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Final Report *DOT-VNTSC-FHWA-04-02*

EFFECTS OF CATASTROPHIC EVENTS ON TRANSPORTATION SYSTEM MANAGEMENT AND OPERATIONS

August 2003 Northeast Blackout Great Lakes Region

U.S. Department of Transportation
John A. Volpe National
Transportation Systems Center
Cambridge, Massachusetts

May 2004

Prepared for

U.S. Department of Transportation
ITS Joint Program Office
and
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Foreword

This report documents the actions taken by transportation agencies in response to the August 14, 2003, blackout throughout the Northeast. It is part of a larger effort to examine the impacts of catastrophic events on transportation system facilities and services and the role that intelligent transportation systems (ITS) play in emergencies. It also highlights the importance of good communications between transportation agency staff and the public safety officials who are the first responders during catastrophic events.

The findings documented in this report are a result of the creation of a detailed chronology of events in the Great Lakes region, a literature search, and interviews of key personnel involved in transportation operations decision-making during the blackout. A companion case study of the New York City area has also been prepared.

As part of a larger effort, four case studies have already been produced examining catastrophic events:

- New York, N.Y., terrorist attack, September 11, 2001
- Washington, D.C., terrorist attack, September 11, 2001
- Baltimore, Md., rail tunnel fire, July 18, 2001
- Northridge, Calif., earthquake, January 17, 1994.

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 Federal Highway Administration Office of Operations and the U.S. DOT's ITS Joint Program Office. The Volpe Center study team consisted of Allan J. DeBlasio, the project manager, and Katherine S. Fichter of the Volpe Center Planning and Policy Analysis Division; Kristin Lovejoy of EG&G Technical Services; Terrance J. Regan and Dan Morin from Planners Collaborative; and Margaret E. Zirker from Cambridge Systematics Inc. Vince Pearce is the U.S. DOT task manager of the review.

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1. Introduction

Thursday, August 14, 2003, was a typical mid-August day in the eastern United States, dawning with a layer of heat and humidity hanging from Detroit to Boston. The network of electric transmission lines that brings power to homes, business, and public infrastructure was carrying a standard load for that time of year, powering air conditioning systems throughout the region. Taken together, the system of transmission lines, power plants, and sub-stations that powers the area east of the Rocky Mountains is known as the Eastern Interconnection, a collection of tens of thousands of individual lines, owned by multiple utility companies, all working in concert to supply even and sufficient power. Several components of that system were out of service on the morning of August 14, including a generating unit in northern Ohio, a major transmission line serving Cleveland, Ohio, and a power plant north of Detroit, Michigan. Such outages are routine, however, and the electrical system is designed to accommodate these events while still maintaining a proper level of electric transmission.

Shortly after 2:00 p.m. on the afternoon of August 14, a brush fire caused a transmission line south of Columbus, Ohio, to go out of service. This was followed at 3:05 p.m. by the failure of a transmission line connecting eastern and northern Ohio, which was in turn followed at 3:32 p.m. by the failure – caused by a sudden excess of power flow – of a second line in the same area of northern Ohio. As more and more portions of the electrical network disconnected from the grid, the events on August 14 quickly accelerated: five transmissions lines between Ohio and Michigan failed within the 30 minutes between 3:30 p.m. and 4:00 p.m.

At 4:10 p.m., the electrical system connecting the region south of the Great Lakes, including the cities of Cleveland and Detroit, to New York and New Jersey experienced a profound failure. This was due, in large part, to the sudden vulnerability of the transmission system and its compromised ability to transfer power over significant distances. Within a single minute, many transmission lines failed throughout the entire area, creating a cascading effect in which lines sequentially overloaded and then failed, leaving a swath of 3,700 miles – including portions of Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, and Michigan, up through portions of the Maritime provinces – in the dark. On one August afternoon, a series of seemingly small events, happening in concert, produced the largest blackout in American history.

Electric transmission

Transmission system voltage is needed to transfer electric power from generation stations to load centers – the places in which the power is used – and is somewhat similar in function to water main pressure. Reactive power is the component of total power that assists in maintaining proper voltages across the power system. As transmission lines become more heavily loaded, they consume more of the reactive power needed to maintain proper transmission voltage. In some instances, the reactive power demand within an area is too great for the local generating units to supply. In those cases, the units can trip off-line, either from reactive power overload or because the system voltage has become too low to provide power to the generators' own auxiliary equipment. The power system is designed to ensure that if conditions on the grid threaten the safe operation of the transmission lines or power plants, the threatened equipment automatically separates from the network to protect itself from physical damage.

