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EFFECTS OF CATASTROPHIC EVENTS ON TRANSPORTATION SYSTEM MANAGEMENT AND OPERATIONS

CROSS CUTTING STUDY

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Foreword

This report was prepared by the U.S. Department of Transportation's (U.S. DOT) John A. Volpe National Transportation Systems Center (Volpe Center) for the U.S. DOT's Intelligent Transportation Systems (ITS) Joint Program Office (JPO) and the Federal Highway Administration Office of Operations. The Volpe Center study team consisted of Allan J. DeBlasio, the project manager; Robert Brodesky from EG&G Technical Services; Margaret E. Zirker from Cambridge Systematics Inc.; and Terrance J. Regan from Planners Collaborative.

This report documents the actions taken by transportation agencies in response to catastrophic events as an overall effort to examine the impacts of different types of events on transportation system facilities and services. The findings and conclusions documented in this report are a result of the creation of a detailed chronology of events, a literature search, and interviews of key personnel involved in transportation operations decision-making for four events:

- New York City, September 11, 2001 – terrorist attack
- Washington, D.C., September 11, 2001 – terrorist attack
- Baltimore, Maryland, July 18, 2001 – rail tunnel fire
- Northridge, California, January 17, 1994 – earthquake

The event summaries and findings for New York City and Northridge, Calif., are adapted from the case studies prepared by the Volpe Center study team consisting of Allan J. DeBlasio, the project manager; Robert Brodesky, Amanda Zamora, and Fred Mottley from EG&G Technical Services; Margaret E. Zirker and Michelle Crowder from Cambridge Systematics Inc.; and Terrance J. Regan, Kathleen Bagdonas, and Dan Morin from Planners Collaborative. The summaries and findings of Washington, D.C., and Baltimore are adapted from case studies done by Science Applications International Corporation (SAIC). The SAIC study team consisted of Mark Carter, the project manager; Mark P. Howard; Nicholas Owens; David Register; Jason Kennedy; Aaron Newton; and Kelley Pecheux. Vince Pearce is the U.S. DOT task manager of both the cross-cutting study and the case studies review.

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Executive Summary

Reason for the case studies and cross cutting study

In order to provide a better understanding of how transportation is both affected and utilized in an emergency situation, the Federal Highway Administration (FHWA) commissioned a series of four case studies examining the effects of catastrophic events on transportation system management and operations. Each of the case studies examined a specific event and the regional response. The events included terrorist attacks in New York City and Washington, D.C., on September 11, 2001; an earthquake in the Los Angeles region; and a rail tunnel fire in Baltimore.

This cross cutting study summarizes the surface transportation activities associated with four catastrophic events and the lessons learned from each. Each of the events resulted in substantial, immediate, and adverse impacts on the transportation system, and each has had a varying degree of influence on the longer-term operation of transportation facilities and services in its respective region.

The case studies have provided material for a series of Transportation Response and Recovery Workshops developed by the FHWA and held in major metropolitan areas around the country.

Organization of the cross cutting study

This document has two main sections. The first section provides an overview of each of the four case studies. This overview includes a chronology of key events on the day of and days after the disaster, a description of the affected area, a description of key decisions taken by agencies, and a brief description of conditions in the months following the event. The four case studies are:

1. New York City terrorist attack on September 11, 2001
2. Washington, D.C. terrorist attack on September 11, 2001
3. Baltimore, Maryland Howard Street rail tunnel fire on July 18, 2001
4. Northridge, California earthquake on January 18, 1994

The second section discusses findings that cut across the four case studies. Each of the four events presented transportation and emergency response agencies with a different set of challenges in dealing with response and recovery. This section includes an assessment of the following key questions:

- How well were the key participants prepared?
- What happened and who took action?
- What aspects of the emergency response worked well and why, and what aspects did not work well and why?
- What role did technology play in these aspects with respect to transportation emergency response and recovery?
- What was learned, what could be done differently, and what can be incorporated into the disaster planning process?

Summary of the four events

New York City:

On September 11, 2001, New York City was the target of the largest terrorist attack in the history of the nation. Both World Trade Center towers were hit and destroyed by hijacked passenger jets. These attacks occurred during the morning rush hour and the transportation network was immediately and dramatically affected. New York City Transit and PATH stations and rail lines were destroyed during the collapse of the towers. Transportation officials were immediately faced with the need to make critical decisions to protect the safety of residents and workers and the critical transportation infrastructure. This task was complicated by the lack of clear information about the scope of the damage to the system and the uncertainty of future attacks.

Within minutes of the first attack, transportation officials were confronted with the need to respond on three critical levels. First, the agencies began the process of closing all of the bridge and tunnel crossings into Manhattan, suspended subway service to Lower Manhattan, and closed the three international airports in the metropolitan area. Second, officials were confronted with the daunting task of evacuating the 1.2 million workers and residents of Lower Manhattan. Third, transportation agencies were mobilizing workers and resources to aid in the response and recovery effort at the World Trade Center site.

Washington, D.C.

A third hijacked passenger jet also attacked the Pentagon, located in Arlington, Virginia, on the morning of September 11, 2001. This event required a coordinated response from multiple agencies within multiple jurisdictions. Jurisdictions involved included those from the states of Virginia and Maryland, the District of Columbia, local and county governments, the United States Department of Defense, and other numerous federal agencies. As with New York City, the lack of clear information about subsequent attacks led to a series of independent public and private decisions to evacuate the city during the end of the morning rush hour.

The transportation agencies had to respond to the attack and subsequent partial evacuation by closing certain key transportation facilities near the Pentagon and other strategic locations in the nation's capital, redirecting transit assets, and coordinating these closing and changes with other agencies. This was all happening during a time when the voice communications networks were overwhelmed with demand and accurate information on closings and redeployments was scarce.

Baltimore, Maryland

On the afternoon of July 18, 2001, a fire broke out inside the 1.7-mile long freight rail tunnel running under Howard Street. A 60-car CSX freight train carrying various potentially hazardous materials had derailed inside the tunnel and some of the rail cars were on fire. Smoke was billowing out of the train portals as local fire, police, and emergency response personnel reported to the scene. Howard Street is a major arterial that runs through the heart of Baltimore's business and cultural districts. A light rail and commuter rail line operated along the Howard Street right-of-way above the rail tunnel.

Officials were confronted with major disruption to the roadway, transit, and freight networks in the central city just as the afternoon rush hour was about to begin. City officials were faced with

multiple challenges once the fire was detected. First, there was the need to determine the exact location of the fire in the tunnel. Second, it was crucial to determine the potential environmental impact from the cargo on the 60 rail cars. Third, a major water main located above the tunnel had ruptured and was flooding sections of the tunnel. Fourth, they needed to quickly determine to what extent an evacuation of the surrounding area would need to occur.

Coordination issues were complicated because of the numerous parts of the infrastructure involved, the uncertainty of the extent of threat, and the freight rail line is owned by a private company, CSX. Also, different Baltimore city agencies maintain the roadway and the water infrastructure, and the Maryland Transit Administration (MTA) operates the light rail and commuter rail lines. When the fire department initially responded, its primary focus was on fire suppression. This focus later shifted to environmental safety once it was realized that hazardous materials might be involved.

Northridge, California

On January 17, 1994, a 6.8 magnitude earthquake shook the Los Angeles region. The actual earthquake only lasted about 1 minute, but caused an estimated \$25 billion in property damage. In addition to the numerous disruptions of local roads, sections of four major freeways were severely damaged. These damaged sections of freeway served an average of 1 million travelers on a daily basis. The local and state transportation officials were confronted with a two-fold problem. The first was to inspect the vast infrastructure network for damage, and the second was to begin and complete the reconstruction effort as quickly as possible.

The Southern California region had dealt with numerous catastrophic events over the past several decades. This included previous earthquakes, mudslides, forest fires, and civil unrest. Because of this history, the region had in place a coordinated strategy for response to and recovery from disasters. The California Department of Transportation (Caltrans) immediately began the inspection of its infrastructure and had agreements with private contractors to begin the removal of debris by the evening of the first day. Detours around the affected areas were in place by the first afternoon. These detours would undergo constant refinement over the next several months. Through innovative design and construction methods, the state was able to reconstruct and reopen some of the damaged sections of the freeway within three months. All of the sections were reopened within 10 months of the earthquake.

Summary of the Findings

Each of the events presented officials with a different set of challenges in the response and recovery effort. There were several key themes that cut across the four events.

Guiding Priority:

The initial guiding priority in every emergency is the protection of life. Transportation officials must begin almost immediately to implement evacuation plans and institute recovery procedures. In each of these cases, officials were charged with making decisions without full knowledge of the rapidly changing existing conditions and uncertainty of what future events might occur to change the situation. Because of this, safety and security took priority over mobility. As time passed and more information was available, officials began to restore mobility. This restoration of mobility varied with each of the events. Within days, mobility was restored to the Washington and Baltimore areas.

Because of the physical damage in Los Angeles and New York, it was months before key pieces of the transportation infrastructure could be reopened to the general traveling public at normal levels.

Plan of Action:

In order to respond to a catastrophic event, agencies need to have a plan of action in place to handle emergency situations and to begin the process of restoring mobility. This plan of action includes both planning and investment in infrastructure and personnel. The plan of action is organized around five categories:

1. Advanced preparation
2. Institutional coordination
3. Technical communications
4. Advance technologies
5. System redundancy and resiliency

Advance preparation:

The need for advance preparation and planning by agencies is crucial in dealing with a range of mishaps and disasters. Several key themes emerged from the four case studies. First, an agency needs to learn from previous events and incorporate that learning into an agency's response plans. The events of September 11 have served as a wake up call to cities and towns across the country about the need to prepare for the unexpected. Second, there is a need to rely on agency staff at all levels to make good and timely decisions, often without complete knowledge of all the mitigating circumstances. Emergencies do not occur at convenient times and it is important that staff at all levels are able to respond to situations and make decisions, often without immediate input from headquarters. Third, there is a need to practice for the expected and the unexpected. Knowledge gained and relationships developed through day-to-day contact are extremely useful when catastrophes strike. In both New York and Los Angeles, existing traffic control centers and organizations whose main function was coordinating daily transportation operations were able to quickly implement emergency procedures.

Institutional coordination:

By their very nature, catastrophes require a coordinated response among multiple federal, state, regional, and local jurisdictions. This coordination needs to occur at several layers simultaneously. Each agency needs to have a pre-established internal coordination plan as well as a system for external coordination with other agencies, the press, and the public. Transportation agencies typically have staff at multiple locations with multitudes of varying responsibilities. The Port Authority of New York and New Jersey, for example, operates bridges, tunnels, transit lines, airports, and water ports within the metropolitan area. Caltrans oversees a highway system of 25,000 kilometers in length and a staff of over 23,000. A requirement for ensuring this institutional coordination is to have an established chain of command through a pre-existing command system. The Incident Command System (ICS), developed in California during the 1970s, is one example of a structure that a region can adopt to help ensure a coordinated response among the various agencies.

Technical communications:

The demand for accurate, timely information increases dramatically after an emergency. Often this increased demand comes at a time when the technology needed to provide that information is most compromised. Agency officials need accurate information to be able to best allocate resources and

set agency priorities in responding to an emergency. There is also a heightened interest by the public at large for information about the event. In the New York, Washington, and Los Angeles events, immediate communication with agency field staff and emergency responders was difficult because telephone landlines were damaged and cellular communications systems were overloaded or did not provide adequate coverage.

On September 11, new technologies proved successful in supplementing communications during the emergency response efforts when landline telephones were either damaged or overwhelmed with demand. Data transmissions using fax machines, e-mails, and interactive pagers that use “push” technology were effective in supplementing communications. On September 11, several transportation agencies activated their “mobile communications centers,” which are buses equipped with satellite and computer technology to allow multiple forms of communications.

Advance technologies:

Once a catastrophic event has occurred, advanced technologies can aid in providing information on existing conditions to decision makers. This information can then be used to make better-informed decisions on when and how to open or restrict facilities. Examples of this included the use of closed circuit television cameras and traffic monitors to gauge traffic volumes on key facilities. It can facilitate better communications with other agencies involved in the emergency response. Traffic management centers were able to share information on current conditions with other agencies. It can also assist in communicating with the public by providing accurate information on the status of the transportation system. This included variable message signs, highway advisory radio broadcasts, 1-800 telephone lines, and web based video feeds of traffic. Through the coordination of TRANSCOM and the I-95 Corridor Coalition, variable message signs all along the East Coast were displaying warnings to the traveling public about avoiding New York City and the Pentagon area.

System redundancy and resiliency:

Redundancy, the ability to utilize backup systems for critical parts of the system that fail, is extremely important to consider in the development of a process or plan for emergency response and recovery. In each of the four cases, the portions of the system that failed or required backup were dependent upon the specific nature and scope of the emergency. At a minimum, emergency response planners should consider designing redundancy into the system in several areas:

- The regional transportation network
- Agency personnel
- Communications and utilities
- Control centers
- Equipment and supplies

In each of the four cases, transportation agencies had to work together to provide alternative travel options to the public. These alternatives shifted over time in response to changes in travel behaviors of the public. Because emergencies can occur at any time, it is crucial to have a redundant system of trained personnel in place who are able to make good, accurate, and timely decisions. With the New York and Los Angeles cases, the recovery effort lasted for several months. Maintaining staff on emergency status for this length of time can take a toll on personnel and highlights the need to have multiple people trained for each job.

As noted before, it is important that agencies be able to utilize multiple technologies to communicate with staff and the public. This allows an agency to shift among technologies depending on the demands on the system, the topography of the land, or the amount of destruction to any one type of technology. In New York, the loss of electricity hampered operations and recovery efforts. Redundant mobile generators allowed for the restoration of power to command centers and to emergency responders. Redundant control centers were needed in New York City when existing centers were destroyed. Los Angeles had to build a new center to increase its capacity to respond to the recovery effort. In both Baltimore and New York, agency officials spoke of the need to have redundant supplies of equipment. It was also important to maintain a good inventory of where supplies are kept or could be readily purchased when needed.

Audience for the case studies

The intended audience for the case studies and the cross cutting study extends beyond the traditional transportation community. These works are intended to help various federal, state, regional, and county and municipal officials at emergency response and management agencies, health and human services agencies, public works agencies, and public safety agencies better understand the ability of the transportation agencies to aid in the response and recovery from catastrophic events. As is seen in the case studies, coordinated and advanced planning across agencies and jurisdictions can lead to better response in times of emergency. The primary purpose of the FHWA Transportation Response and Recovery Workshops was to bring together representatives of these various agencies to better understand the issues and understand the importance of planning and coordination before, during, and after events. These case studies help document the value in planning, coordinating, and investing in infrastructure and technology that can help in times of crisis.

Additional information

This cross cutting study, the Baltimore rail tunnel fire case study, and the Northridge earthquake case studies can be found on the FHWA ITS Electronic Data Library (EDL) site at <http://www.its.fhwa.dot.gov/cyberdocs>. Additional information on the New York City and Washington, D.C., case studies can be obtained by contacting Vincent Pearce at vince.pearce@fhwa.dot.gov.

Introduction

This cross cutting study summarizes the events associated with four case studies looking at how transportation agencies responded to the events of unforeseen disasters.

Each of the four events studied provide useful lessons to be learned for transportation officials across the country:

- New York City terrorist attack on September 11, 2001
- Washington, D.C., terrorist attack on September 11, 2001
- Baltimore, Maryland, rail tunnel fire on July 18, 2001
- Northridge, California, earthquake on January 17, 1994

Each of these events resulted in substantial, immediate, and adverse impacts on the transportation system, and each has had varying degrees of influence on the longer-term operation of transportation facilities and services in their respective region. Each event revealed important information about the response of the transportation system to major stress and the ability of operating agencies and their public safety and emergency management partners to respond effectively to a crisis. This cross cutting report emphasizes the transportation aspects of these catastrophic events and lessons learned that could be incorporated into future emergency response planning.

The document first gives an overview of each of the four areas affected, the sequence of the events that occurred on the day of and weeks or months after and describes the actions taken by transportation agencies in response to the events. The second section, Findings, details lessons to be learned from the events. The findings are grouped into two main sections:

- Guiding priority
- Plan of action

New York City

On Tuesday, September 11, 2001 at 8:45 a.m., a hijacked commercial passenger jet, American Airlines Flight 11 out of Boston, Mass. crashed into the north tower of the World Trade Center. At 9:03 a.m., a second hijacked airliner, United Airlines Flight 175, also from Boston, crashed into the south tower of the World Trade Center. These airplane attacks occurred during the morning rush hour when the city's roads, bridges, and transit system were operating at peak capacity. Transportation officials were immediately faced with the need to make critical decisions to protect the safety of the traveling public. In the chaos and devastation of the September 11 disaster, the New York City regional transportation network remained the primary support system, both for those evacuating New York's lower Manhattan as well as for those headed to the area for emergency response activities.

By the second hour, the two towers began collapsing. Thousands of tons of debris and ash were spread over Lower Manhattan. Emergency response coordination was hampered because of the destruction of a number of emergency control centers and communications failures that spread throughout Lower Manhattan. At 11:02, Mayor Rudy Giuliani instructed the 280,000 residents and 1 million workers in Lower Manhattan to evacuate the area. For the next several hours, the 1.2 million people who live and work in lower Manhattan fled.

