.nwsource.com), 14 September 2005.

Nancy W. Okasaki (2003), "Improving Transportation Response and Security Following a Disaster," *ITE Journal* (www.ite.org), August 2003, pp. 30-32.

B. Preston (2005), *Less Than A Mile From The Dome*, JunkYardBlog (http://junkyardblog.net/archives/week_2005_08_28.html).

John Renne (2005), *Car-less in the Eye of Katrina*, Planetizen (www.planetizen.com/node/17255), 6 September 2005.

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

Safety and Security Website (http://transit-safety.volpe.dot.gov), Federal Transit Administration, provides information on transit safety and security issues, including disaster preparedness.

TRB, *Public Transportation Security: Volume 7: Public Transportation Emergency Mobilization and Emergency Operations Guide*, Transit Cooperative Research Project, Transportation Research Board (www.trb.org), 2005; available at www.trb.org/publications/tcrp/tcrp_rpt_86v7.pdf.

VTPI (2005), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org).

Wikipedia (2005), "Hurricane Katrina," (http://en.wikipedia.org/wiki/Hurricane_Katrina).

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

Brian Wolshon (2002), "Planning for the Evacuation of New Orleans," *ITE Journal* (www.ite.org/itejournal/index.asp), February 2002.

Acknowledgements