The blackout of August 14 left tens of millions without electricity and created confusion and disruption across the northeastern United States and portions of Ontario, particularly in the cities of New York, Cleveland, and Detroit. Subways were stopped in their tunnels, airports halted operations, and elevators stalled mid-ride. Water systems shut down. The communications network was disrupted: cellular telephones ceased to work reliably and eventually ceased working altogether, emergency response networks were hampered, and automated teller machines went dark. Many restaurants and shops shuttered their doors, and vehicles and pedestrians trying to find their way home rapidly overwhelmed streets. Without air conditioning, many buildings rapidly became stifling. Stranded commuters spent the night in train stations, hotel lobbies, and emergency shelters. Others spent many hours on the roads trying to get home: on foot, in their vehicles, in shared taxis, on rented bicycles, hitchhiking, or on rollerblades.

Figure 1 shows the area of the blackout 20 hours before it began. Figure 2 shows the same geographical area seven hours into the blackout. Figure 3 shows the region of the United States affected by the blackout.

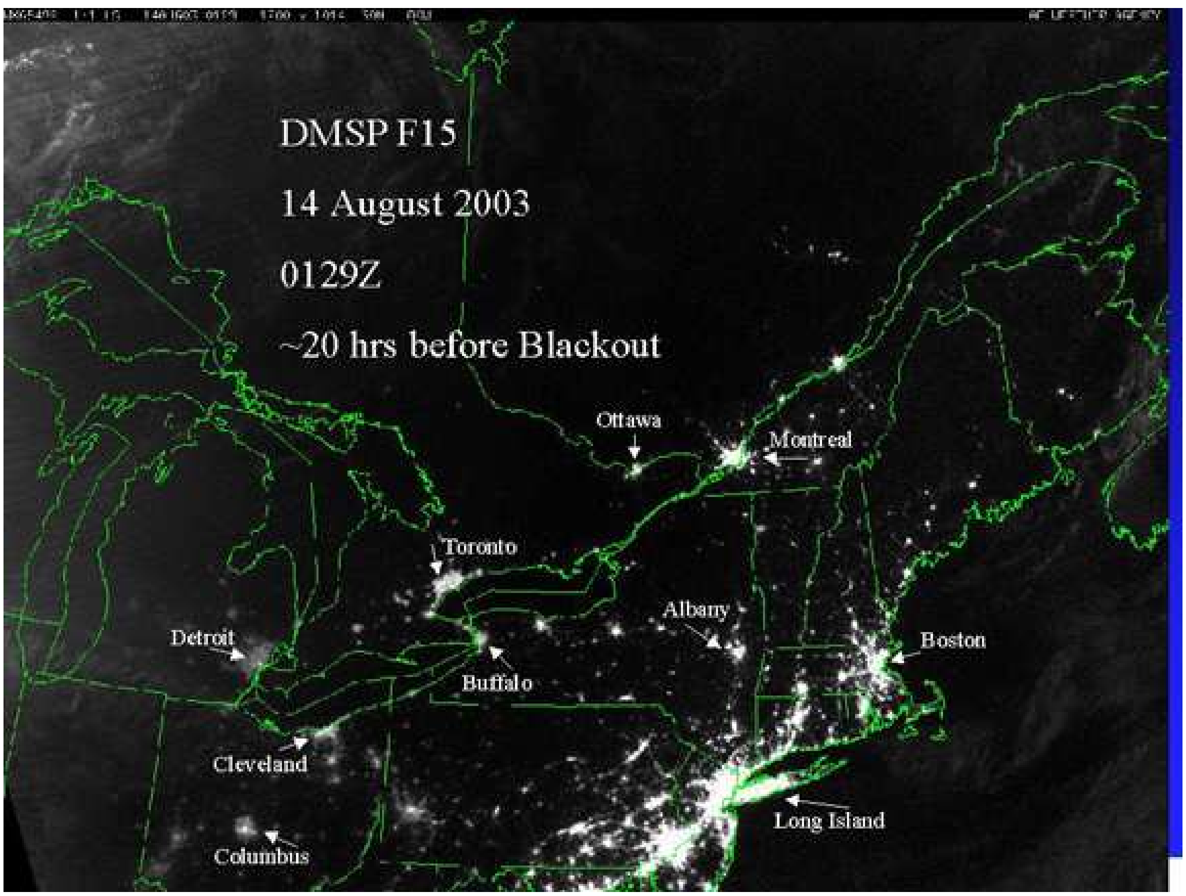

Figure 1. Twenty hours before the blackout
(Source: U.S. Geological Survey)

Within a few hours, power began to return to portions of the darkened region, while emergency response teams worked through the afternoon and evening to free those trapped in subways and elevators, to secure public facilities, and to ensure the safety of the general public. Officials in the cities most impacted by the blackout treated August 15, a Friday, as a holiday, as they urged the public to remain at home. Public services were provided on a limited basis. Despite early fears, both arrests and injuries were significantly below anticipated levels, and the weekend following the blackout passed quietly as the electrical network returned to operation and many in the affected areas stayed close to home. Power was restored throughout the impacted region within 30 hours, and water quality was deemed acceptable within several days. By Monday, August 18, the blackout of 2003 was largely over.