The following table shows a brief chronology of the events the first day of September 11, 2002 in New York City:

September 11, 2001 Chronology-

Time of Day	Elapsed Time	Event/Actions Taken
8:46 a.m.:		First plane crashes into the north tower of the World Trade Center (WTC).
8:47 a.m.:	[1 min.]	An MTA subway operator alerts MTA Subway Control Center of an explosion in the WTC and begins emergency procedures.
8:52 a.m.:	[6 min.]	PATH trains begin emergency procedures and proceed to evacuate WTC station and express Manhattan trains to New Jersey.
9:03 a.m.:	[17 min.]	Second plane crashes into south tower of WTC.
9:10 a.m.:	[24 min.]	Port Authority of NY and NJ closes all their bridges and tunnels .
9:12 a.m.:	[26 min.]	George Washington Bridge VMS flash "Bridge Closed."
9:17 a.m.:	[31 min.]	FAA shuts down all NYC airports .
morning:		Amtrak suspends all nationwide train service ; Greyhound cancels Northeast US operations.
morning:		NYC DOT reports that police ordered highways shut down.
9:40 a.m.:	[54 min.]	FAA halts all US flights.
9:43 a.m.:	[57 min.]	Third plane crashes into the Pentagon.
9:59 a.m.:	[1 hr. 13 min.]	South tower of WTC collapses. Impact measures 2.1 on the Richter scale.
morning:		NY state activates its Emergency Operations Center in Albany. Governor activates the National Guard.
10:20 a.m.:	[1 hr. 34 min.]	NYC Transit suspends all subway service.
10:29 a.m.:	[1 hr. 43 min.]	North tower of WTC collapses. Impact measures 2.3 on the Richter scale. Port Authority headquarters destroyed in the collapse.
10:30 a.m.:	[1 hr. 44 min.]	NJ Transit stops rail service into Manhattan's Penn Station.
10:45 a.m.:	[1 hr. 59 min.]	PATH operations were suspended.
10:53 a.m.:	[2 hr. 7 min.]	NY primary elections are postponed.

11:02 a.m.:	[2 hr. 16 min.]	As tens of thousands abandon cars and subway to stream across Manhattan bridges on foot, Mayor Giuliani urges, "Stay calm, stay at home... If you are south of Canal Street, get out. Walk slowly and carefully. If you can't figure what else to do, just walk north."
~ Noon:	[3 hr. 14 min.]	A NYC Transit employee stands in front of Grand Central Terminal with a megaphone to try to dispense advice to travelers.
12:48 p.m.:	[4 hr. 2 min.]	Partial NYC Transit subway service resumes, with many routes truncated or diverted to avoid Lower Manhattan.
1:15 p.m.:	[4 hr. 29 min.]	Long Island RR runs limited service eastbound only from Penn Station.
2:30 p.m.:	[5 hr. 44 min.]	Subway system begins to return to normal except for trains under Lower Manhattan.
3:50 p.m.:	[7 hr. 4 min.]	FEMA activates four urban search and rescue teams in New York.
4:12 p.m.:	[7 hr. 26 min.]	PATH service between Newark and Journal Square resumed.
4:40 p.m.:	[7 hr 54 min.]	PATH uptown New York line to New Jersey resumes service.
afternoon:		By evening rush, several public and private water ferry companies are providing additional ferry service to New Jersey, Queens, and Brooklyn, evacuating about 160,000 people from Manhattan.
afternoon:		200,000 phone lines in Lower Manhattan are crippled, telephone and cellular service is overloaded when Verizon central hub at WTC damaged.
5:20 p.m.:	[8 hr. 34 min.]	WTC Building 7, headquarters of NYC Office of Emergency Management (OEM), collapses.
6:00 p.m.:	[9 hr. 14 min.]	Amtrak resumes passenger rail service.
7:02 p.m.:	[10 hr. 16 min.]	Some NY bridges open to outbound traffic.
7:30 p.m.:	[10 hr. 44 min.]	Long Island Rail Road restores full schedule east and westbound.
Nightfall:		750 National Guard troops are in NYC to assist police.
End of day:		65% of subway service is back in operation. Throughout the day, MTA bus service continues running north of Lower Manhattan. AT&T reports that it has handled the largest one-day volume of calls in its history

Transportation System: Description of the Affected Area

The 2,440-square-mile region of the New York Metropolitan area has one of the most complex and extensive transportation networks in the world. There are 500 route miles of commuter rail, 225 route miles of rail rapid transit, nearly 23,000 centerline miles of roads, streets, and highways, three major commercial airports, and maritime facilities for passengers and goods. The network is operated by a multitude of state, local, and regional authorities as well as private companies. Figure 2, Transportation conditions before September 11, gives an overview of traffic volumes on major crossings and transit boardings. The following list demonstrates the level of interdependence involved:

- The Port Authority of New York and New Jersey operates 3 major airports, 2 tunnels, 4 bridges, the PATH interstate rail system, 2 bus terminals, 2 ferry services, and 7 marine cargo terminals in the Port District, comprising a 25-mile radius of the Statue of Liberty.
- The NYC Department of Transportation (DOT) manages city streets, highways, and parking facilities, 4



*Figure 1. VMS sign on Sept. 11
Source: Port Authority of NYNJ*

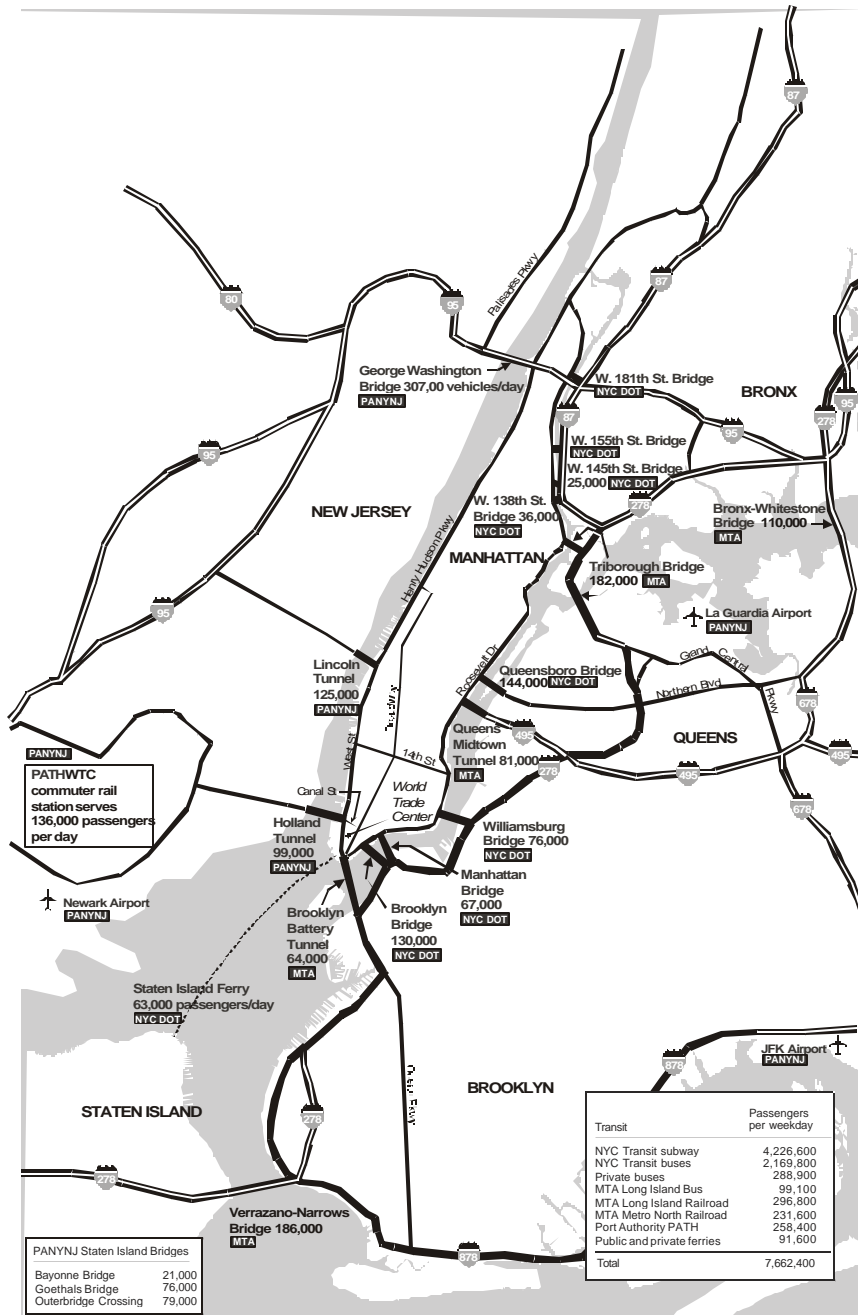


Figure 2. Transportation conditions before September 11

major bridges, 6 tunnels, 1 ferry service, and oversees 5 private ferry and 7 private bus companies serving New York City.

- The Metropolitan Transportation Authority (MTA) runs the NYC subway and bus system (the largest subway and bus systems in the country), 2 commuter rail systems, a Long Island bus service, 7 bridges, and 2 tunnels.

Additionally, New York City is the most densely populated urban area in the nation. The region is heavily dependent upon its transit system and has the most widely used public

transportation network in the nation. The typical weekday transit ridership for all the transit modes in New York City is 7.6 million riders per day.

Taking Action

Within six minutes after the first plane struck, New York City Transit began emergency procedures from its Cortlandt Station transporting its passengers to City Hall Station before the station collapsed. The Port Authority Trans-Hudson (PATH) train master gave orders to stop service of PATH trains to the World Trade Center. Twenty-four minutes after the initial attack, the Port Authority of New York and New Jersey closed all bridges and tunnels. At 9:12 a.m., the George Washington Bridge variable message sign (VMS) flashed, “Bridge Closed.” Around 11 a.m. the VMS on highways leading into the city flashed “New York City Closed To All Traffic.”

TRANSCOM, a coalition of 16 transportation and public safety agencies in the New York metropolitan region, began the process of alerting other agencies of the status of facilities and providing updated transportation information to agencies all along the Northeast Corridor. As facilities were closed, agency personnel began performing vulnerability assessments of their own facilities.

While NYC transportation agencies had individual and regional emergency response plans in place, no one had planned for an attack of the magnitude of September 11. In addition to the loss of key emergency response and transportation personnel who worked in the command center, the transportation and communications networks in Lower Manhattan sustained substantial damage. The World Trade Center served as the major intermodal transportation hub for Lower Manhattan. The Cortlandt subway station and the PATH World Trade Center station were both severely damaged during the collapse of the Twin Towers. The Federal Emergency Management Agency (FEMA), the NYC Office of Emergency Management (OEM), and the Port Authority emergency control centers were all located in the World Trade Center complex and were not able to be used for emergency response that day. Communications hubs for Verizon, TRANSCOM, and the Port Authority as well as the MTA’s fiber-optic network were all located either within or in close proximity to the World Trade Center. All of these were totally or partially destroyed, severing communications during the first few hours after the attack. This hindered the ability to communicate internally and externally during the first few critical hours.

With the closing of the subway and rail service approximately an hour and a half after the attack, transit options were limited. With most New York City businesses closing mid-morning for the day, the remaining 2.6 million New York City workers outside Lower Manhattan were forced to improvise whatever sequence of trip routes would get them home. For many, the trip home took several hours longer than normal. Intercity travel ground to a halt as the Federal Aviation Administration (FAA) shut down the commercial air network and Amtrak and bus lines halted service. To facilitate evacuation and emergency response the bridges along the East River were open for pedestrians leaving Manhattan and for emergency vehicles entering Manhattan. The Coast Guard began the process of overseeing a makeshift flotilla of water ferries and private boats to help evacuate people from Lower Manhattan. Figure 3, Transportation Conditions on September 11, gives an overview of the facilities closed leading into and around Manhattan.

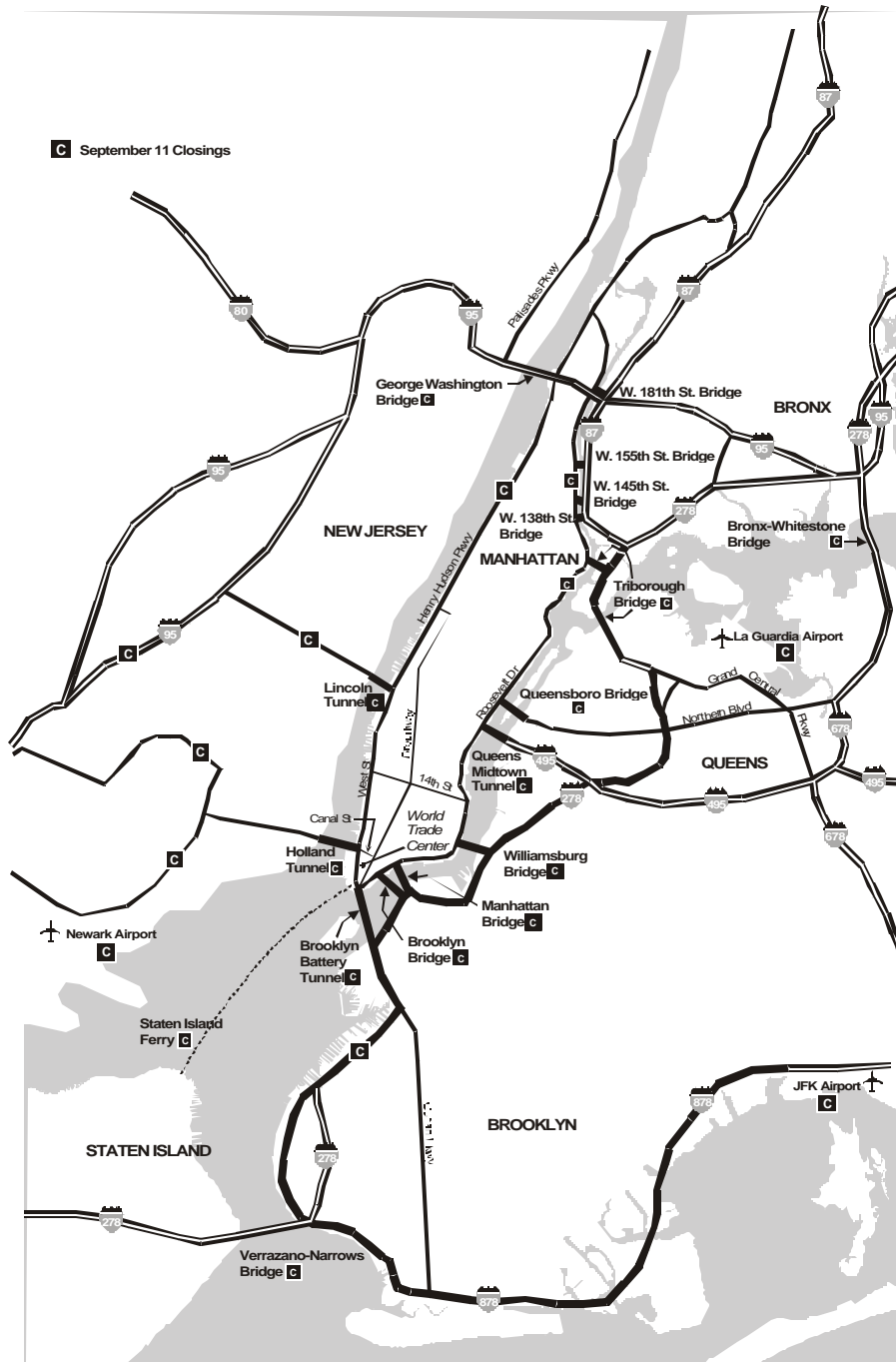


Figure 3. Transportation Conditions on September 11

Within hours of these events, federal, state, and local agencies had begun internal emergency procedures and coordination with other agencies. The table below indicates key decisions, coordination, and communication by agency.

Key Decisions by Agency

Agency	Key Decisions. Coordination, and Communication
U.S. Coast Guard	Began process of getting boats to Manhattan to aid in the water evacuation of Manhattan.
Federal Aviation Administration (FAA)	Ordered the closing of the three NYC-area airports. Later, ordered the halt of all aviation traffic across the country.
Federal Emergency Management Agency (FEMA)	Began the process of implementing response to the “federally declared disaster.”
Federal Highway Administration (FHWA)	Implemented “quick release” option for Emergency Relief (ER) funds enabling state and local agencies to send emergency response teams; helped coordinate relationships between state and local agencies.
Information FOR Motorists (INFORM)	Immediately coordinated with police to open up Long Island Expressway for EMS vehicles; displayed traffic information on regional VMS and deployed portable VMS to NYC bridge and tunnel entrances; disseminated traffic reports to local agencies, media, and the public; sent all spare resources to WTC.
Metropolitan Transportation Authority (MTA)	Coordinated transit closures and re-routed subway trains by maintaining operations staff round-the-clock at the Mayor’s OEM who interfaced with Subway Control and Bus Command Centers. Several bus drivers were forced to make “ad hoc” decisions in Manhattan after communications were cut off, buses sustained damage from debris, and hazards blocked roadways.
New Jersey Transit	Coordinated trains and closures through OEM at mobile command center.
New York State Department of Transportation (NYSDOT)	Supplied portable VMS, barriers, and backhoes to NYC region with promise of FHWA ER funds; coordinated with INFORM (a NY State DOT facility) for information dissemination; provided temporary offices for New York Metropolitan Transportation Council (NYMTC) employees.
New York State Police (NYSP)	Deployed 23 Highway Emergency Local Patrol (HELP) vehicles to locations in Rockland and Westchester Counties; deployed 500 troopers to NYC region (to NYC limits) who cleared highways for EMS vehicles; helped direct EMS vehicles to WTC.
New York City Department of Transportation (NYCDOT)	Worked with police to coordinate closing every road, bridge, and tunnel in Lower Manhattan and show closures on regional VMS; coordinated with NY State DOT out of Queens TMC.
NYC Office of Emergency Management (OEM)	Coordinated regional response by issuing general “directives” to agency liaisons (police, fire, transportation, etc.) on-site at OEM; coordinated with Governor and FEMA for disaster declaration.
NY Police Department (NYPD)	Evacuated lower Manhattan by evacuation protocol, tallest buildings first; directed people and traffic from “high threat areas” (bridges and tunnels); secured bridges and tunnels for EMS vehicles.
Port Authority of New York and New Jersey (PANYNJ)	Coordinated with FAA to close three major airports: Kennedy, LaGuardia and Newark. Ferry division oversaw ferry operator, NY Waterway; contacted NY Waterway to make sure that vessels were at Battery Park for evacuation; coordinated with Coast Guard and Coast Guard security zone. Coordinated

	with police for closures of bridges and tunnels, and for EMS access. Closed the water port to freight activity.
Transportation Operations Coordinating Committee (TRANSCOM)	Issued reports of member agency operating decisions via fax; 800 reports issued in total, terminating on Jan. 21, 2002.

