This is a continuing series of quarterly articles on lessons learned and best practices in civil engineering education. The intent of the series is to reinforce good practices, describe new or developing practices, and provide a forum for what works well and what does not.

Lessons From Katrina and Rita: What Major Disasters Can Teach Transportation Planners

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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 forum 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 problems in the future.

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

This analysis is not intended to fault individuals but 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 assistance during a disaster, and many emergency responders make significant personal sacrifices to help. This forum 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 forum 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. The cities have well-established hurricane response plans and there was time to prepare. Travel conditions were good during the evacuation period. 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 (see Table 1). 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 nondrivers was careless and incompetent. Public officials provided little guidance or assistance to people who lacked automobiles (Renne 2005). The city established 10 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. 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).

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.

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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 nondrivers
• Failure to define who is in charge; conflicts over authority; and inadequate communication among top-level decision-makers	• Failure to prioritize evacuation to ensure that the most vulnerable (residents of the riskiest areas and people with special needs) leave first
• Failure to distributed 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 failure 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 use public transit, school buses, charter buses, and trains for evacuation	• Failure to accommodate pets
• Failure to show respect and compassion to disadvantaged people	

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.

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).

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*:

> "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 nondrivers 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 nonmotorists (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.

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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, and frustration experienced by evacuees, and the feeling of distrust and resentment that this generates (Bullard and Wright 2005).

Rita

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

An estimated 3 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 to 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 (Blumenthal 2005).

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. Don't follow the example of New Orleans and think someone's going to get you." But after 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.

Harris County emergency management coordinator Frank E. Gutierrez explained that their evacuation models envisioned 0.8 to 1.2 million people but that 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 midafternoon, with traffic immobile on 290, the plan was dropped, stranding many and prompting others 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.

Overcoming Resistance to Evacuation

It is important to understand residents' reasons for refusing to evacuate when ordered before and after Katrina struck. Interviews and surveys of people who stayed in New Orleans indicate various reasons for their decision:

- 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 the risks and discomfort of the disaster.

Various strategies would probably be needed 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

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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 ("Basic Mobility," VTPI 2005). 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 Web site (New Orleans 2005), but it places 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 guidance for people who lack neighbors, friends, or relatives with extra capacity in their evacuation vehicles, which is likely to be common in areas where poverty is concentrated.

Nondrivers include a diverse group of people who face various combinations of physical, economic, and social disadvantages. A system designed for nondrivers 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 nondrivers 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 resources may be stressed. For example, a typical bus can normally carry about 50 passengers, but in an emergency, with evacuees carrying baggage and some in wheelchairs, and drivers stressed, 30–40 passengers is a more realistic load. It is therefore important to provide 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 fewer 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 h 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 h 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.

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 faced by consumers from increased fuel prices is reduced if their community has good travel alternatives (walking and cycling conditions, rideshare and public transit services, telecommuting, and delivery services that substitute for physical travel), and so have the ability to reduce their 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 greater price elasticities, so fuel price rises will tend to be smaller.

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Table 2. Major Transportation Issues

Disaster	Geographic Scale	Warning	Evacuation	Emergency Services	Search and Rescue	Quarantine	Infrastructure 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							
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	×	×	×	—	×

Note: Different types of disasters present different types of transportation issues.

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

- Include disaster response as part of all transportation planning (local, regional, national, transit, etc.). Consider the widest possible range of possible disaster and stresses on the transport system, and consider the widest possible range of possible solutions.
- Develop an emergency action plan that identifies who will do what during disasters. Update the plan regularly, particularly after a disaster event tests its effectiveness.
- Value diversity, flexibility, and redundancy("Evaluating Transport Diversity," VTPI 2005). Develop a multimodal 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.
- Develop plans to provide basic mobility under all conditions. Ensure 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 energy conservation 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; and
- 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 (see Table 2).

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

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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 typically adds a minimum of $2,500 in annual operating expenses for insurance, fuel, tires, and repairs, representing a quarter of annual income for a minimum wage worker or pensioner. 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 multiagency practice sessions.

Automobiles are important for disaster response. Officials can give motorists directions, coordinate vehicle rentals and fuel supplies, provide special services along evacuation routes, use counterflow and highway shoulders as traffic lanes, and apply other traffic management strategies. But automobile transport alone is inadequate because some people lack vehicles and traffic capacity is often limited. 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.

Emergency transportation plans should include

- Communication and support networks that serve the most vulnerable people. This involves a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation, and establish a chain of responsibility for caregivers.
- Planning to allow quick deployment of buses, vans, and trains. This requires an inventory of such vehicles and their drivers, and clearly established instructions for their use.
- A system to prioritize evacuations based on factors such as geographic location (evacuate the highest risk areas first), and individual need and ability.
- Emergency evacuation information distributed to at-risk populations and all officials, including instructions on pickup locations and what evacuees should bring. This information should be distributed regularly, not just during major emergencies.
- Coordination of fuel, emergency repair, and other support services.
- Priority for buses and other high occupancy vehicles where critical resources (road space, ferry capacity, fuel, etc.) are limited.

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 forum identifies ways to improve emergency response transportation services based on problems encountered during two recent hurricanes. Katrina and Rita provide important and different lessons. Katrina's evacuation was relatively effective for people with automobiles but failed those who rely on public transit, causing death, suffering, and indignity. From a transport planning perspective, the greatest mistake was the failure to deploy buses to evacuate transit-dependent residents without charge.

Due to lessons learned from Katrina, nondrivers received much better services during Rita's evacuation, but excessive automobile traffic created problems for motorists. Mistakes include failure to implement counterflow lanes as announced, failure to manage fuel distribution, failure to provide basic

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services (such as washrooms) along the evacuation route, and failure to give buses (and perhaps other HOVs) priority in traffic.

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 nondrivers, 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 many nondrivers face due to inadequate and poorly integrated public 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.

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