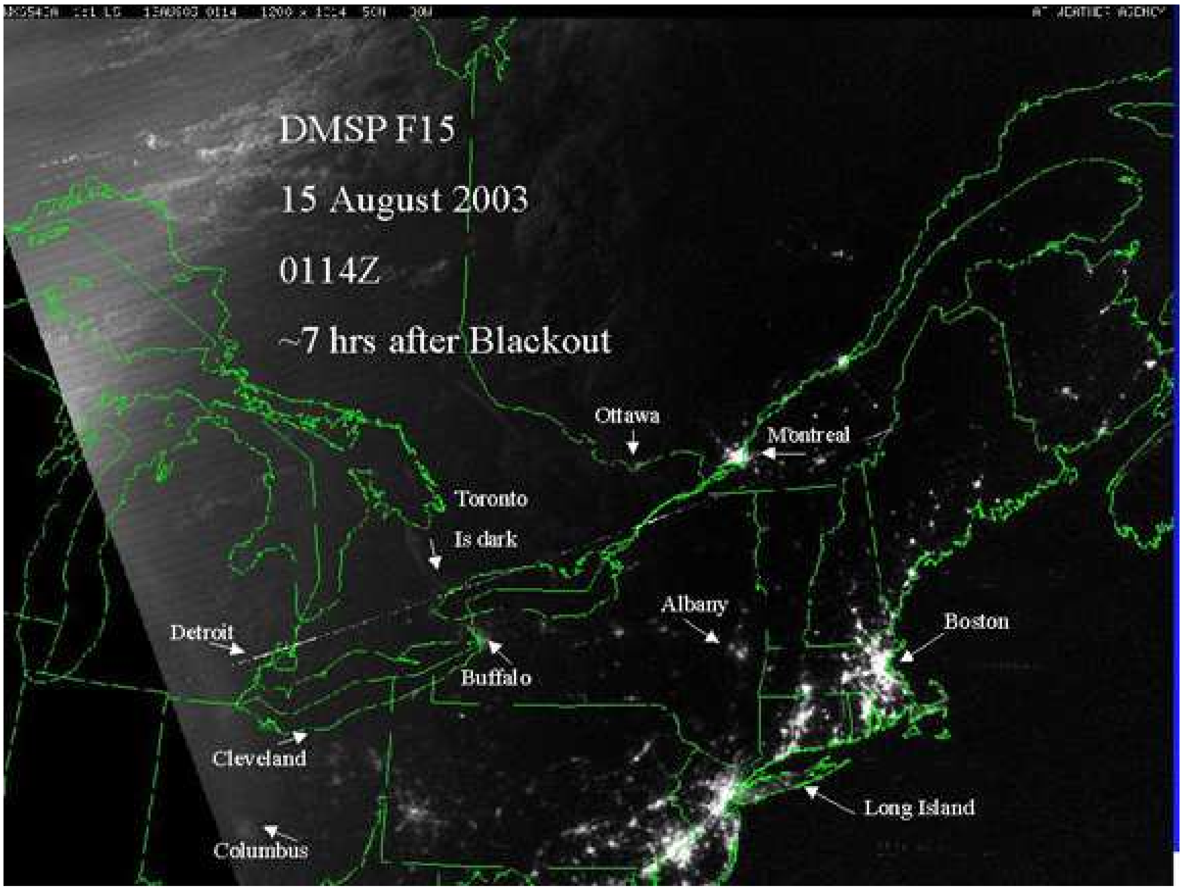

Figure 2. Seven hours after the blackout
(Source: U.S. Geological Survey)

In a report released in mid-December, the U.S.–Canada Power System Outage Task Force concluded that the blackout had many causes, some of them still unknown, but most of them small and, individually, preventable. As the task force reported, widespread, cascading failures of the electrical system are rare, although they occur more frequently than would be statistically expected. Although robust, electrical systems are vulnerable to simultaneous, independent, small failures, which – if not quickly and properly managed – can overwhelm the system and cause the type of massive outage seen on August 14. For this reason, blackouts should be considered as part of standard emergency preparations and planning for all types of public infrastructure, including transportation.