Transportation Conditions After September 11

In the three months after September 11, the transportation network was slowly returning to normal as mobility was increased and security checkpoints were reduced. The airports and water freight port are back in full operations. Certain segments of the transit infrastructure within the World Trade Center area are still out of service and motor vehicle restrictions are still in place for Midtown and Lower Manhattan. Figure 4, below, shows the destruction at the World Trade Center site as of late September 2001. As of September 2002, the SOV ban remains on crossings into Lower Manhattan, vehicles are still being checked at key crossings, commercial vehicles restrictions are in place for the Holland Tunnel, and PATH subway service only operates to Midtown Manhattan.



The New York City subway system was able to restore service to all but four stations in Lower Manhattan but has seen security-related service delays increase markedly since September 11. With significant job relocation to Midtown Manhattan, transit services in that area have become extremely congested. Meanwhile, combined public and private ferry service has seen a 91% overall growth in their use after September 11, the highest since the 1940s. To respond to the increased demand for ferry services, the Port Authority concentrated on building more facilities in Lower Manhattan.

Figure 4. World Trade Center, late September, 2001
 Source: FEMA

Washington

On Tuesday morning, September 11, 2001 at 9:43 am, a hijacked commercial airline jet, American Airlines Flight 77 from Washington Dulles International Airport, deliberately crashed into the Pentagon. The airliner crashed low and diagonally into the Pentagon's outside "E" ring limestone wall. The impact with the Pentagon, and the conflagration caused by the fuel, created a catastrophic structural failure of the hit section. Within minutes, the upper floors collapsed into the 100-foot-wide gap, which extended most of the way through the office rings to the central courtyard. Staff at the Arlington County Virginia Fire Department actually saw the plane fly overhead at a dangerously low altitude. When they heard a crash and saw the thick smoke, they headed toward the site. In minutes, they were joined by other firefighters as well as the Arlington police, providing aid to the wounded and working to put out the blaze.

In comparison with the extensive impacts of the terrorist attack on the World Trade Center in New York, the attack on the Pentagon was relatively circumscribed. Even so, the tragic loss of life, the psychological impact, and the actions taken in response to the attack by local, state, and federal agencies had major impacts on the transportation system in the Washington, D.C., region.

The following is a brief chronology of the events of September 11, 2001 involving the terrorist attack and transportation responses.

September 11, 2001 – the first day

Time of Day	Elapsed Time	Event/Action Taken
8:46 a.m.		First plane crashes into the north tower of the World Trade Center (WTC). MDOT activated the Emergency Operations Center (EOC) (between the first and second attacks at the World Trade Center) and readied emergency operations plans. In addition, MDOT directed the Maryland State Highway Administration (SHA) and the Maryland Transportation Authority (MdTA) to keep as many people and as much equipment as possible on the roads.
8:50 a.m.:	[4 min.]	Metro Transit Police Department (MTPD) telephoned FBI Terrorism Task Force, Washington, D.C., Field Office, to determine if any threats had been received for the District of Columbia. The response was negative.
9:03 a.m.:	[17 min.]	Second plane crashes into south tower of WTC.
9:40 a.m.:	[54 min.]	FAA halts all US flights. Metrorail Operations on heightened state of alert.
Soon after	[54 min.]	WMATA Transit Police receive a call from a representative with D.C. Police about a threat to Metro and that closing the system should be considered.
9:40 a.m.:		
9:43 a.m.:	[57 min.]	American Airlines Flight 77 crashes into the Pentagon. Evacuation of building begins immediately. VDOT Statewide Transportation Emergency Operations Center (TEOC) is already in the process of implementing a statewide terrorism alert.
9:53 a.m.:	[1 hrs. 7 min.]	MTPD notified of Pentagon blast.
9:55 a.m.:	[1 hrs. 9 min.]	Metrorail and Metrobus notified that Command Post is established by Chief McDevitt of MTPD. All track maintenance canceled on entire railroad.
10:00 am:	[1 hrs. 14 min.]	America's military put on high alert status. Metrorail Yellow Line trains re-routed to segments of Blue Line still in operation. This effectively closes Yellow Line bridge over Potomac River.

Time of Day	Elapsed Time	Event/Action Taken
10:30 a.m.:	[1 hrs. 44 min.]	Federal Office of Personnel Management decided that 260,000 federal workers could be released from work.
10:32 a.m.:	[1 hrs. 46 min.]	Amtrak, Virginia Railway Express commuter rail, and the Maryland Transit Administration's MARC commuter rail shut down rail service.
10:41 a.m.:	[1 hrs. 55 min.]	Metrorail Blue Line trains run through Pentagon station without stopping.
10:45 a.m.:	[1 hrs. 59 min.]	Blue Line restored - No station stops at Pentagon and Reagan National Airport stations.
10:46 a.m.:	[2 hrs. 0 min.]	MPD Command Center requests Metrorail to cease operations due to perceived threat. Metrorail determined that threat was not credible and continued operations.
10:59 a.m.:	[2 hrs. 13 min.]	National Airport closed.
11:05 a.m.:	[2 hrs. 19 min.]	Metrorail notified to run trains through Union Station without station stop.
11:31 a.m.:	[2 hrs. 45 min.]	Blue Line train service suspended due to warning of unidentified aircraft. Blue Line trains to keep underground in area of Pentagon.
11:39 a.m.:	[2 hrs. 53 min.]	Arlington County Manager declared a local state of emergency
11:43 a.m.:	[2 hrs. 57 min.]	Service restored to Blue Line.
11:44 a.m.:	[2 hrs. 58 min.]	All above ground trains in Virginia suspended.
12:00 p.m.:	[3 hrs. 14 min.]	Governor Jim Gilmore of Virginia declares a statewide emergency.
12:22 p.m.:	[3 hrs. 36 min.]	State of Maryland EOC established.
12:45 p.m.:	[3 hrs. 59 min.]	Union Station / Amtrak reports partial service restoration to Union Station - one route will open at 1:00 p.m. from Washington to Baltimore only.
1:15 p.m.:	[4 hrs. 29 min.]	The Maryland Transportation Authority states that all facilities are under heightened security and remain open.
1:27 p.m.:	[4 hrs. 41 min.]	A state of emergency is declared by the city of Washington.
2:30 p.m.:	[5 hrs. 44 min.]	The FAA announces there will be no U.S. commercial air traffic until noon EDT Wednesday at the earliest.
4:00 p.m.:	[7 hrs. 14 min.]	Virginia Department of Emergency Management announces that all northbound lanes on I-395 have been closed from the Beltway to Washington, D.C.
6:00 p.m.:	[9 hrs. 14 min.]	Amtrak resumes passenger rail service.
6:30 p.m.:	[9 hrs. 44 min.]	George Washington Memorial Parkway reopened
6:42 p.m.:	[9 hrs. 56 min.]	Roadway traffic is slowly returning to normal. U.S. Park Police have reopened the southbound GW Parkway and traffic on the Clara Barton and Rock Creek parkways is now moving in both directions. Northbound I-395 is closed. Pentagon and National Airport Metro stations are closed.
7:09 p.m.:	[10 hrs. 23 min.]	Normal Metrorail service restored. No station stops at Pentagon and National Airport stations.
7:15 p.m.:	[10 hrs. 29 min.]	Yellow Line bridge service restored.
7:20 p.m.:	[10 hrs. 34 min.]	WMATA Command Center secured.

Transportation System: Description of the Affected Area

The Washington, D.C., metropolitan area is among the most complex multi-jurisdictional environments in the United States. The profusion of state and local governments, along with federal agencies and regional transportation operating agencies, gives rise to significant challenges in coordination and cooperation. Aside from the challenge of coordination across political boundaries, the events of September 11 and the aftermath required coordination and cooperation from agencies with different jargons, command and control structures, and philosophies – the transportation, law enforcement, emergency management, and public safety communities that had to respond to the crisis.

The Washington, D.C., metropolitan area is also one of the most congested in the nation. While it has one of the highest proportions of transit use in the nation – 16 percent of commuters use transit to get to work – the D.C. region ranks high in measures of traffic congestion and travel delay. Metropolitan Washington, D.C., is in the top five among the nation’s 68 largest urbanized areas in five of the Texas Transportation Institute’s indices of congestion, and is in the top ten for all ten measures.

A complex structure of agencies and organizations shares control of the transportation network. Figure 5 shows the political boundaries of the Capital region. Operating agencies with responsibility for major highways in the area include the Maryland Department of Transportation (MDOT), the District of Columbia Department of Public Works (Transportation Division) (DCDPW), and the Virginia Department of Transportation (VDOT), as well as the National Park Service (NPS) for the region’s parkways and the Arlington Memorial Bridge. The Washington Metropolitan Area Transit Authority (WMATA) operates the Metro rapid transit system and the bulk of surface bus service in the region, but local jurisdictions also run some transit service, including routes that utilize the newly redesigned Transit Center at the Pentagon.



Figure 5. National Capital Region

Federal agencies often exercise control over the transportation network of the region. This became especially clear on September 11, as streets were closed at the direction of the Secret Service and the Capitol Police to establish secure perimeters around critical governmental sites.

Taking Action

Washington, D.C.

In Washington, D.C., traffic into the city was detoured, as Washington declared a state of emergency. Ramps were closed from interstates and variable message signs (VMS) alerted motorists to avoid the area. Retiming traffic signals for very heavy peak-period outbound traffic facilitated traffic flow out of Washington. HOV restrictions were removed, and overhead sign changes, travelers advisory radio (TAR), and the media alerted motorists to changes in traffic patterns. The District of Columbia Division of Transportation (DDOT), which is part of the District’s DPW, had D.C.’s signal system changed to “PM mode” at around 10:30 AM.

The Secret Service contributed to downtown traffic problems by expanding the White House perimeter and closing streets. As quickly as possible, DDOT deployed portable VMS signs and traffic cones to redirect traffic away from street closings. As in many other jurisdictions, rumor control was a significant problem; erroneous reports about the transportation system status (including reports that Metrorail had closed) had to be verified or discounted. Figure 6 displays the major closing that occurred in the Washington, D.C. area on the morning of September 11.

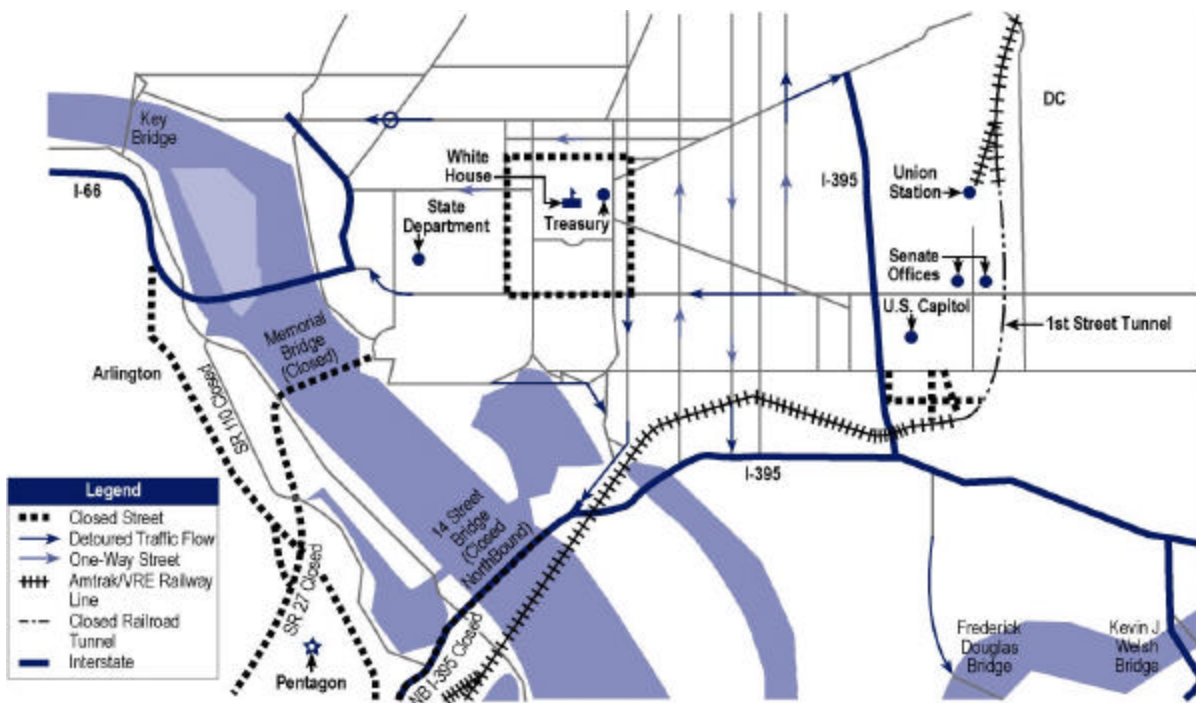


Figure 6. Transportation facility closings on September 11

WMATA reported that Metrorail’s ridership was 445,038 between opening and 6 p.m. on September 11, about 40,000 fewer rides than the previous Tuesday. WMATA closed its stations at the Pentagon and Reagan National Airport, and rerouted the Yellow Line away from the bridge across the Potomac River. WMATA also provided buses to help transport the injured, and provided several Metrobuses to assist D.C. Metropolitan Police in moving personnel to various locations throughout the District. Traveler information was also valued highly during the crisis. Local and state government traveler information Web sites saw a significant spike in activity. Figure 7, below, shows a snapshot of the congestion on the morning of September 11 as people tried to leave the D.C. area.

Northern Virginia

The statewide Transportation Emergency Operations Center (TEOC) was in the process of implementing a terrorism alert via the Virginia Operational Information System (VOIS) in response to the New York events when the third hijacked aircraft flew directly over the Smart Traffic Center (STC) in Northern Virginia. After the plane hit the Pentagon, VDOT went to the highest state of readiness, invoking existing emergency plans, activating its Statewide TEOC, and implementing disaster response protocols at the Northern Virginia STC.

The Pentagon is located in Arlington County and is served by the Arlington Fire Department. Because of a prior formal agreement, the department assumed incident command. Arlington's Emergency Operations Center (EOC), which coordinates all of the County's disaster response efforts, was activated, and employees on the County's emergency response teams made their way to the center. Less than two hours later, a local state of emergency was declared.



Figure 7. Traffic congestion on September 11.

The Northern Virginia STC made itself available to the military as a command post for dealing with the Pentagon incident. The Northern Virginia District of VDOT augmented STC, Safety Service Patrol (SSP), and traffic control assets to facilitate clearance of the D.C. area. Signal coordination, suspension of construction lane closures statewide, and reversing and opening of high occupancy vehicle (HOV) lanes in the outbound direction were immediately implemented. Tiger teams were deployed to assist the Northern Virginia District. (Tiger teams are VDOT crewmembers who are deployed to regions in the state that need additional assistance in preparing for and responding to severe weather events or any other emergencies involving the roads and highways.) VDOT's representative to the Governor's Terrorism Task Force met with other members of the Task Force to provide transportation input to actions recommended to the Governor.

Maryland

In Maryland, the first concern was to make sure there were no imminent threats to infrastructure and to secure the bridges, tunnels, and miles of roadway against future threats. After that was accomplished, the focus became getting the traffic exiting from downtown Washington, Baltimore, and Annapolis safely home. Although there was near-gridlock as many employers (including the Federal and state governments) allowed employees to leave early, there were no formal evacuations.

MDOT activated their EOC between the first and second attacks on the World Trade Center and readied their emergency operations plans. In addition, they directed the Maryland State Highway Administration (SHA) and the Maryland Transportation Authority (MdTA) to keep as many people and as much equipment as possible on the roads. Maryland transportation authorities implemented a number of specific actions statewide in response to the situation. Stranded or abandoned vehicles, especially under bridges, were moved. All video surveillance cameras at high-profile locations, including major bridges and tunnels, were activated and monitored. Retiming traffic signals for very heavy peak-period outbound traffic facilitated traffic flow through suburban Montgomery County. All construction work zones involving lane closures were terminated. State troopers and MdTA Police worked on clearing fender-benders and disabled vehicles more aggressively. Physical barriers were placed in front of facilities that housed command centers, and heightened security measures were instituted at all facilities. SHA helped the National Security Agency (NSA) to evacuate non-essential personnel. They also sent a technician to manually reset and operate the traffic lights to improve flows.

The table below indicates key decisions, coordination, and communication by agency.

Key Decisions by Agency

Agency	Key Decisions, Coordination and Communication
FAA	Ordered halt of all flights across the country.
Maryland Department of Transportation(MDOT)	Activated the Statewide Transportation Emergency Operations Center (TEOC). Directed Maryland State Highway Administration and Maryland Transportation Authority to keep as many people and equipment as possible on roads. Coordinated with VDOT command center. Maryland Transit Administration shut down commuter rail operation (MARC).
Maryland Transportation Authority (MdTA)	Inspected highways, land bridges, overpasses under its jurisdiction and monitored video cameras at high-profile locations. Also towed suspicious and abandoned cars from the roadway.
Maryland State Highway Administration (SHA)	District engineers provided regular patrols of high risk structures, and also dispatched bridge inspectors to high risk bridges for observation. These are now part of their routine duties. Also set traffic controls manually to improve flow.
Maryland State Police	Directed traffic, and investigated and towed abandoned vehicles.
Metrorail	Initiated operations on high alert. Rerouted trains to avoid the Potomac River Bridge.
Virginia Department of Transportation (VDOT)	Statewide Transportation Emergency Operations Center (TEOC) implemented a statewide terrorism alert. Augmented STC, Safety Service Patrol and traffic control assets to facilitate clearance of the D.C. area in terms of traffic management. Provided essential rescue and recovery equipment requested by authorities at the Pentagon site.
Governor's Terrorism Task Force	Recommended actions to the Governor of Virginia. VDOT representative a part of the task force providing transportation input.

Metro Transit Police Department (MTPD)	Established command post, monitoring system surveillance, alerting tactical police, and sent bomb-sniffing dogs to stations. Kept in close contact with the FBI, fire departments, and other law enforcement agencies in the region.
Arlington Fire Department	Assumed incident command and carried out fire-fighting and emergency medical services.
Arlington Police Department	Performed traffic and crowd control at the Pentagon, as well as securing the perimeter. Also investigated and towed abandoned vehicles.
State Highway Administration (Maryland)	Inspected high-risk bridges for irregularities. Reset traffic signals to improve traffic flow. Rerouted traffic to control access to Andrews Air Force Base and provided concrete barriers to secure access to the base.
Motor Carrier Division	Stepped up vehicle inspections with special emphasis on hazardous material loads and drivers.
D.C. Division of Transportation (DDOT)	Kept in close contact with Northern Virginia STC to check on status of roads in that region. Changed signal system in the D.C. area to PM mode. Redirected traffic away from closed streets.
Secret Service	Expanded White House perimeter and closed streets.
WMATA	Set up command center and kept close contact with FBI, fire departments and other law enforcement agencies in the region. Closed station and rerouted the yellow line away from the bridge across the Potomac River. Provided buses to transport injured and D.C. Metropolitan Police personnel. Also heightened system surveillance and alerted tactical police.
National Park Service	Closed and monitored parkway roadway in and around Washington and Maryland.

Transportation Conditions After September 11

In the Washington metropolitan area, congestion around federal facilities and military bases caused by new security procedures has continued to present transportation-related problems. These problems range from relatively minor closures and restrictions, such as the street closings near the White House and truck restrictions around the Capitol, to significant issues such as the closure of a major commuter route that passes through a Northern Virginia military base. WMATA made several changes in response to the events of September 11. The new Pentagon bus terminal and transfer facility was completed and opened for business on December 16, 2001, restoring full service to the Pentagon and eliminating the temporary transfer facility at Pentagon City.

However, heightened security continues to cause problems for transit and highway operations alike. Portable VMS are used to advise commuters about changing traffic patterns at these security choke points. Transportation agencies have experienced mixed results in terms of travel demand and ridership levels following the events of September 11 and subsequent terrorist acts, security alerts, hoaxes, and scares. Complicating the recovery of the transportation system has been the anthrax attack on various agencies and institutions of the Federal Government. Metrorail patronage, which had started to recover after September 11, dropped off again after the anthrax scares. Since then, while Metrobus ridership has begun to rise and peak period ridership on Metrorail is approaching normal levels, discretionary off-peak travel is substantially lower than pre-September 11 levels.

Baltimore, Maryland

At 3:04 PM on Wednesday, July 18, 2001, the 60-car CSX freight train L412-16 entered the Howard Street Tunnel in downtown Baltimore. The train, being pulled by three engines, carried 31 loaded and 29 empty cars, with a mix of freight that included empty trash containers, paper products, plywood, soy oil, and several tanker cars. The engineers felt the train lurch and come to a rough stop. They tried to radio the CSX dispatcher to give notice, but they were in a dead zone in the tunnel. A few minutes later, one of the engineers was able to reach the train master on his cell phone.

As the fumes from the diesel engines got worse (the engineers did not know at that point that several cars had derailed and a fire had broken out), the engineers exited the tunnel. They were then able to notify the CSX dispatcher in Jacksonville, Florida. The engineers noticed that the smoke from the tunnel was increasing, evidence of a fire somewhere among the cars. After reviewing the bill of lading, and seeing the words “hazardous materials” they radioed Jacksonville again, asking the dispatcher to notify Baltimore City that not only had a train derailed in the tunnel and caught fire, but that the load carried hazardous materials. Whether these were also on fire was unknown. Figure 8 shows the smoke billowing out of the Howard Street tunnel the afternoon of July 18, 2001.



Figure 8. Smoke from the south portal of the Howard Street Tunnel

Baltimore City firefighters received notification of the event somewhere between 3:35 PM and 4:15 PM¹. The Fire Department crew also reviewed the bill of lading and

¹ Published reports have listed two different times regarding when the Fire Department was notified. CSX records indicate that notification was provided at 3:35 PM, while Fire Department records indicate that notification was received at 4:15 PM. See RailFan and Railroad, November 2001, “Fire in the Hole”, p. 44.

assessing the scene, realized that the freight train was carrying a variety of hazardous materials (including tripropylene and hydrochloric acid). Emergency response efforts were further complicated when a break in a forty-inch water main located under the intersection of Howard and Lombard Streets, almost directly above the site of the derailment, spilled water into the tunnel and onto the street. These events occurred as the City of Baltimore was preparing for both the evening rush hour and the second game of a baseball doubleheader at Oriole Park at Camden Yards. The City thus found itself facing a potentially catastrophic situation at peak demand hours for transportation services.

The following chronology presents a brief summary of the events of July 18, 2001, involving the Howard Street tunnel train derailment and transportation and emergency management responses.

July 18, 2001 Chronology

Time of Day	Elapsed Time	Event/Action Taken
3:07 p.m.		60-car CSX freight train carrying hazardous materials derails in the Howard Street Tunnel in Baltimore, Maryland
3:15 p.m.	[8 mins.]	Engineers detect fire in 1.7 mile-long tunnel.
3:25 p.m.	[18 mins.]	Engineers decouple engines from burning train, exit from tunnel
4:15 p.m.	[1 hrs. 8 mins.]	Baltimore City Fire Department arrives as first responder, assumes incident command responsibilities. CSX Engineers provide bill of lading indicating derailed train is carrying hazardous materials.
4:15 p.m.	[1 hrs. 8 mins.]	CSX Transportation notifies Maryland Department of the Environment-Emergency Response Division (MDE ERD) of the derailment of train cars carrying hazardous materials.
4:20 p.m.	[1 hrs. 13 mins.]	MDE ERD personnel arrive on scene, contact National Transportation Safety Board, Baltimore City Fire Department Battalion Chief 6, and Baltimore City Fire Department hazardous materials (HazMat) coordinator. Units begin assisting city personnel with analysis of train documentation and potential hazardous products.
		MARC commuter rail, MTA's Central Light Rail Line, and rail freight movement are disrupted by tunnel street fire. MTA initiates bus bridge to bring MARC passengers from Dorsey Station south of Baltimore to the City.
TBD		Chief of the City Fire Department requests that all major roads (I-395, I-83, US-40) into Baltimore City be closed
4:30 p.m.	[1 hrs. 23 mins.]	Baltimore City Police Department and Department of Public Works start rerouting downtown traffic away from the scene using signs and physical barriers; Howard Street and all streets crossing over the Howard Street tunnel are closed. Interstate highways I-395 northbound and I-83 southbound are closed to traffic trying to get into the City.
4:35 p.m.	[1 hrs. 28 mins.]	MDE requests consulting chemist assistance through South Baltimore Industrial Mutual Aid Plan (SBIMAP). MDE advises Baltimore City HazMat of potential hydrogen fluoride (HF) vapor hazard due to thermal degradation of fluorosilicic acid; identifies specialized treatment needed for HF exposures.
4:45 p.m.	[1 hrs. 38 mins.]	Baltimore City Emergency Management contacts MDE to report that city officials are preparing to sound siren system to notify nearby residents to shelter in place. MDE concurs with shelter order.

Time of Day	Elapsed Time	Event/Action Taken
4:53 p.m.	[1 hrs. 46 mins.]	MDE contacts U.S. Coast Guard and requests assistance. MDE and SBIMAP personnel conduct air quality monitoring along Howard Street Corridor and in the vicinity of the Mt. Royal Station.
5:00 p.m.	[1 hrs. 53 mins.]	U.S. Coast Guard closes Inner Harbor to boat traffic. Orioles' office workers are told to leave B & O Warehouse.
5:45 p.m.	[2 hrs. 38 mins.]	Civil Defense warning sirens sound.
6:15 p.m.	[3 hrs. 8 mins.]	Water from the broken water main located under the Howard and Lombard Street intersections surfaces and floods the street. MTA closes Metro's State Center station due to smoke entering the station via subway tunnel and station ventilation fans.
8-9:00 p.m.	[4 hrs. 53 mins.]	Roads and entrance/exit ramps on major thoroughfares into the City reopen sporadically.
11:00 p.m.	[7 hrs. 53 mins.]	Baltimore City Fire Department Command Staff direct primary Command Post operations to be relocated to the vicinity of Camden Yards stadium complex. Water is cut off by BCDPW at the point of the water main break.

Transportation System: Description of the Affected Area

The City of Baltimore is the principal metropolitan area in the State of Maryland. The City is located in the heart of the state and is a central transportation hub for the Northeast Corridor. Figure 9 gives an overview of the Baltimore region with road closures shown in red and yellow. I-95, the main north-south interstate along the east

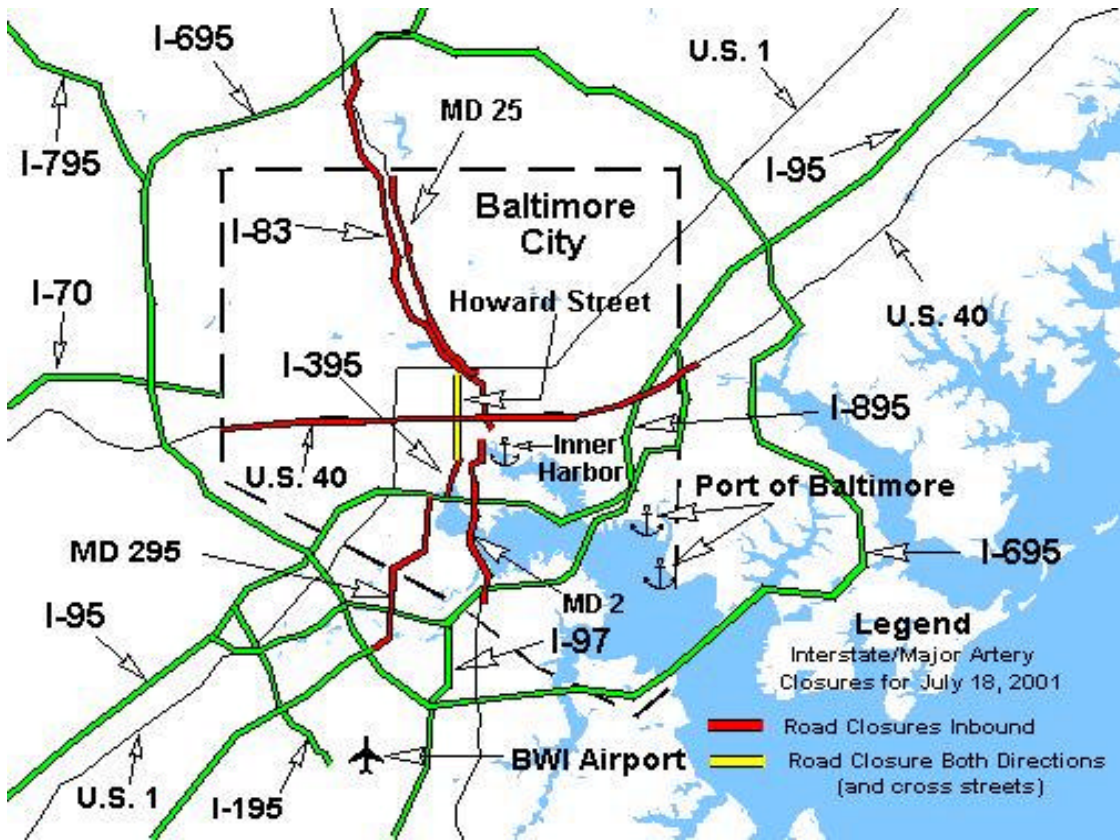


Figure 9. Baltimore regional highway system with closures on July 18

coast, runs through the heart of the City, connecting to the Inner Harbor and downtown Baltimore via I-395. I-695, the Baltimore beltway, links I-95 with I-70, a major interstate route that connects the mid-Atlantic region with the Midwest, and I-83, which links Baltimore with York, Pa., Harrisburg, Pa., and points north. In addition to the above roads, there are two tunnels passing under the Port that connect the interstate system. These are the Fort McHenry Tunnel, which is part of I-95, and the Baltimore Harbor Tunnel, which part of I-895 connecting with I-95.

Baltimore City and the State of Maryland share responsibility for the operation of transportation facilities located within the City. The Baltimore Department of Public Works has responsibility for all surface roads within the City, including non-interstate routes and I-83, I-295, and MD Highway 40, while the Maryland Department of Transportation (MDOT) modal administrations are responsible for most of the Interstate network, transit, and the Port of Baltimore. The Maryland Transit Administration (MTA) operates all transit services in the City, including bus, light rail, heavy rail (Metro), and commuter rail (MARC). The Maryland Transportation Authority (MdTA) owns and maintains parts of I-95 and I-395. In addition, regional and district offices of federal transportation agencies are also located in Baltimore and at BWI. The City's Office of Emergency Management is responsible for handling emergencies and incident management within Baltimore.

Maryland's CHART system is a state-of-the-art transportation management center. The system includes cameras located along the interstate system, HAR, DMS/VMS, and a Web Site. The State Operations Center responsible for the operation of CHART is located south of Baltimore City near BWI Airport. The CHART system offers multiple capabilities, including traveler information services, incident management, and congestion management.

Baltimore is also a major transit point for the movement of freight, served by two major railroads, Norfolk Southern and CSX. The Howard Street Tunnel, which is owned and operated by CSX, represents the only direct rail link between the northeast, southeast, and mid-Atlantic region. The Port of Baltimore is one of the largest container ports on the East Coast, and is also one of the leading ports for RO/RO traffic (roll-on/roll-off, including automobile imports into the United States). The Port generates significant freight traffic, with approximately 80,000 truck trips on an annual basis.

The Maryland Transit Administration (MTA) operates an extensive mass transit system within the City and the surrounding region. The Central Light Rail Line travels a 29-mile corridor, with an average daily light rail ridership of about 30,000 passengers. MTA also operates the Baltimore Metro subway system, with daily ridership of 45,000 passengers, and a city-wide bus service, with daily ridership of approximately 250,000 people. Commuter rail service (MARC) is operated between Baltimore and Washington, DC. The Camden Line, with daily ridership of 3,500 passengers and a terminus at the Camden Yards Station near the stadiums, was the only one of the three MARC services impacted by the event on July 18.

In 2000, Baltimore ranked in the top thirty out of 75 U.S. urban areas in each of the ten congestion indices developed by the Texas Transportation Institute, and in the top twenty for annual person hour delays, annual excess fuel consumption, and congestion cost. Even so, Baltimore does have a relatively high proportion of mass transit use, with 16% of commuters using transit to get to work.

Howard Street and the Howard Street Tunnel are located in the heart of Baltimore City's business and cultural districts, and are adjacent to the core of the City's tourist and sports attractions and the Inner Harbor. Howard Street is the extension of I-395, serves as a major north-south arterial for the city and runs adjacent to Oriole Park at Camden Yards and the Baltimore Ravens' football stadium. It is also close to the Inner Harbor and the National Aquarium, the heart of Baltimore's tourist area.

The Howard Street Tunnel is along CSX's major freight through-route on the Northeast corridor, from the southern states through Washington, DC and Baltimore and on to New York and Philadelphia. The tunnel, constructed in 1895 out of brick, runs for 1.7 miles through the heart of Baltimore and is said to be the longest underground conduit of freight on the Atlantic seaboard. The tunnel ranges from 60 feet underground at its deepest and rises to three feet underground at its shallowest. Before the accident, there were an estimated 28 to 32 freight rail trains passing through the tunnel daily. Figure 10, below, shows the Howard Street Corridor diagram.

Taking Action

City officials faced three challenges once the fire was detected:

- Identify the exact location of the fire in the tunnel.
- Determine the potential environmental impact from the burning cars containing hazardous materials.
- Determine whether downtown Baltimore would need to be evacuated.

The problem of identifying the potential environmental impact was resolved by the Maryland Department of the Environment's (MDE) Emergency Response Division (ERD). Following a review of the bill of lading provided by the CSX engineers, the ERD personnel contacted members of the South Baltimore Industrial Mutual Aid Plan. SBIMAP is a voluntary consortium of manufacturers, emergency response personnel, Baltimore City environmental and emergency management personnel, and MDE, focused on the South Baltimore industrial area. The consortium's purpose is to plan for and respond to incidents such as the Howard Street Tunnel fire where hazardous materials and potential environmental incidents are involved. SBIMAP was established in 1982 and is largely funded by industry. SBIMAP member companies provided two chemists, who quickly determined that the hazardous materials involved in the fire would not, in fact, either individually or in combination, present a serious environmental hazard.