Figure 3. Region of the United States affected by the electrical power loss

1.1 Regional Context

This report studies the effect of the blackout in the Great Lakes region, particularly in Detroit, Michigan, and Cleveland, Ohio, the largest cities in the Great Lakes blackout area. Figure 4 shows the Great Lakes area in more detail.

1.1.1. Detroit Area

The six-county area in southeast Michigan, including Detroit, which is located in Wayne County, is home to approximately 4.9 million residents, 5 percent more than 10 years ago. Meanwhile, the number of residents in the city of Detroit has decreased. A larger share of people in the region live in Detroit (20 percent) than work in Detroit (14 percent), suggesting that less of the region's activity is concentrated within its largest city compared to some other metropolitan areas nationwide. In the last quarter, about 29 percent of the office space in Detroit's central business district was vacant. Table 1, Regional statistics, gives an overview of the two areas, Detroit and Cleveland, for the year 2000.

Table 1. Regional statistics, 2000

	Southeast Michigan	Northeast Ohio
Population	4,833,368	2,148,143
Workers	2,208,906	993,648
Area in sq. mi.	4,591	2,015
Density of residents per sq. mi.	6,868	1,066
Density of workers per sq. mi.	481	493

(Source: U.S. Census 2000)

Several features in southeast Michigan, however, make its transportation networks particularly important. The region is home to the auto industry's "Big Three," with General Motors, Daimler-Chrysler, and Ford, all headquartered in the area and requiring extensive just-in-time delivery services. Another important aspect of the region is its international border. In 2001, 43 percent of U.S.–Canada trade, totaling over $142 billion annually, crossed at southeast Michigan–southwest Ontario borders, including about 62 million tons of merchandise. Border management along the area's high-volume throughways is important not only for national security but also for regional safety as a large number of hospital workers and other essential employees commute internationally.

Figure 4. Great Lakes region affected by electrical power loss

1.1.2. Cleveland Area

The five-county area surrounding Cleveland at the southern edge of Lake Erie covers about 2,015 square miles and is home to about 2.1 million residents. Like Detroit, the population of Cleveland diminished over the past decade. At the same time, other parts of the region have experienced dramatic growth, especially in Medina and Geauga Counties.

Commuters in both southeast Michigan and northeast Ohio are overwhelmingly dependent on automobile travel. In southeast Michigan, only 2 percent rely on public transportation, and the average passenger miles per person on public transportation was approximately 66 in 2001. Congestion is somewhat light, however, relative to the size of the metro area. Out of 75 metro areas in the country, Detroit ranks 6th in population and 18th in the Texas Transportation Institute's (TTI) Travel Time Index, a measure of system delay.

In the Cleveland metropolitan area, single-occupancy vehicles (SOVs) are the most prevalent mode. Just 4 percent of commuters use public transportation, and travelers put in approximately 150 passenger miles per person on public transportation in 2001. In 2001, Cleveland ranked 21st in population and 56th according to the TTI Travel Time Index. Table 2 shows the mode split for both regions.

Table 2. Journey to work (mode split), 2000

	Southeast Michigan (%)	Northeast Ohio (%)
SOV	84	81
HOV	9	9
Transit	2	4
Other	5	6

(Source: U.S. Census 2000, SEMCOG, NOACA)

2. Transportation System in the Detroit Area

2.1 Pre-Event

2.1.1. Streets

Wayne County maintains approximately 1,420 traffic signals in the Detroit area, about four of which are under closed-loop or central system control. The Road Commission for Oakland County (RCOC) maintains over 230 miles of state highways and 2,600 miles of county roads in the Oakland County area, including about 1,300 county, city, and state traffic signals. Approximately 575 intersections operated by RCOC are instrumented with FAST-TRAC (Faster And Safer Travel Through Routing and Advanced Controls) technology. The heart of FAST-TRAC is a signal system known as the Sydney Coordinated Adaptive Traffic System (SCATS), which uses adaptive control technologies to regulate traffic signal timing and coordination to meet changes in vehicle demand. Close to 100 intersections include 1,200 loop detectors, and 475 intersections have approximately 2,000 video detection cameras connected to a central computer at the RCOC traffic operations center.

2.1.2. Highways

The major highways that run through Detroit include Interstates 75 94, 96, 275, and 696. Some area highways are depressed and equipped with electric-powered pumps to prevent flooding during heavy rainfall. Michigan Intelligent Transportation Systems (MITS) Center, managed by the Michigan DOT, oversees 180 freeway miles in the Detroit area that feature numerous types of intelligent transportation systems (ITS) equipment:

- 170 closed circuit television (CCTV) cameras
- 64 variable message signs (VMS)
- 1,600 inductive loops
- Fiber optic, coaxial cable, microwave, and radio communications network
- Integrated software includes device control, incident management, and automated traveler information systems (ATIS) capabilities

Media partner traffic reporters are on-site at the MITS Center, and MITS also maintains a link with the RCOC.

2.1.3. Bridges, Tunnels, and Waterways

Several bridges and tunnels span the Detroit River, linking the city of Detroit with Windsor, Ontario. These include the Ambassador Bridge, managed by the Detroit International Bridge Company; the Detroit–Windsor Tunnel, managed by the Detroit & Canada Tunnel Corporation; and the Detroit–Windsor Rail Tunnel. In addition, the Detroit–Windsor Truck Ferry provides an alternate route for motor carriers.

The Ambassador Bridge is accessible from Interstate Highways 75, 96, 94, and Jefferson Avenue in Detroit, and Highways 3 and 401, and Wyandotte Street in Windsor. It provides two lanes in each direction and is the busiest international commercial crossing in North America. Out of 12.3 million vehicles crossings in 2000, approximately 3.5 million were trucks crossing. Approximately 12,000 trucks use the bridge daily. The bridge adjoins U.S. and Canada Customs facilities and is equipped with electronic toll collection and scales that determine a fee based on in-motion weight.

The Detroit–Windsor Tunnel is the only automotive international underwater border crossing in the world. The two-lane tunnel serves as a downtown-to-downtown connection, with a capacity of 2,000 vehicles per hour. Of the 8.5 million vehicles that the tunnel serves annually, about 96 percent are passenger vehicles. They have a large commuter base, about one-third to one-half of whom are Canadians that work in Detroit-area hospitals. Approximately 700 trucks use the tunnel daily, 350 each way. The tunnel is equipped with VMS, CCTV cameras, lane controllers, and limited highway advisory radio (HAR), as well as lighting, heating, ventilation and air conditioning (HVAC) systems. There is electronic toll collection for commercial carriers, linked to weight scales. U.S. and Canadian Customs cap each end of the tunnel.

The Detroit–Windsor Truck Ferry is a marine border crossing for motor carriers. The ferry primarily transports hazardous materials that are restricted from the bridge and tunnel and oversize and overweight vehicles. The ferry can handle eight tractor-trailers and a few vans per 15-minute crossing. An electronic advanced notice and reservation system helps streamline U.S. and Canadian Customs' processing of freight crossing the border on the ferry.

In addition to the Detroit River crossings for motor carriers, the river itself is used to move approximately 80 million tons of cargo annually. The Detroit/Wayne County Port Authority handled approximately 17.3 million tons of cargo in 2000, or roughly 20 percent of the freight handled by Michigan ports. The more than 40 commercial ports in the state contribute to 80 percent of Great Lakes cement shipments.

2.1.4. Transit

The city of Detroit's DOT operates about 430 buses during peak hours, enabling approximately 140,000 unlinked trips on an average weekday. The Detroit People Mover, an elevated monorail through downtown, covers a three-square-mile area. On a weekday, it supports an average of 6,100 unlinked trips.

The Suburban Mobility Authority for Regional Transportation (SMART) operates 300 fixed-route buses and about 100 demand-responsive vehicles in the metropolitan area. SMART vehicles are equipped with automatic vehicle location (AVL) equipment linked to computer-automated dispatching. On-board mobile data terminals are also capable of sending a signal indicating congestion to the RCOC system.

2.2 Day of the Event

The transportation facilities in the Detroit area that normally depend on electricity include traffic signals; ITS equipment such as cameras, loop detectors, and VMS; public transit services (dispatching); toll collection; tunnel lighting and ventilation; pumps to control flooding; and Customs services. The blackout hit Detroit at about 4:00 p.m., just at the beginning of rush hour, and lasted through much of the weekend. Power in some areas was restored as early as Thursday evening and in most areas by Saturday night.

Abbreviated Chronology: August 14, 2003

Time of Day	Event/Actions Taken
12:05 p.m.	Generators shut down at the American Electric Power plant in Conesville, Ohio.
4:10:41 p.m.	The *Beaver-Davis Besse* line, which connects the Cleveland and Toledo areas, disconnects, leaving Cleveland isolated from the Eastern Interconnection. Cleveland loses power.
4:15 p.m.	The Detroit–Windsor Tunnel closes.
4:54 p.m.	Federal officials rule out terrorism as cause of blackout.
5:00 p.m.	Four of Cleveland's water pumping stations and their backup systems – used to pump and clean drinking water from Lake Erie – lose power and fail.
8:00 p.m.	Cleveland International Airport regains power and resumes operations.
9:30 p.m.	The City of Cleveland imposes a curfew for anyone under the age of 18.
10:15 p.m.	The Detroit–Windsor Tunnel re-opens.
11:00 p.m.	The final person is freed from a Cleveland elevator.