The tunnel fire had an immediate impact on transportation services in Baltimore City. Several specific actions were taken, and specific short-term transportation impacts resulted from the tunnel fire and water main break. The first was a request by the Incident

Commander to close the major roadways into the City. The roadway system was opened to traffic the following morning. The closing of city streets in the vicinity of the tunnel, and the rerouting of passenger, bus, and commercial vehicle traffic followed that action. The day of the incident, drivers were trapped on gridlocked streets, and people waited at curbs for buses diverted from their regular routes. However, once traffic management procedures were put in place, the City was cleared of traffic within two hours of normal rush hour times (8:00 pm as compared to 6:00 pm). Figure 10 is a map from the *Baltimore Sun* detailing road and transit closing.

During initial response to the fire, the Metro subway's State Center station (the station closest to fire) was closed due to smoke accumulation. Light rail service in the vicinity of the water main break was disrupted, as was the MARC commuter rail and Oriole game day service. MARC trains were stopped at the Dorsey Station near BWI Airport, and a bus bridge was set up by the MTA to bring passengers into the City.

The closing of the Inner Harbor to boat traffic by the U.S. Coast Guard occurred at 5:00 PM. The disruption of rail freight movement along the East Coast resulted in reported delays of 18-24 hours for rail freight from Chicago to Baltimore/Philadelphia, and delays of 24-36 hours for north-south movements resulted from the tunnel being closed due to the fire.

One other major impact of the accident was on the telecommunications front. Keynote Systems, an Internet performance company, had significant Internet backbone slowdowns. The Howard Street Tunnel houses an Internet pipe serving seven of the biggest U.S. Internet information service providers (ISPs). The fire burned and severed fiber optic cable, causing backbone slowdowns for Metromedia Fiber Network, Inc., WorldCom, Inc., and PSINet, Inc. Reports were received from the whole East Coast on service disruptions and delays (for example, the Hearst Corporation lost e-mail and its main links to its Web pages on the Internet), and even the U.S. embassy in Lusaka,

Gridlock grips city

Downtown Baltimore expects traffic disruptions again today, two days after a freight train derailed and fire blocked the Howard Street Tunnel. A fiber-optic line had to be rerouted and a broken water main continues to cause delays.



Figure 10. Howard Street Corridor diagram in the *Baltimore Sun*, July 20

Zambia, experienced problems with e-mail. Both WorldCom and MFN had fully redundant service restored by July 20.

The table below indicates key decisions, coordination, and communication by agency.

Key Decisions by Agency

Agency	Key Decisions, Coordination, and Communication
Baltimore City Fire Department	Fire suppression
Baltimore City Police Department	Closing of streets crossing over the Howard Street Tunnel.
Baltimore City Department of Public Works	Repairs to water main and street surface at Howard and Lombard Streets. Traffic control in Baltimore City.
Baltimore City Office of Emergency Management	Media Information
Maryland Department of Transportation	Worked with Baltimore Department of Public Works (DPW) to establish a plan on how to repair the infrastructure damage once the fire was extinguished (procurement issues – having a contractor in place to do repairs, developing a plan on how repair work would be implemented once the “green light” would be received, plans for site survey, traffic diversion plan, etc.).
Maryland State Highway Administration	Through CHART system, posted notices on fixed and mobile DMS advising that major routes into the City were closed.
Mass Transit Administration	Light rail and bus operations. Establishing bus bridge between north and south segments of light rail. MARC operations. METRO subway operations – tunnel inspection.
Maryland Transportation Authority	Responsible for ensuring I-395 route into Baltimore was closed off during initial incident response activities.
Maryland Dept. of the Environment, Emergency Response Division	Obtained information on possible environmental impact of train fire (hazardous materials). Monitored air and water quality in area around the tunnel and the Inner Harbor. Worked with Coast Guard to contain leakage into Inner Harbor. Checked rail cars pulled from tunnel for structural integrity. Coordinated removal and disposal of hazardous materials from the train.
Maryland Emergency Management Agency	Coordinating activities of state agencies. Media relations and rumor control.
US DOT, U.S. Coast Guard	Implemented waterway safety measures, including closing of Inner Harbor. Supported hazardous material detection and containment.
U.S. Environmental Protection Agency	Assisted with monitoring of air and water quality.

Transportation Conditions After the July 18 Incident

Suppression of and initial clean up from the tunnel fire took approximately five days. The tunnel was reopened to rail traffic on July 23. For five days following the incident, streets in the vicinity of the tunnel and the water main break remained closed, and all

vehicle traffic was diverted. On July 24, nearly all streets were opened to traffic. Only a two-block stretch of Howard Street (around the intersection with Lombard Street) and a portion of Lombard Street from Sharp Street to Eutaw Street remained closed.

The major long-term impact from the tunnel fire was on the Central Light Rail Line. The light rail track in downtown Baltimore runs directly over the Howard Street Tunnel and the water main. When the water main broke and the area around the break collapsed, much of the foundation support for this section of the light rail track was removed. The light rail track is embedded on a concrete slab, but much of the fill underneath the slab was washed away or collapsed. Completing repairs to the water main required twelve days while reconstruction of the light rail bed and tracks took a total of 53 days. The slab is still being monitored monthly to determine whether there is any shifting or movement of the rail now that service has been restored.

Northridge, California

On Monday, January 17, 1994, at 4:30 a.m., an earthquake of a magnitude of 6.8 shook Los Angeles, California. The actual earthquake (and its subsequent aftershocks) lasted only about 1 minute. But it damaged 114,000 residential and commercial structures spread over 2,100 square miles, took 72 lives, and significantly impaired the Los Angeles regional transportation system. January 17th was also Martin Luther King Day, a national holiday, and so roadway volumes throughout the day were lower than on a typical workday. The earthquake's aftermath generated a year's worth of highway work in a single event. The Federal Emergency Management Agency (FEMA) reported the Northridge earthquake as one of the largest and most costly federal disasters, with initial cost estimates of total damages at \$25 billion.



Figure 11. I-5 damage at Gavin Canyon

The most severe damage caused by the Northridge earthquake was on I-5. I-5, the main north/south artery in Southern California connecting the Los Angeles basin to Northern California, had collapsed at both the interchange with SR-14 (which connects the cities of Lancaster and Palmdale with Los Angeles) and on top of Old Road at the Gavin Canyon underpasses. I-5 also suffered damage north of the I-5/SR-14 interchange, effectively closing the main highway link over the mountains. Figure 11 shows some of the damaged sustained on the I-5.

The connector at the I-5/14 interchange in Sylmar collapsed. This connector was the only freeway link over the mountains to Lancaster and Palmdale. Except for the extensive damage at the interchange, Route 14 to the north was unaffected. The major east/west freight corridor (the highly traveled Santa Monica freeway) was destroyed at four overpasses. Structural damage to buildings, roads, and utilities also occurred in the I-10 corridor connecting Los Angeles and Santa Monica, with the most severe damage in Northridge. Figure 12 shows the damaged sections of the interstate.

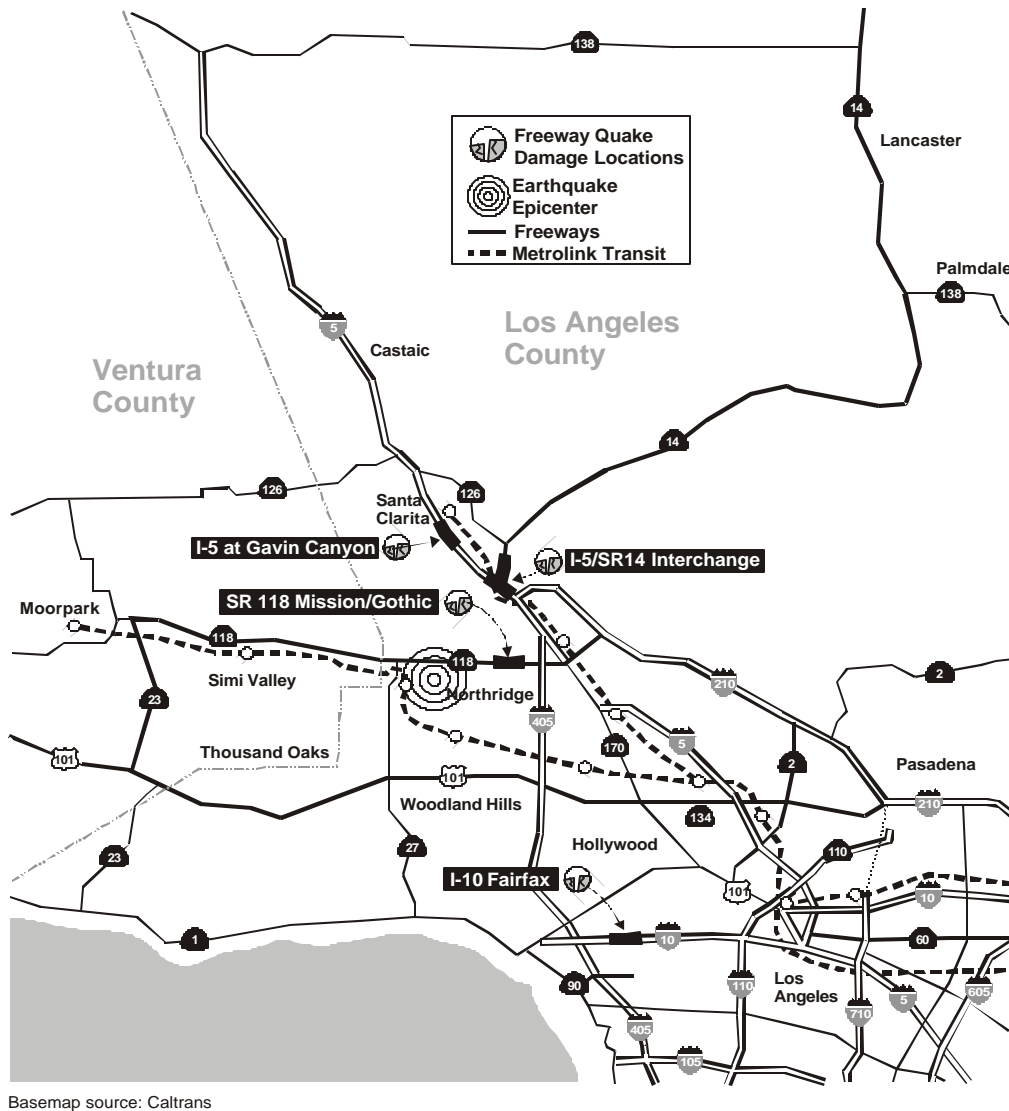


Figure 12. Transportation conditions on January 17, 1994

SR-118, just north of Northridge (the earthquake epicenter), had sustained extensive damage. The eastbound roadway had collapsed completely at two separate places. Additional damage over other areas along SR-118 closed the entire section of highway between I-405 and I-210 in both directions.

Chronology of Events

January 17, 1994

<u>Time of Day</u>	<u>Elapsed Time</u>	<u>Event/Actions Taken</u>
4:30 a.m.:	0 minutes	An earthquake of a magnitude of 6.8 occurred in the Los Angeles area, centered in Northridge. Damage spread over 2100 square miles and through three different counties.
4:31 a.m.:	[1 min.]	5.9 aftershock.
4:35 a.m.:	[5 min.]	Los Angeles City and County Emergency Operations Centers are activated.
4:45 a.m.:	[15 min.]	FEMA Response began.
5:45 a.m.:	[1 hr. 15 min.]	Los Angeles Mayor Riordan declared a state of emergency.
6:00 a.m.:	[1 hr. 30 min.]	FEMA Headquarters Emergency Support Team was activated.
6:45 a.m.:	[1 hr. 45 min.]	As many as 50 structural fires were reported, in addition to numerous ruptures in water and natural gas mains. Power outages reported citywide.
9:05 a.m.:	[4 hr. 35 min.]	California Governor Pete Wilson declared a State of Emergency.
9:45 a.m.:	[4 hr. 45 min.]	All active fires were under control.
2:08 p.m.:	[9 hr. 38 min.]	President Clinton declared a national disaster for Los Angeles County.
7:00 p.m.:	[14 hr. 30 min.]	First of several contracts put in place and crews began work on debris clearance and highway demolition.

Transportation System: Description of the Affected Area

Southern California is a 6-county region spanning 38,000 square miles. In Southern California, Los Angeles County is both one of the region's and the nation's largest counties with 4,081 square miles, an area approximately 800 square miles larger than the combined area of Delaware and Rhode Island. Southern California has more than 200 faults long enough to produce earthquakes as large as magnitude 6 on the Richter scale. Between 1980 and January 16, 1994, these faults produced 19 minor earthquakes.

Considered the most extensive highway network in the world, the Los Angeles region has 27 freeways and over 882 centerline miles of highways. There are over 6 million registered vehicles in Los Angeles County alone, and about 90 percent of all regional households have access to a vehicle. The Los Angeles metropolitan area is also one of the most congested in the nation. In 1994, it ranked first among the nation's 68 largest urbanized areas in all ten measures of the Texas Transportation Institute's indices of congestion. The region ranked number one in delays caused by heavy traffic flow and incidents, and number one in annual delays in person-hours per capita.

In Los Angeles County, driving is the overwhelming mode of choice for commuting. Approximately 85 percent of workers commute by personal automobiles, while less than 10% rely on public transportation. Motorists make about 23 million vehicle trips daily.

Geographically, Los Angeles is separated from central and northern California by the San Gabriel Mountains to the north and San Bernardino Mountains to the northeast. Access over the mountains is limited to two major freeways: I-5, which runs the length of the state and SR-14, which provides access to the Antelope Valley. The I-5 corridor is especially important to Northern Californians who depend on I-5 freight movements originating at the Port of Los Angeles destined for the Sacramento area and other cities in northern California. East-west traffic is mainly dependent on I-10.

Freeways, highways, and traffic management are handled by both state and local agencies as a cooperative venture. The California Department of Transportation, better known as Caltrans, has run the Los Angeles Traffic Management Center (TMC) from the Caltrans District 7 Office building in downtown Los Angeles since its inception in 1971. At the time of the earthquake, the TMC was being staffed 24 hours a day, 365 days a year with Caltrans and California Highway Patrol (CHP) personnel. Extensive traffic management

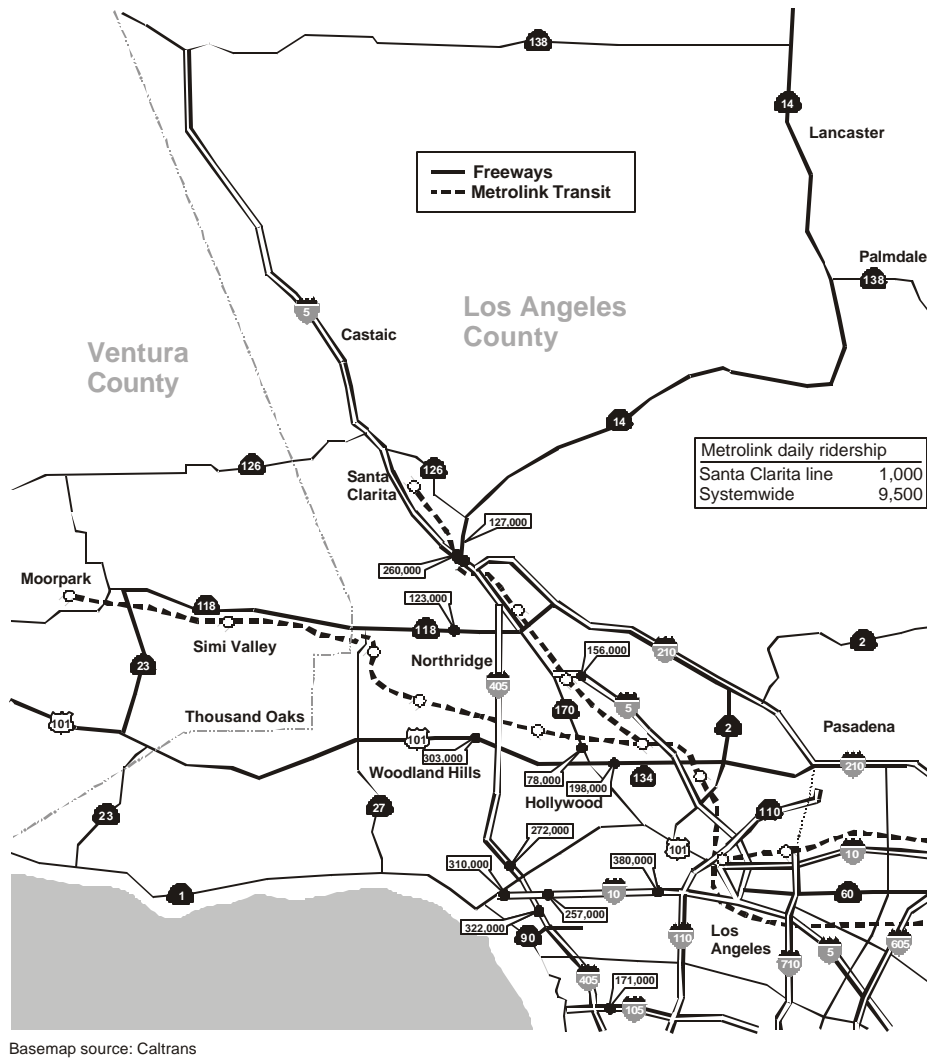


Figure 13. Pre-event transportation conditions and traffic volumes

capabilities were already in place on most of the major freeways well before the earthquake, including speed monitoring loop detectors, closed circuit television (CCTV), on-ramp meters, and permanently mounted VMS. In an emergency, the Caltrans TMC serves as the regional communications hub, providing up-to-date information on closures, detours, and reconstruction activities. This information is distributed through the TMC to public officials, media, and other agencies.