2.2.1. Streets

On Thursday, August 14, in addition to typical 4 p.m. traffic, many people simultaneously left work shortly after the blackout began, further clogging roadways. One employee observed, "About 10 minutes after the lights went out, people were pouring out of the buildings. The roads were just packed." Traffic that normally would have been staggered throughout the evening was concentrated in the period right when the blackout began.

One of the most immediate effects that impacted surface transportation was the loss of traffic signals. Reports indicate that drivers exhibited remarkable courtesy in treating darkened intersections as four-way stops. This treatment, however, gave no priority to major corridors, which slowed traffic everywhere to a crawl. "Gridlock was horrible…People were taking two to three hours for trips that would normally take 15 minutes," according to one report. To try to relieve the congestion at key intersections, many citizens attempted to direct traffic themselves.

Police normally respond to darkened signals first, by directing traffic if necessary until a managing agency can relieve the officer by supplying backup generation, repairing the signal, or by erecting portable stop signs. But in this case, because the outage was so widespread, police were able to cover only a few intersections. A Detroit motorist reported that even if there was an officer directing traffic at one intersection, the very next one was jammed with no one directing. There were anecdotal reports that "at some intersections, people had just assumed the role of the police and were trying to help direct traffic."

In Oakland County, the RCOC staff faced 1,300 darkened signals, with just 20 portable generators to service them. On the fly, they tried to identify the most important intersections and deployed crews to install and supervise generators at the intersections. The RCOC staff maintained some computers and other essential or sensitive equipment at their Traffic Operations

Center but lost all FAST-TRAC capability in the field. Furthermore, an RCOC representative explained that any ITS functionality would have been useless without signals to moderate traffic.

The gridlocked traffic depleted gas tanks more rapidly than usual. Unfortunately, most gas stations could not pump gas. In Detroit, “Only 9 percent of the city’s gas stations were open, producing long lines that in some cases were monitored by police,” according to *The Washington Post*. In general, traffic let up between 8 p.m. and 9 p.m. on Thursday evening, although traffic persisted through Saturday at select facilities such as the Ambassador Bridge. “Once everybody got home, they stayed there,” an agency staff person speculated. On Friday, the roads were relatively empty, as people seemed to heed media announcements directing people to stay home. Detroit Mayor Kwame Kilpatrick reported that there had been one quarter of a normal day’s traffic crashes-about 50-because so few people were on the roads, reported *The Washington Post*.

By Saturday, RCOC staff had deployed generators to service traffic signals in the area where Detroit’s annual Woodward Dream Cruise-an event that can draw up to 1.5 million people-was scheduled to occur. That day, power began to return in many areas and approximately 90 percent of the RCOC’s signals became operational, according to one estimate.

2.2.2. Highways

In general, highways can function well without electricity. However, toll collection, tunnel ventilation, lighting, pumps to control flooding, and ITS equipment such as cameras, loop detectors, and VMS, depend on electricity. In the Detroit area, only the Ambassador Bridge was able to maintain these types of functions.

Heavy rain began to flood several sections of depressed freeways Friday morning and continued through Saturday. The pumps that normally remove excess water still had no power, and the contractors that would have normally supplied generators for the Michigan DOT pumps in case of an outage had deployed their generators elsewhere.

The MITS Center and its field equipment lost all power, leaving Michigan DOT staff unable to collect data, receive video feeds, or control VMS. They also had no telephones and had only spotty two-way communications with field staff. Like other agencies, they reported the loss of communications to be most frustrating. Staff reported that the data-collection devices that would have been most helpful during the blackout were the cameras. When the freeways flooded on Saturday, they could not see the incident on their cameras and could not use their VMS to warn motorists. Normally, the video information is useful for the on-site state police in deciding what resources to devote to a particular incident. MITS Center staff also lamented the lost opportunity to record traffic volume data during what was essentially a full evacuation of Detroit on Thursday.

2.2.3. Bridges, Tunnels, and Waterways

The Detroit–Windsor Tunnel has quadruple redundancy, as it is serviced by four separate power feeds. For the first time ever, all four feeds went dead. At 4:15 p.m. on Thursday, lighting, fans, and other emergency and life-safety systems in the tunnel ceased, rendering continued operations unsafe. The tunnel operator followed a pre-planned protocol in declaring a tunnel emergency and shutting down the facility. The tunnel cleared in less than 15 minutes. For the tunnel authority, the loss of communications was a challenge because the phones were dead. A backup battery and then a portable generator supported a radio system. They were able to notify the media and other agencies of their plans to close and, later, to re-open. Power returned at 10:00 p.m. on Thursday. The tunnel had a "soft" opening at 10:30 p.m. and a full opening at 11:00 p.m., at which point there was little traffic.