Traffic intersections within the City of Los Angeles are monitored by the LADOT Automated Traffic Surveillance and Control System (ATSAC) in the ATSAC control center located in the Los Angeles City Hall. Constructed for the Olympics in 1984, this system has the ability to adjust signal timing in response to real-time traffic data and monitor key intersections throughout the city. Los Angeles itself has a commuting population of over 2 million people daily.

The CHP also deploys a Freeway Service Patrol (FSP), comprised of both tow truck crews and police officers, which is operated jointly by CHP, Caltrans, and the Metropolitan Transportation Authority (MTA), the regional transit agency, from the Caltrans TMC. The goal of the FSP is to reduce travel delays through early detection and clearance of incidents during peak commute hours. On January 16, the FSP was operating 144 tow trucks on 40 freeway sections covering 381.3 centerline miles of freeways in Los Angeles County. The FSP makes about 220,000 freeway assists annually.

The MTA and the Southern California Regional Rail Authority (SCRRA) provide the majority of public transportation in the Los Angeles region. On a typical workday, less than 10% percent of all commuters utilize public transportation services.

The Los Angeles area is a critical intermodal transfer point for the west-to-east movement of goods across the United States. The Port of Los Angeles is the busiest intermodal freight port in the United States and among the 10 busiest ports in the world, with over 3,000 vessels arriving per year. Trucks leaving the port are typically headed for the major Southern California interstates I-5 and I-10 for distribution throughout the country.

Taking Action

At 4:31 a.m. on the morning of the Northridge earthquake, the “event” itself was already over. Fourteen minutes later, after both the City and the County of Los Angeles’s Emergency Operations Centers were activated, FEMA responded, and government officials began making decisions on what should happen next. By 5:45 a.m., the mayor of Los Angeles had declared a state of emergency in the city while Caltrans began sending out its own traffic management teams to assess the damage to the regional transportation system. Power outages were widespread, communications were impaired, structures were damaged, water and gas mains were ruptured, and four critical Southern California freeways (I-5, SR-14, I-10, and SR-118) were severely crippled. For the motorists that were driving that day, initial detours allowed the regional highway network to continue to function while decisions about alternative transportation routes were being

made. Recommended detours, however, added as much as 50 miles to trips. The media played a large role in both disseminating detour information on the day of the earthquake and discouraging motorists from driving if at all possible.

Caltrans sent traffic management teams to inspect recognizable hazards and implement initial closures and detours on local streets. These teams were in the field on January 17 directing traffic, but because the earthquake occurred early in the morning, there was very little traffic on the roadways. By 2:08 p.m., Caltrans had completed an initial damage assessment, hazards such as earthquake-related fires were extinguished, and President Clinton had declared a national disaster in Los Angeles County.

On the transit side, the Southern California Regional Rail Authority (SCRRA) had expanded Metrolink commuter rail service north and west within three days. Bus services were changed, shuttle services were implemented, detours were put in place, and employers offered free shuttle services while federal, state, and local governments partnered to reconstruct the highway system in record time. According to the California Department of Transportation (Caltrans)/Federal Highway Administration (FHWA) *The Lessons Learned from the Northridge Earthquake*, “Everyone involved was driven by the desire to ‘be part of the recovery effort,’ and ‘take pride in showing what we could do.’” Figure 14, below, shows the reconstruction effort underway.



Figure 14. Reconstruction after the Northridge earthquake

FHWA reacted immediately to the declaration by releasing Emergency Relief (ER) funds to Caltrans. The ER program funds are available for use by the FHWA to help with the repair or reconstruction of federally funded roadways that are damaged as a result of a natural disaster or catastrophic failure from an external cause. Within hours, FHWA field representatives were working with Caltrans on reviewing and approving all

reconstruction efforts. At the same time, several contractors who had prior experience with disaster recovery began to mobilize manpower, equipment, and demolition supplies directly to the damaged freeway locations, where they were prepared to work around the clock. Using emergency contracting procedures, under orders to immediately begin debris removal and demolition activities, Caltrans paid the demolition contractors for actual costs of materials, labor, and equipment with an agreed profit. The contractors started work based on these informal contracts. And, by 7:00 p.m. that first night, the first contracts were in place and work had already begun on I-5 and I-10 demolition.

The Caltrans TMC served as the center of initial decision-making efforts by the traffic management teams, and on the day of the earthquake, all coordination of traffic operations was handled there. The TMC used backup electrical generators for power and relied on landline telephones for primary communications. The FSP also was run out of the Caltrans TMC. While the TMC was very functional, its technological capabilities were limited for real-time decision-making purposes. Many of the areas affected by the earthquake did not have ITS technologies in place in 1994. On the day of the earthquake, Caltrans and the LADOT immediately began strategizing about ways to upgrade facilities to handle the overload on the Caltrans TMC and ATSAC.

The table below indicates key decisions, coordination, and communication by agency.

Key Decisions by Agency

Agency	Key Decisions, Coordination and Communication
Caltrans	Assessed damage to the regional transportation system. Used emergency contracting procedures to start work on rebuilding the network immediately. Established detours. Caltrans Traffic Management Center (TMC) provided information on closures, detours and reconstruction activities. Later, also developed a Traffic Management Plan. Established the Emergency Detour Management center along with LADOT, SCRRA and other agencies.
Federal Highway Administration (FHWA)	Released Emergency relief funds to Caltrans and good faith agreements to completely fund the rebuilding of the highway network.
Los Angeles DOT	Along with Caltrans, retimed traffic signals and installed informational signage. Monitored traffic intersections from the ATSAC control center.
Southern California Regional Rail Authority (SCRRA) Metrolink	Expanded Metrolink commuter rail service. Purchased new cars and decreased ticket prices.
Metropolitan Transportation Authority (MTA)	Changed bus services adding new emergency services including new routes and service revisions. New park and ride lots were created. With Caltrans, Metrolink and LADOT, among others, developed multi-faceted public awareness campaign on traveler information.
Federal Emergency Management Agency (FEMA)	Coordinated response of 27 federal agencies involved using FEMA ICS to provide quick services, expedite decisions, and overcome financial challenges. Opened an earthquake service center to aid victims.
California Highway Patrol(CHP)	Using the Freeway Service Patrol (FSP) covered strategic highways and provided extra trucks, extended peak schedules to earthquake affected areas. This is operated jointed with Caltrans, LADOT and the MTA.

Transportation Conditions After the Earthquake

Rebuilding the Los Angeles regional freeway network required a sustained effort by Caltrans and unprecedented cooperation between local, state, and Federal Government agencies. Through demolition, construction bidding, and reconstruction, the agencies involved exercised innovative solutions to existing “red tape” problems to restore the highway network. The use of ER funds and innovative contracting procedures allowed for the expedited rebuilding of the Los Angeles regional transportation network.

In the first days following the earthquake, Caltrans and FHWA discussed bidding, and eventually signed a memorandum of understanding (MOU) on January 26, 1994, which outlined the three bidding procedures:

1. A+B bidding.
2. Invitation to bid procedures.
3. Design-build bidding.

A+B Bidding is a “cost-plus-time” bidding procedure that selects the lowest bidder based on a combination of the contract bid items (A) and the amount time (B) needed to complete the project or a critical portion of the project. A+B Bidding is used to motivate the contractor to minimize the overall time on high priority and high usage projects. This encourages contractors to finish early by offering bonuses (incentives) for early completion and assessing fines (disincentives) for late completion.

Invitational bidding was another procedure used to expedite contract administration by FHWA and Caltrans. This concept was used for those projects that had high user delay costs and an urgent need for early completion. These projects were expected to have short time frames for Caltrans to prepare the bid packages, greatly expedited advertising periods for the contractors to submit bids, and one-day bid openings and awards. Limiting the number of bidders on these critical projects allowed Caltrans to provide packages to the contractors quickly and answer questions. The MOU, signed on January 26, 1994 between Caltrans and FHWA, outlined the criteria to be used for the invitation-to-bid approach. Caltrans Headquarters Structures Division identified contractors to be on a “short list” for the invitational bidding based on internal criteria. Caltrans used the invitation-to-bid approach on 8 of the 10 A+B earthquake reconstruction contracts.

Design-build construction is another contracting mechanism that allows initial construction to begin before final drawings for design are approved. Following the Northridge earthquake, Caltrans had 70 design engineers in place and ready to being work on plans for the damaged freeway sections. Contractors submitted technical proposals for construction work, and those proposals that met the minimum technical guidelines were allowed to participate in the price proposal section of the bidding. In order to keep the public informed, Caltrans embarked on an extensive public relations effort. Figure 15 is one example of the agency’s efforts to keep the public informed.

The following chart shows a summary of the freeway reconstruction and incentive efforts:

Freeway Reconstruction Incentives

Freeway Segment	Work began	Work Finished	Incentive-Disincentive	Bonus
I-10	February 5, 1994	April 11, 1994 – 74 days early	\$200,000/day	\$14.8 million
SR-14/I-5 Interchange*	March 19, 1994	July 8, 1994 – 35 days early	\$100,000/day	\$3.5 million
SR-14/I-5 Interchange**	July 9, 1994	November 4, 1994 – on schedule	\$20,000/day	N/A
I-5 at Gavin Canyon	January 29, 1994	May 17, 1994 Southbound; May 18, 1994 Northbound – 33 days early	\$150,000/day	\$4.95 million
SR-118 Eastbound	February 10, 1994	May 13, 1994 – 8 days early	\$50,000/day	\$400,000

Following the earthquake, a \$12.64 million design/build contract was put into place to install new traffic monitoring and commuter information equipment to areas that were affected by freeway damage but were not covered by the existing traffic operations equipment. The contract between Caltrans and National Engineering Technology was signed on January 20, 1994. The establishment of the Emergency Detour Management Center, which was later re-named the Earthquake Planning and Implementation Center (EPI-Center), was also part of this contract. Housed within the Caltrans district office in Los Angeles, it was built in order to maintain and monitor the new field equipment. The Emergency Detour Management Center also took some of the burden off of the existing Caltrans TMC by solely focusing on the earthquake affected areas and detour routes.

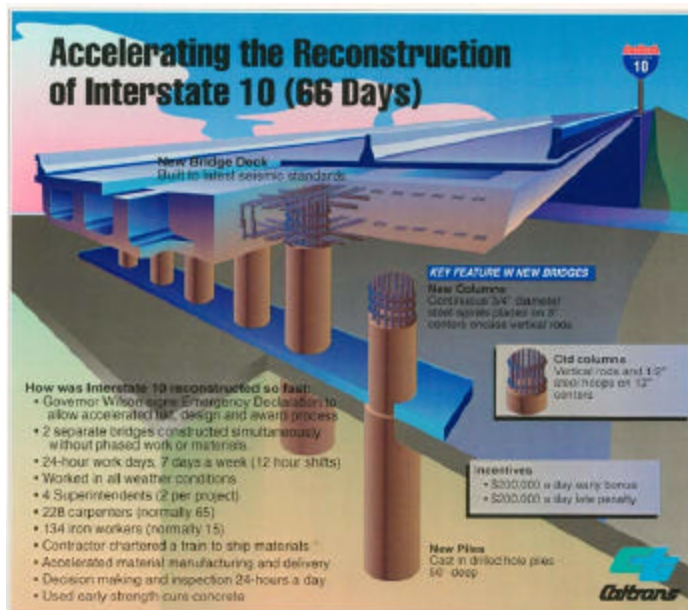


Figure 15. Caltrans reconstruction public outreach product

Findings

Each of the events from the four case studies presented transportation officials with a different set of challenges in dealing with response and recovery. The findings section of the case studies attempted to answer questions about how transportation agencies responded to the events presented to them and what lessons were learned. This included an assessment of the following questions:

- Were the key players prepared?
- What happened?
- Who took action?
- What aspects of emergency response worked well and why, and what aspects did not work well and why?
- What role did technology play in these aspects with respect to emergency response and recovery?
- What was learned, what could be done differently, and what can be incorporated into the planning process.

Guiding Priority

The initial guiding priority in every emergency is the protection of life. While police, fire, and other emergency responders have the primary task of ensuring public safety and resolving the dangerous conditions, transportation officials must begin almost immediately to implement evacuation plans and institute recovery procedures. A major concern with each event is the level of uncertainty of what exactly is involved. This uncertainty ranges from the concern over the potential for additional terrorist actions to the possible presence of hazardous materials to the uncertainty of the structural integrity of the transportation infrastructure.

One of the major goals of transportation agencies is to provide mobility for the efficient movement people and freight on a daily basis. The challenge that transportation officials face during an emergency is how and when to begin restoring the level of mobility to the surrounding area that existed before the event took place. The level of damage and impact on the transportation system was different in each of the four cases studied. In each case transportation officials had to respond in a different manner as events unfolded.

The 1994 earthquake centered in Northridge, California, produced a massive amount of physical damage to the Los Angeles area. Four major interstate connections were destroyed. Approximately 800,000 commuters used these four interstates daily. Because the earthquake occurred in the early morning hours of the Martin Luther King holiday when traffic volume was extremely light, emergency response needs were limited to putting out scattered fires. The state reported that all active fires in the region were under control by 9:45 a.m. the same morning. Because of this, transportation agencies were able to shift their overriding focus rather quickly from safety and security to restoring mobility. Debris removal at the affected interchanges began that night and work to repair the structures was expedited through innovative design build techniques. A TRB report on the aftermath of the event reported several findings:

- Providing immediate transportation solutions took precedence over the opportunity to change motorist's behavior.
- Stabilization of traffic conditions took several weeks to several months.
- Where sufficient alternative routes existed, motorists continued driving; where convenient detours were not available, transit options became much more attractive.
- Availability of accurate traffic data was critical in developing emergency detours.
- Areas with well-developed traffic management centers were able to accommodate sudden traffic changes more easily.

Because Caltrans was able to focus on the reconstruction of the interstate from the first day, it was able to meet an aggressive schedule for reopening the damaged interstate connections to restore mobility to the region as quickly as possible. Work was completed on the I-10 in less than 3 months, the I-5 and SR-118 in less than 4 months and the complicated work involved in the SR-14/I-5 interchange in 9 months.

First responders to the Baltimore rail tunnel fire believed that they were initially concerned only with the need to put out a particularly difficult fire. But once officials learned more from the manifests about the cargo on the train, a main priority was to ensure the containment of a potential environmental hazard. Because of the location of the fire beneath a corridor that contained a light rail line, a commuter rail line, and a major north-south arterial, mobility for the area was severely compromised.

This incident demonstrates the changing nature of incident response. First responders initially moved into the tunnel, but then had to delay response until MDE, EPA and CSX identified the chemical contents of each rail car and determine the appropriate response. The prompt response by MDE in identifying the potential environmental impact of the fire in the cars containing hazardous materials helped to resolve the differences between this priority and the transportation and fire suppression priorities.

Suppression of and initial clean up from the tunnel fire took approximately five days and the rail tunnel was opened to freight traffic on July 23. Within six days, nearly all the streets in the affected area were reopened to traffic. Repairs to the Central Light Rail Line were completed within 53 days, and MTA reported that ridership on the line was back to normal within two months of the reopening of service.

In Washington, D.C., there was no significant physical damage done to the major components of the transportation infrastructure. The challenges facing transportation officials revolved around how to best facilitate the evacuation of the D.C. area on September 11. The uncertainty of what might happen next introduced a high degree of uncertainty into the decision-making process.

The fact that there are so many various actors who control different portions of the transportation system highlighted a real need for coordination. Actions to close access to portions of the system were taken by officials for Washington Metro, the City of

Washington, DC, Arlington County, the Secret Service, the National Park Service, the military, the states of Maryland and Virginia. While there was no physical damage done, security was a top priority in the weeks following the attack as officials were on high alert for another attack.

New York City officials were presented with the greatest degree of difficulty in shifting from security to mobility. The physical damage done in Lower Manhattan was unprecedented. The need to maintain high security enforcement and give primary access for rescue and recovery operations took priority over the need for restoring mobility to the general public for several months. The transportation officials responded to the needs of emergency personnel in deciding what facilities to open and close. Their primary goal was to support the needs of the police, fire, and emergency rescue agencies, which included two actions:

1. Allow priority access for emergency vehicles and personnel to and from the scene
2. Give transportation agencies time to inspect their own facilities to ensure the safety of the facility from further attack

Within two hours of the first plane crash, most of the major transportation facilities in Manhattan were closed. This included all the major bridges and tunnels into and out of Manhattan, most local streets below Canal Street and all airports in the region. While restrictions were in place for the general public, these facilities remained open to provide mobility for the emergency response efforts in the months following. Even one year later, there remain certain restrictions in place such as the ban on single occupancy vehicles entering Southern Manhattan, truck restrictions in the Holland Tunnel, and vehicles restricted from the Staten Island ferry. It will be several years, and cost several billion dollars, before subway service will be restored on the PATH corridor to Lower Manhattan or on NYC Transit service to the World Trade Center area.

Plan of Action

In order to properly respond to a catastrophic event, agencies need to have in place a plan of action to handle emergency situations and to begin the process of restoring mobility.

This section groups the actions needed into four sections:

- Advanced preparation
- Institutional coordination (both internal and external)
- Technical communications
- Advance technology
- System redundancy and resiliency

Advance Preparation and Planning

The need for advance preparation and planning by agencies is crucial in dealing with a range of mishaps or disasters. Several key themes emerged from the four cases in regards to advance preparation and planning. One is *the need to learn from previous events and incorporate that learning into an agency's response plans*. The events of September 11

have served as a wake up call to cities and towns across the country about the need to prepare for the unexpected. Cities and towns across the nation need to prepare for natural and manmade catastrophes that can strike with little warning. In 2001, there were a total of 45 federally declared disasters within the United States, an average of one every eight days. These disasters were located in 29 different states and included fires, terrorist attack, tropical storms, and earthquakes.