Immediate backup generating capability enabled the Ambassador Bridge to remain fully operational throughout the blackout, as did U.S. Customs at one end of the bridge. A lost data link between the Canadian customs facility and its headquarters, however, created a bottleneck at the Canadian end of the Bridge. According to an anecdotal report, by 9:00 p.m., there was a quarter-mile backup to get into Canada; by midnight, the backup was about three-quarters of a mile; and by 6:00 a.m. on Friday, the backup was four miles long and two lanes deep. A bridge representative estimated that there was about a three- to four-hour backup to get into Canada during the blackout. There were also U.S.-bound backups, but they were much less severe. Traffic began to clear by about 2 p.m. on Friday.

The Detroit–Windsor Truck Ferry continued operations and even had excess capacity, though they had to function without their advanced notice system and reservation system. They maintained radio communications and processed freight documentation manually.

2.2.4. Transit

Since the blackout hit right at the beginning of rush hour, most of SMART's fleet was already out on the road at the time. Supported by generator power, SMART's operations center was fully functioning throughout the blackout, with dispatchers, phone lines, fax machines, e-mail, computers, and a website, which was updated with current information. Staff also maintained their radio system, used to communicate with drivers, for 10 or 12 hours. Therefore, it was a "no brainer," as one SMART representative explained, to finish Thursday evening's service. However, when they lost their radio communications system overnight, they decided not to run service on Friday except for critical paratransit customers, some of whom depend on SMART for life-saving dialysis treatment. *The Washington Post* reported, "City buses were halted" in Detroit that day. SMART ran a Sunday schedule on Saturday and Sunday.

Abbreviated Chronology: August 15, 2003

Time of Day	Event/Actions Taken
4:10 a.m.	Power returns to the rail yard of the Greater Cleveland Regional Transit Authority (RTA).
Morning	150,000 Cleveland residents remain without power, out of 1.4 million without power on Thursday afternoon.
Morning	130,000 Detroit residents remain without power, out of 2.1 million without power on Thursday afternoon.
12:20 p.m.	Greater Cleveland RTA restores power to its light rail system.
General	The public bus system in Detroit remains out of service all day.

According to SMART executives, one of the biggest challenges during the blackout was communicating with drivers, paratransit customers, and the public. Even though SMART's operations center was fully functional, many people had lost phone service, computer access, and had no TV or radio. Messages relayed from SMART managers to the media were a low priority and aired infrequently. Managers were not certain of how many drivers would come in. Furthermore, it was particularly difficult to find out what medical facilities were open. In some cases, drivers physically went to customers' houses and to clinics to exchange information and call it in to the operations center. In one instance, SMART's staff was able to coordinate with an area fire department that borrowed vehicles and drivers in order to provide cooling stations for senior centers. In addition, had the blackout persisted longer, other area agencies probably would have relied on SMART for refueling.

2.3 Post-Event

Power began to return to the area on the afternoon of Saturday, August 16, 2003. In the aftermath of the event, it took several days for all the ITS equipment to come back on line. Some had to be reset manually, some suffered damage from the blackout, and some had communications problems that required in-field maintenance visits, once power was restored late on Saturday. RCOC staff reported that while most of their controllers came back up when power returned, many of them still required the clocks to be reset. Although approximately 90 percent of Oakland County's signals returned without trouble, approximately 200 signals required restorative maintenance.

One problem the MITS Center staff encountered was that their VMS had already been programmed for the whole weekend to announce lane closures for anticipated construction areas. So when power returned, there was not a good match between what the signs were saying and the actual situation on the road. Complicating the restoration process for a number of agencies, power returned to different equipment at different times on Friday and Saturday, and the power was not immediately stable when it returned. Rolling outages across the region meant that some equipment had to be reset more than once. Some agency staffs concluded that delaying restoration until they were absolutely sure stable power was restored was in their best interests.

Since the blackout, a number of agencies have thought about lessons learned during the blackout. The Detroit Homeland Security Office reported the need for communication system redundancy, additional alternative power resources, improved resource identification and management, and improved notification procedures.

On August 22, 2003, the Detroit–Canada Tunnel Corporation hosted a Detroit–Windsor regional border transportation debriefing. Participants discussed issues such as backup power generation, coordinated radio communications, emergency operations centers, border operations, and communications with the public.