Two, there is *a need to be able to rely on agency staff at all levels to make good and timely decisions, often without complete knowledge of all of the mitigating circumstances.* It is critical that staff at all levels be able to respond to situations and make decisions. As one public official commented “emergencies do not happen at convenient times, therefore it is important to train not just your first string but also your second and third string for emergencies.” The Northridge earthquake occurred at 4:00 a.m. when most of the residents of Southern California were asleep. The events in New York City and Washington, D.C., occurred during the morning rush hour. The Baltimore fire occurred at the beginning of the evening rush hour. Often these decisions have to be made without the luxury of obtaining detailed guidance from headquarters. In New York City, an official at one of the Port Authority’s tunnels responded that he was not able to check with headquarters because “it was not there.” The Port Authorities headquarters were located in the WTC and were destroyed in the attack.

Three, there is *a need to practice for the expected and unexpected. Knowledge gained and relationships developed through day-to-day contact are extremely useful when catastrophes strike.* The events of September 11 were beyond the scope of what agencies had ever prepared for. Simultaneously, communications technologies were lost or overwhelmed, accurate information about the scope of the attacks was limited, and the loss of electricity compounded the ability of first responders to perform their jobs. But many of the actions that helped in the response were the result of years of day-to-day contact among transportation and police agencies. In New York, TRANSCOM had served as the collector and disseminator of daily traffic and travel information. During a crisis, it was able to expand upon its daily operations structure to provide accurate, timely information to the public and agencies involved in the response and recovery efforts. The I-95 Corridor Coalition was able to help its member agencies disseminate information on roadway conditions all along the Eastern Seaboard.

New York City had dealt with previous emergencies including the 1993 World Trade Center bombing, a blackout in Queens in 1999 and a threatened subway strike during the 1980s. The 1999 blackout forced a number of city agencies to increase its ownership of emergency generators which were invaluable on September 11 in providing power to the recovery effort and powering pumps to alleviate the flooding of the underground utilities and subways in Lower Manhattan. During the 1980s, the City prepared a draft single occupancy vehicle (SOV) ban on automobiles in case of the subway strike. This SOV ban was not needed at the time but served as the basis for the SOV ban 20 years later, when New York City began to experience debilitating traffic jams as security checks were put in place at key points.

As a result of the 1993 World Trade Center bombing, New York City began the process of upgrading its response to emergencies. In 1996, the Mayor's Office of Emergency Management was established to be responsible for providing interagency coordination in the event of a natural, technological, biological, chemical, terrorist or other emergency in the City. A new, state-of-the-art control center was built and opened in 1999 so that various agencies had command desks located in close proximity to one another to facilitate interagency coordination. Unfortunately, the command center was located within the World Trade Center complex and was destroyed that morning forcing the OEM to move to three different temporary headquarters the first day.

Due to prior training and relying on personnel in the field to take action, NYC Transit was able to begin emergency operations of its subway system within 1 minute of the attack because a subway train operator stopped at Courtlandt Station felt the vibrations below ground from the plane crashing into the towers and reported that something was wrong. The PATH system began similar procedures six minutes after the first attack as an employee at the train control center in New Jersey ordered the trains to evacuate people at the World Trade Center station and express to safety in New Jersey.

The crash of an Air Florida flight into the Potomac River in 1982, which coincided with a major snowfall and an unrelated Metrorail subway crash, pointed out the inability of agencies within the Capital District to communicate with each other. Each of the various state, county and municipal emergency response agencies communicated internally over a different radio frequency. While several of the jurisdictions had updated their communications to be interoperable in 2001, not all had. On September 11, local, state and federal agencies once again had trouble communicating with each other because of differing technological standards and equipment.

As a result of September 11, officials from the states of Maryland and Virginia, the District of Columbia and the Federal Government signed an agreement on June 20, 2002 to improve the region's handling of transportation emergencies. The agreement commits the agencies to updating evacuation plans, integrating emergency operations centers, developing a regional data sharing network and performing inventories of resources.

Southern California had taken several steps to improve its regional response to a catastrophe. In response to a series major forest fires during the 1970s in Southern California, a consortium of local fire officials developed the Incident Command System (ICS). ICS helped local and regional agencies better plan and confront issues such as non-standard technology and a lack of integrated communications systems.

Minutes after the Northridge earthquake, the City and County of Los Angeles was able to activate its Emergency Operations Center and begin emergency response procedures. This center was built in response to the events associated with the 1992 Los Angeles riots. State and local officials realized that they needed a regional operations center to handle large-scale events that required the coordination among emergency response and other related agencies, such as transportation. In addition, the numerous state and local transportation and safety agencies within the region had coordinated on safely moving

large numbers of people on the transportation network for numerous large-scale events like the 1984 Olympics, political conventions and special sporting and entertainment events.

The earthquake in the Los Angeles region created damage over a 2,100 square mile area. Transportation officials had to quickly assess damage to the system and prioritize where to immediately place its resources. Caltrans immediately mobilized technical experts among its staff of 23,000 workers spread across the state to descend upon the Los Angeles region to begin the response and recovery efforts. By the late morning of the first day, engineers were assigned the task of evaluating the structural integrity of the portions of the system and setting up temporary detours. To expedite the clean up process, Caltrans officials in the field were able to quickly enter into “handshake agreements” with private contractors to begin demolition and debris removal within 16 hours of the earthquake. This initial day-1 response occurred on a state holiday, Martin Luther King Day.

Learning from the 1989 Loma Prieta earthquake near San Francisco, Caltrans began a statewide retrofit program for bridges judged to be at risk to damage from an earthquake. The retrofit program was underway in the Los Angeles area and not one of the 122 state bridges that were retrofitted in Los Angeles County as a result of the program sustained severe damage.

While the City of Baltimore was prepared to fight a fire and to deal with a hazardous materials incident, it had not planned for a situation where both a hazardous materials spill and a fire occurred in the same incident. The rail tunnel fire presented emergency response officials with numerous uncertainties and only cursory information about the potential hazards. Because the fire was in a tunnel, it was difficult to know which boxcars were on fire and exactly which chemicals or combinations of chemicals were affected. At the same time a major water main ruptured pouring thousands of gallons of water into the tunnel. In response to the problems presented by the complexity of the tunnel fire, the Mayor of Baltimore has instructed local emergency planners to conduct a comprehensive review of the City’s emergency response plan.

The train engineers in Baltimore were not able to immediately contact their supervisors to alert them of the situation because their radio was inoperable because of their location within the tunnel. One of the engineers eventually was able to establish communication with his cellular telephone after decoupling the engines and exiting the tunnel. Agency officials involved in each of the case studies repeatedly stressed the need and value of practicing for emergency response. In the words of one transit official from New Jersey, the most important thing is “practice, practice, practice.” The practice of emergency procedures can teach and reinforce lessons first learned in classroom training. A practice exercise is most useful when it involves representatives from multiple transportation and emergency response agencies and results in relationship-building among these agencies in how best to respond to a crisis.

Institutional Coordination

By their very nature, disasters require a coordinated response among multiple federal, state, regional and local jurisdictions. This coordination needs to occur at several layers simultaneously:

- Internal agency coordination
- External coordination with other agencies as well as the public

A requirement for ensuring institutional coordination is to have an established chain of command. In New York City, the Mayor's Office of Emergency Management was in charge of emergency response measures. After the September 11 attacks, OEM made general command decisions, such as closing access to Lower Manhattan. Those orders were communicated to the individual transportation agencies and they would coordinate among themselves on how best to carry out the directives. In California, the pre-established structure of the ICS in Southern California helped with establishing areas of responsibility among multiple agencies after the Northridge earthquake.

In Baltimore, the various local, state and federal agencies did not typically work together on a single incident and had not established a pre-existing chain of command. But the Governor did arrive on the scene and helped direct the response and recovery efforts. In Washington, the lack of formal coordination has led to a June 20, 2002 regional agreement among federal, state and local officials on how to coordinate response to transportation emergencies. At the federal level, FEMA coordinates the response of 26 federal agencies involved in post-event recovery. This coordination of federal efforts through one federal agency allows local officials to be able to rely on one point of contact in obtaining assistance.

Transportation agencies typically have staff at multiple locations with multitudes of varying responsibilities. The Port Authority of New York New Jersey, for example, operates tunnels, bridges, transit lines, airports and water ports within the New York/New Jersey region. The California Department of Transportation, Caltrans, oversees a state highway system of 25,000 kilometers in length and has a staff of over 23,000 employees with 12 district offices located throughout the state. It is important that each of the different parts of an agency understand the scope of an emergency involving transportation and the agency's intended coordinated response.

Just as important as being able to communicate an agency's coordinated response internally, is the need to be able to communicate with outside agencies, both public and private. As stated before, a finding that is present in each of the four cases is the importance of how day-to-day routine operations coordination helped in times of crisis. Numerous times, agency personnel relayed stories of how beneficial it was to be able to pick up the phone and communicate with someone at another agency in which there was a pre-established working relationship. The pre-existence of well-established interagency relationships among the many transportation and emergency personnel in New York City was one of the most important success factors in managing the post-event situation. The agencies built working relationships through their day-to-day coordination. As one official remarked, they view the management of each daily commute as an event that

relies on the coordination of officials from transportation agencies, fire, police, and the news media.

In New York City, TRANSCOM set up a fax broadcast list that grew to 400 public and private agencies. The faxes contained updated transportation information from the city and regional transportation agencies and were distributed as frequently as once every hour during the first few days after September 11. The New York City Office of Emergency Management helped coordinate information disseminate among transportation agencies as well as with other outside agencies such as health and human resource agencies that have a vital interest in the state of the transportation network.

In Montgomery County, Maryland, the county's emergency operations center was able to serve as a mini-clearinghouse for information to other local governments and emergency response personnel. It quickly added additional phone lines to hand the increased call volume and also relied on cell phones, two-way pagers, and laptop computers connected to a local area network.

The lack of existing institutional coordination was evident in several cases in Washington, D.C. These examples of poor emergency coordination might be the result of the lack of day-to-day coordination among the agencies. As an example, at 10:46 a.m. on September 11, the Metropolitan Police Department requested that Metrorail cease operations due to the uncertainty of events. But Metrorail officials declined the request and decided to continue operations to aid in the evacuation of people leaving the city. At about the same time both the Secret Service and the military were closing roads considered at risk, but the closures were not announced through any central coordinating agency like TRANSCOM in New York. In addition, the failure to coordinate the release of federal workers, such as would occur during a weather related incident, resulted in an unanticipated rush of commuters just as the region's transportation system was ending its morning peak rush service patterns.

Washington, D.C., had additional communication problems. There was no communication to Virginia DOT (VDOT) from agencies in D.C., including the National Park Service and DDOT, regarding transportation facility closures that affected traffic volumes into Virginia, although requests were made. This put VDOT in a reactive mode. As one example, there was no communication between the VDOT center in Northern Virginia responsible for traffic operations in the area and WMATA, the region's transit provider. So in Northern Virginia, the local STC reversed HOV lanes to facilitate movement of southbound traffic out of the District, thus preventing the use of these facilities as a route for Metrobuses to return to the District to pick up more transit-dependent travelers.

With Baltimore, communications between responding agencies were not as effective as might be desired. This was due in large part to the differences in guiding priorities as well as the fact that the Incident Commander was initially only concerned about fire suppression. It was only later that officials realized that the potential for a hazardous

chemical event would require a different level of response, including the possible evacuation of a section of the downtown area.

While every emergency requires some level of coordination between the public and the private sector, the Baltimore fire tunnel was unique among the four cases in that it involved a private freight rail train operating within a private-sector rail tunnel with a public-sector light rail line operating above it. This situation required an additional layer of coordination. In order to help the media disseminate accurate information about the status of the Baltimore rail tunnel fire and its associated impacts, public officials held a series of daily press conferences. The press conferences included the Governor of Maryland, and representatives from various Maryland state offices, the City of Baltimore, and CSX.

Communicating with the public about the impacts and consequences of an emergency can be an on-going process. The Interstate highway reconstruction effort after the Northridge earthquake lasted for nine months. It was approximately two months after the Baltimore rail tunnel fire that the light rail system was restored. Restrictions on certain bridge and tunnel crossings are still in effect a year later in New York City.

In order to disseminate information, agencies can rely on the traditional print, television and radio media, but also increasingly, their own web sites. Although the Internet is an increasingly important means of communications, *USA Today* reported that during the week of September 11, 80% of Americans got their information from TV, 11% from radio and 3% from the Internet.

To better disseminate updates and status reports on the transportation impacts of the Northridge earthquake, Caltrans implemented an extensive campaign to keep the public informed. Cooperating with LADOT and the California Highway Patrol, they produced about 200 each of *Los Angeles County Road Closure Reports* and *Special Bulletins*. In addition, it distributed over 2.6 million copies of *Accelerate, Caltrans' Action Plan to Get All our Freeways Moving Again*. To deal with daily changes, officials held daily news conferences each day at 2:00 p.m. to ensure that the information would be available for the evening news. Representatives from the Governor's office, Caltrans, FHWA, and other state agencies were present to give status reports and answer questions from the press. Caltrans made a point of having both policy makers and technical experts to handle a wide range of questions.

Transportation officials in New York City implemented a similar multiple action strategy to disseminate information. Agencies used maps, handouts, and personnel to disseminate public information on the street. The MTA reported printing and distributing 1.5 million each of "take-ones" (one page handouts noting changes in service) and black and white maps in two 12-hour shifts after September 11. Figure 16 is an example of a take-one produced by NYC Transit showing the changes in subway service the week after the attacks.

Subway service to lower Manhattan

Mon and Tue Sep 17 and 18

There are no **C** **N** **R** **Z** or **9** trains.

2 **3** run local between 96 and Canal Sts only. Franklin, Chambers Sts and Park Place are closed.

1 runs between 242 and 14 Sts only. Trains run local between 242 and 96 Sts and express between 96 and 14 Sts. Cortlandt, Rector Sts, and South Ferry stations are closed.

E trains stop at all **C** stations in lower Manhattan, except Chambers St.

2 **4** **5** **6** **A** **E** **J** **M** service is operating to lower Manhattan, but some stations are closed.

For service to nearby stations, use the chart below.

Closed station	Take this train	To this nearby station
City Hall N R	J M 4 5 6	Chambers St Brooklyn Bridge-City Hall
Chambers St A C E 1 2 3 9	2 3 4 5 A E J M	Fulton St-Bdwy-Nassau St
Park Place 2 3	2 3 4 5 A E J M	Fulton St-Bdwy-Nassau St
World Trade Center E	2 3 4 5 A E J M	Fulton St-Bdwy-Nassau St
Cortlandt St N R 1 9	2 3 4 5 A E J M	Fulton St-Bdwy-Nassau St
Wall St-Bdwy 4 5	J M 4 5 A E J M 2 3	Broad St Fulton St-Bdwy-Nassau St Wall St-William St
Rector St N R 1 9	J M 2 3	Broad St Wall St-William St
Whitehall St N R	4 5 J M	Bowling Green Broad St
South Ferry 1 9	4 5	Bowling Green

Travel information: 718 330-1234, 24 hours

For Monday and Tuesday Sep 17, 18 Post at All Stations
www.mta.nyc.ny.us

Service Notice
New York City Transit. Going your way.

Figure 16- NYC Take One

The Mayor's office coordinated press conferences, which included transportation updates. Agencies utilized radio, TV, and newspapers to relay information on the changing conditions. Highway Advisory Radio (HAR) broadcasts by INFORM and other transportation agencies in the NYC area gave up-to-date traveler information, and news stations ran INFORM and TRANSCOM reports on the morning and afternoon news shows. MTA reported 10 million hits on its web site in one day, five times the normal volume, one day after September 11 as people tried to obtain up to date information on conditions.

With the Baltimore rail fire, the Maryland Governor coordinated daily press conferences from Camden Yards. The briefings had representatives from both public agencies as well as CSX, a private freight rail company. The City of Baltimore and state of Maryland each assigned public information officers to handle all press inquiries. This proved particularly effective in providing information to the public about the absence of a severe environmental hazard and helped to control rumors.

Rumor control can be a real problem when trying to assure the public of the safety of facilities or the need to close certain facilities. This was certainly a problem across the country on September 11 as people were uncertain if there would be additional terrorist attacks. In Washington, D.C., rumors of the closing of the Metrorail service kept many people out of the subway and instead on the street, which were congested by motorists trying to leave the city. MDOT experienced problems with judging the reliability of information it had at its disposal. On September 11, there was a fair amount of information, particularly disseminated by the media that turned out to be false. Examples include bombing of the State Department and other federal buildings causing undue alarm in the Capital area. The lack of accurate information could result in the wrong deployment of resources by officials working under the pressure of making decisions without a full knowledge of the events.

Technical Communications

The demand for accurate, timely information increases dramatically after an emergency. Often this increased demand comes at a time when the technology needed to provide that information is most compromised. Accurate information is needed by agency officials to allow them to make good decisions as to allocation of resources and setting of priorities in responding to an emergency. There is also a heightened interest by the public at large in gathering information about the emergency to be able to make decisions that might change their daily routine. While good communications depends upon human response to make the decisions, it is important to have the proper technology to disseminate the information.

In New York City, and to a lesser extent Washington, D.C., immediate communication with agency field staff and emergency responders was difficult because telephone landlines were damaged and cellular communications systems were overloaded. Radio communications for the NYC Fire and Police departments were compromised because of

the use of outdated equipment and the destruction of radio towers and repeaters located on or in the buildings in the World Trade Center complex. Two-way radios helped field personnel communicate during the evacuation; however, field personnel without radios were out of touch.

New technologies provided communication alternatives that proved successful in the emergency response efforts for internal agency decisions. The central telephone-switching center for all the Port Authority divisions was located in the World Trade Center and ceased working soon after the attack. In both cities, agencies reported that interactive pagers that use push technology, such as the Blackberry pager, were extremely useful on September 11 when other forms of communication were unavailable. Internal e-mail, for example, helped Port Authority staff communicate internal decisions to the various divisions of the agency when telephone communications were difficult. Both NYC Transit and New Jersey Transit had “mobile” communications centers (transit buses equipped with satellite and computer technology), which were used as command posts for communications and decision-making.

Communications immediately after the Northridge earthquake was difficult for both emergency workers and residents. Power was out for most of the area, which affected the operation of the central phone system. There were numerous fires at electrical stations and telephone switching stations. In addition, switching stations shut down because they are programmed to shut down if a certain percentage of telephones are off the hook at one time. This occurred on the morning of January 17 as the vibrations from the earthquake knocked a large percentage of telephone receivers off the hook.

During a previous disaster, the 1989 Loma Prieta earthquake in San Francisco, transportation officials found that cell phones proved to be invaluable as radio communications were damaged. As a result California officials came to rely more on cell phone technology over radio. But because of the location of the Northridge earthquake, cell phone communications in the canyon areas was intermittent due to terrain and limited coverage and Caltrans has now also incorporated satellite and radio communications to its system.

Role of Advanced Technologies

Once a catastrophic event has occurred, advanced technologies and intelligent transportation systems (ITS) can aid in providing information and assisting decision-makers in these ways:

- Help make better informed decisions on when and how to open or restrict facilities.
- Aid better communications with other public and private agencies involved in the response.
- Assist in communicating with the public about the status of the transportation system.

ITS technologies aided both agencies and travelers on September 11 in several ways. It was able to alert motorists of problems long before they reached the Manhattan area was critical. Both customers and facility operators benefited in having traffic diverted before it reached the bridges or tunnels. After TRANSCOM alerted I-95 Corridor member agencies of problems in the New York City region, these agencies used HAR and VMS on I-95 as far south as Delaware and as far north as New Haven, Conn., to alert travelers to avoid the New York City region. Figure 17 shows one such VMS altering motorists about the traffic restrictions into Manhattan.



*Figure 17. VMS on evening of Sept. 11
Source: Port Authority*

Traffic along key sections of the roadway system including bridges and tunnels leading to Manhattan was measured, and the information was used to help determine changes in the hours of the lower Manhattan crossings SOV ban.

VMS were used to communicate real-time information to travelers. Within two minutes of the decision to close the George Washington Bridge, the VMS alerted motorists ten miles away. The information provided by its 1-800 telephone lines was simultaneously updated and the information was electronically transmitted for broader dissemination.

Transportation/Traffic Management Centers (TMC) functioned as focal points for emergency management. New York City's TMC located outside of Lower Manhattan proved to be successful in communicating and disseminating agency decisions both internally and with the public. Both the multi-agency TMC in Queens (covering New York City streets) and the NY State DOT's INFORM TMC in Long Island (covering Long Island highways) served as command centers for state DOT personnel and local liaisons from NYC DOT, NYPD, and NY State Police, as well as sites of public information dissemination via their ITS applications. NYC DOT's TMC in Long Island City, Queens, has 55 CCTVs trained on major arteries. It also controls 6,000 of the 11,000 traffic signals in NYC via computer. All 2,650 traffic signals in Manhattan are computerized. Communications at both centers were working properly on September 11 allowing for automated dissemination of traveler information. In addition, the Interregion Video Network (IRVN) operated by TRANSCOM allows 13 traffic management centers in the New York region to share video feeds of its network. This allows other agencies to better understand what is happening outside of its purview but that might have a significant impact on its operations. Figure 18 is a screen shot of the IRVN network. This system is available on a more limited basis to the general public through the MetroCommute web site, giving motorists real-time information through the web.



Figure 18. IRVN screen shot Source: TRANSCOM

The Caltrans TMC served as the center of decision-making efforts by the traffic management teams after the 1994 Northridge earthquake. Extensive traffic management capabilities were already in place on most of the major freeways well before the earthquake, including speed monitoring loop detectors, CCTV, on-ramp meters, and permanently mounted VMS. The TMC used backup electrical generators for power and relied on landline telephones for primary communications. Since the 1994 Northridge earthquake, the TMC has updated the means by which they relay traffic information. Cable TV is now being used, real-time traffic information is available on the Internet, and Teletext, a scrolling sign placed at key points in the freeway system, updates commuters to potential back-ups.

Communication complimented the ITS capability of the agencies during the events. ITS technologies employed in Virginia included advanced traffic management center, VMS, and CCTV. According to VDOT, imagery from the CCTV network was extremely useful in assessing the progress and effect of traffic management operations. However, VDOT personnel perceived the telephone as one of the most important items of technology in use on September 11. Maryland made use of many of the same technologies, finding CCTV surveillance of particular utility. Dynamic message signs (DMS) and highway advisory radio(HAR) were used for traveler information, along with websites advising travelers of road closings and transit disruptions.

In Baltimore and Washington, D.C., the most significant contribution from advanced technology came in the use of DMS/VMS and HAR to provide information to travelers on the closing of roadways into Baltimore on the day of the event. Maryland's CHART system is state-of-the-art, and the State was able to post messages that covered the portions of the Interstate system impacted by the incident.

ITS technologies enabled active management of the transportation network. In Washington, D.C., and in neighboring Montgomery County, computerized traffic signal systems enabled these jurisdictions to handle the “early rush hour” as District workers self-evacuated. Montgomery County in particular made effective use of traffic surveillance systems, which were largely unavailable in the District.

In response to the attacks, at least one transportation authority is looking at how security components can be integrated with existing ITS and added to the proposed ITS extensions. Prior ITS installation was done mainly for operations but is flexible enough to be adapted for security applications. Television monitors can be modified to provide station emergency evacuation procedures and other security notices. The existing series of traffic operations cameras throughout the region can be used for security monitoring as well as traffic operations. The existing weather monitoring system on the George Washington Bridge could be used to help with hazardous material incidents by providing accurate weather information such as wind direction.

While these useful forms of ITS are provided by the public sector, the private sector plays a significant role in providing other forms of traveler information including in-vehicle communications and navigations that could be used in emergency situations. On September 30, OnStar Communications, for example, added real-time traffic reports to its in-vehicle navigation services in a dozen cities, including New York City.

Although the Caltrans TMC was able to initially deploy the Freeway Service Patrol and serve as an emergency command center for the regional highway network, it quickly became evident that the existing TMC could not handle all the unprecedented congestion generated by an earthquake, as it was already operating at capacity. The TMP recognized this, and with federal emergency relief funding of \$12.64 million, implemented the Earthquake Planning and Implementation center (EPI-center). The 2000-square-foot EPI-center opened on April 17, 1994, and acted as a hub for many advanced technologies that facilitated the traffic management in the disaster areas. Connected with the TMC, the EPI-Center is used only when an earthquake occurs to relieve some of the burden on the TMC. The goal of the EPI-center was to focus on communication between transportation and emergency officials and commuters, relaying important information directly to those affected. The EPI-center was vital in coordinating the traffic management deployments and giving traffic engineers accurate and immediate information. This allowed them to make better decisions and to collect information about the changes in the traffic behavior during a disaster.

System Redundancy and Resiliency

The ability to respond to an emergency in an effective way is significantly enhanced through advance preparation and planning. This includes taking action to assure that backup systems are in place for a variety of critical elements that support rescue, evacuation, and restoration of mobility. In the event of an emergency that compromises the quality or timing of the response due to a failure in any of these areas, public safety and welfare are jeopardized and lives may be lost as a result.

Redundancy, the ability to utilize backup systems for critical parts of the system that fail, is extremely important to consider in the development of a process or plan for emergency response and recovery. The backup systems needed in any one emergency are determined by the nature and scope of the particular emergency. In each of the four cases, the portions of the system that failed and needed backup were dependent upon the specific characteristics of the emergency. At a minimum, emergency response planners should consider designing redundancy into emergency response and recovery plans in several areas:

- The regional transportation network
- Agency personnel
- Communications
- Utilities
- Control Centers
- Equipment and supplies

It should be noted that building redundancy into the system can be expensive and be seen as “wasteful spending” in ordinary times. It is always cheaper to have only one of a particular type of infrastructure, but when that item fails during a crisis, it can have a domino effect on hampering response and recovery efforts. But as can be seen from examples from each of the four studies, the existence of parallel systems or the rapid implementation of additional service was extremely helpful in restoring the system’s capacity to move people and goods.

Regional transportation network: In each of the four cases, transportation agencies, both public and private, had to work together to provide alternative travel options to the public. But the level of complexity and the alternatives used varied in each of the four cases. The solutions depended on the circumstances presented to decision makers. And the solutions shifted over time in response to changes in travel behaviors of the public to the options presented to them.

In the case of New York City, Lower Manhattan has a dense set of redundant transportation infrastructure. The infrastructure consists of a pattern of local streets connected to arterials along the perimeter, a multitude of subway lines, on-street bus service, water ferries, and pedestrian accommodations. Because of that, people have multiple options for getting around on a daily basis. On September 11, when the tunnels, bridges, roadways, and subways were temporarily closed, local MTA buses continued running north of Canal Street. Public and private boats were pressed into emergency water ferries service. And the major form of transportation that day: people walked. Subway service was restored between Manhattan and Brooklyn by 6:00 p.m. that night as trains were rerouted away from the World Trade Center area through NYC Transit systems redundant set of subway tunnels.

The Los Angeles highway system in the urban area has a fairly extensive set of redundant arterial and local streets. At the time of the earthquake, the Los Angeles DOT was implementing a “Smart Corridor” project that had identified parallel arterials as an

important option for commuter traffic. This system has the ability to divert freeway traffic onto the arterial streets during times of heavy congestion. Being able to implement this after the earthquake allowed the agencies to minimize some of the traffic congestion that occurred as a result of the closing of the damaged interstate segments. But to the north, the canyons and valleys restricted the number of alternative roads that are feasible. Because of this officials were presented with fewer options for rerouting traffic and these areas experienced the heaviest traffic backups in the weeks and months after the earthquake.

In addition to roadway redundancy, the transit system helped alleviate some of the initial congestion caused by reconstruction. With an already extensive bus system, the LACMTA increased Metrobus service following the earthquake to respond to the demands of commuters. Metrolink, though still in its infancy, was able to extend its commuter rail lines into northern Los Angeles County and into neighboring Ventura and Orange counties within a matter of weeks. During interstate reconstruction, transit usage tripled on selective MTA and Metrolink rail and bus lines; however, transit usage fell to pre-earthquake ridership levels one year later.

In Washington, the highway departments were able to take advantage of reversible lanes to help increase the volume of traffic that could exit the Washington, D.C., area that morning. WMATA had the ability to reroute its subway lines to avoid crossing the Potomac River bridge. One of the major infrastructure improvements that WMATA has considered is the construction of a second rail tunnel through the central rail system to provide redundancy in case of problems to the main line.

In Baltimore, Howard Street and the tunnel below it are located in the heart of Baltimore's business, cultural, and sports districts. Howard Street serves as a major north-south artery with I-395 feeding directly into it. The day of the incident, drivers were trapped on grid locked streets and buses had to be rerouted around the closures. However, once traffic management procedures were put in place, the city was cleared of traffic within two hours of normal rush hour times (8:00 p.m. compared to 6:00 p.m. normally). In response to the disruption of light rail and commuter rail service, MTA quickly instituted a "bus bridge" to supplement service. Because the freight tunnel serves as CSX's main route along the Eastern Seaboard, freight movement became a problem. Working cooperatively with its main competitor, CSX was able to reroute its freight traffic onto Norfolk Southern tracks to help alleviate some of the freight congestion.

Agency personnel: As stated earlier, emergencies can occur at any time. Therefore it is crucial to have a redundant system of trained personnel in place who are able to make good, accurate, and timely decisions in the face of rapidly changing circumstances. With two of the cases (New York City and Northridge), the recovery response effort lasted for several months. Maintaining staff on emergency status for this length of time can take a toll on personnel and highlights the need to have multiple people trained for each job.

With New York City, the need for redundancy in personnel was highlighted when a number of key transportation decision makers were lost or temporarily missing in the

attack. Critical decisions were made by personnel in the field who, at times, were cut off from communications with headquarters.

With Northridge, the reconstruction effort lasted for 10 months. On several of the major interchange reconstruction projects, crews were working 24 hours a day, seven days a week. The incentive/disincentives built into the construction contracts were as high as \$200,000 a day, requiring Caltrans and FHWA to ensure that it had staff members who could settle disputes on call 24 hours a day for months on end.

Communications: As noted before in the section on Communications, it is crucial that agencies be able to utilize multiple technologies to communicate with staff and the public. By having a redundant set of communications technologies available, agency personnel can shift from one technology to another depending upon the emergency scenario, geography of the land, or other unforeseen outside forces. Technologies used in the four areas included landline telephones, wireless telephones, two-way radio, satellite link ups and e-mail. As seen in the four case studies, landline telephone communications were disrupted by the vibrations of the California earthquake and severely affected in New York City because of the location of a Verizon substation in the World Trade Center area. Overwhelming customer demand on September 11 also taxed the portions of the system that were not destroyed. The Baltimore rail tunnel contained major trunk lines of fiber optic cable, disrupting Internet communications across the country when the fire spread.

Agencies must also utilize multiple outlets to reach the public with information. The public is now used to getting its information from a number of different sources: print media, radio, television and increasingly the Internet and e-mail.

Utilities: In New York City the loss of electricity severely hampered operations and recovery efforts. When the Brooklyn Battery Tunnel lost electrical power, its lights and ventilation systems failed forcing hundreds of motorists to abandon their vehicles in the tunnel and run towards Brooklyn as smoke and debris filled the tunnel. Redundant mobile generators allowed for the restoration of power to emergency control centers and allowed agencies to begin flood prevention efforts to preserve subway tunnels and communications networks from extensive water damage.

Control centers: Redundant control centers helped when the NYC OEM Command Center was destroyed. The Port Authority was able to move to a backup control center in New Jersey. Both New Jersey Transit and NYC Transit were able to deploy mobile command centers. In response to the events of September 11, Mayor Bloomberg has proposed constructing and opening five “Help Centers”, with one in each borough, that brings together representatives from city, state, and federal agencies.

Equipment and supplies: In both Baltimore and New York, agency officials spoke of the need to have redundant supplies of equipment. But even more important is maintaining a good inventory of where supplies are kept or could be readily purchased. Bridge and

tunnel officials talked about the heavy volume of filters, batteries, and other routine supplies the agencies used in the days after September 11.

Conclusion

In conclusion, each of these catastrophic events has produced lessons to be learned that are applicable to every region within the country.

The need for advance preparation and planning was evident in each of the four case studies. New York and Los Angeles were somewhat better prepared to handle its disaster because of their reaction, and response to past events. New York City learned valuable lessons from such varied events as the 1993 World Trade Center bombing, the 1999 Queens electrical blackout and the threatened 1980s transit subway strike. The Los Angeles region had been subject to numerous natural disasters- earthquakes, forest fires, and mud slides- as well as human events such as the riots following the Rodney King verdict. The Washington, D.C., region has identified shortcomings in its advance preparations for the region and has produced an inter-governmental agreement to improve the Washington region's handling of transportation emergencies.

Catastrophic events require a coordinated response among various state, local, and federal agencies. It is important to have an established chain of command in place and framework for response such as the Incident Command System (ICS) developed in California in the 1970s. The events of September 11 pointed out a number of weak links in the institutional coordination structure in both New York City and Washington, D.C. It is important that this serves as a wake up call to regions across the country to better integrate safety, health, and transportation agencies into a coordinated response plan.

The Baltimore event showed the need to ensure that those response plans incorporate private industry. Private carriers transport the overwhelming majority of the freight shipped throughout the country on rail, water, and roadway. It is important to include these major shippers in designing response and communications plans.

Communications has both a personal and technical aspect to it. It is important for decisions made by officials to be clearly and quickly disseminated within an agency and to the general public. The press plays a crucial role in this dissemination of information as shown in each of these four case studies. One area of communications failure that occurred in each of the four cases involved working with a technology that failed at crucial times. In California, landline telephones were knocked out by the earthquake and cell phones failed to work in the canyons north of the city. In New York City and Washington, communications networks were overwhelmed by demand and the failure of interoperability among emergency responders hampered relief efforts.

Technology can play a crucial supporting role in aiding transportation decision-makers. It can help agency personnel make better-informed decisions as events unfold. It allows agencies to better coordinate responses with other agencies. And it allows agencies to distribute real-time information to people so that they can make individual decisions on when and how to travel. A prime example of this is the IRVN network that allows 13 transportation control centers within the New York region to share live video feeds

among the member agencies and the public to view video feeds of major transportation nodes to aid in individual decision-making.

Redundancy within the system allows for parts to be disabled and the whole to still function. The four case studies pointed out the need for redundancy in the regional transportation network, in personnel, in communications technology, in utilities and in control centers.

Building redundancy into a system costs money. Money that at times can be seen as an inefficient use of resources, until it is called upon in an emergency. There is a need to educate the public and policy makers that expenditures to ensure redundancy are worthwhile and even necessary in preparing for emergency response.