Since the blackout, some of the agencies in the Detroit area have taken or planned actions:

- Establish uniform generator testing and maintenance plans
- Maintain telephones that do not require a power source
- Configure dial-around capability for voice messaging systems
- Upgrade cell phone and radio services

- Install redundant communications such as wireless, digital subscriber line (DSL), and dialup network connections
- Clarify who may activate certain emergency plans
- Install storage tanks for fuel needed by generators
- Budget for purchasing media spots during emergencies
- Conduct additional training using interagency event data management software.

3. Transportation System in the Cleveland Area

3.1 Pre-Event

3.1.1. Streets

The Cleveland area does not currently employ any ITS technologies in managing its arterial network.

3.1.2. Highways

Several major highways serve Cleveland, including the north-south Interstate Highways 71 and 77, the east-west Interstate Highways 80, 90, and 480, and the Ohio Turnpike. District 12 of the Ohio DOT serves the region.

3.1.3. Waterways

The Cuyahoga River runs through Cleveland, providing access for freight and cargo ships traveling from the Great Lakes, and the commercial railroads Norfolk Southern and CSX Corporation provide freight service to Cleveland. The Port of Cleveland is the largest overseas general cargo port on Lake Erie, and the third largest in the Great Lakes. Drawbridges over the Cuyahoga River depend on electricity to be raised and lowered.

3.1.4. Transit

The Greater Cleveland RTA, a rail and bus system provides public transit to metropolitan Cleveland. Greater Cleveland RTA carries more than 45 percent of all public transit riders in Ohio—an average of 182,865 riders each weekday. In 2002, more than 52.7 million passengers rode their trains, buses, Community Circulators, and paratransit vehicles. About 500 of the 733 fixed-route buses and all 97 of the demand-responsive buses in the Greater Cleveland RTA fleet are equipped with AVL, mobile data terminals, and dispatching software. They also have 108 heavy and light rail vehicles, which are all equipped with dispatching software. The majority of Greater Cleveland RTA track is at grade and runs parallel to another right-of-way.

3.2 Day of the Event

At 4:10 p.m. on Thursday, August 14, the *Beaver-Davis Besse* electrical transmission line, which carries power between the Cleveland and Toledo areas, disconnected, leaving Cleveland isolated from the Eastern Interconnection. Approximately one million residents in the Cleveland area, which receives the bulk of its electricity from FirstEnergy Corporation of Akron and Cleveland Public Power of Cleveland, immediately lost power. Cleveland then remained in the dark for over 24 hours, impacting transportation, public health, and public safety.

Cuyahoga County, of which Cleveland is a large part, maintains an emergency response center for use in times of crisis. During the blackout, however, public officials were unable to use the response center immediately after the blackout started due to a lack of backup power within the facility. A portable generator arrived about eight hours after the blackout started, which enabled facility staff to begin official operation. As a result, the major public agencies of the city of

Cleveland – including the transportation agencies – worked together, in a collaborative and sometimes improvised way, to see the city through the hours of the blackout.

Of greatest significance to Cleveland during the period of the blackout was the failure of its water system. At 5:00 p.m. on August 14, four of the city's water pumping stations and their backup systems – used to pump and clean drinking water from Lake Erie – lost power and failed, allowing millions of gallons of untreated sewage to be released into Lake Erie and the Cuyahoga River. At the height of the water crisis, 1.5 million Cleveland area residents had low or no water pressure.

At 8:45 p.m. on Friday, Mayor Jane Campbell and county officials requested and received a declaration of a state of emergency from the state of Ohio. In an effort to ensure public safety, municipal officials in Cleveland imposed a curfew at 9:30 p.m. for anyone under the age of 18. At 11:00 p.m. on Friday, the final person was freed from a Cleveland elevator. During the overnight period between Thursday the 14 and Friday the 15, Cleveland police made 19 arrests, fewer than half the summer average. During the nighttime hours, Cleveland police deployed twice the typical number of officers to patrol the streets of the city.

Cleveland firefighters responded to approximately 12 fires during the first night of the blackout. The danger of fire was a source of great concern in Cleveland during the hours of the blackout. Cuyahoga County activated an emergency response plan that allowed tankers of water to be brought to Cuyahoga County from elsewhere in Ohio, staged outside Cleveland, and then distributed throughout the county as needed for fire suppression.

At 12:45 a.m., lights inside the Cleveland Terminal Tower flickered, signaling the beginning of restoration of power to downtown and other parts of Cuyahoga County. By early evening on Saturday, August 16, FirstEnergy declared that full service has been restored to the Cleveland area. Many FirstEnergy customers had seen their power restored by Friday afternoon.

3.2.1. Streets

Following the loss of power at 4:10 p.m., most traffic signals in Cleveland went dark, which – exacerbated by the sudden, intense volume of traffic leaving the city – produced gridlock at many intersections. Cleveland executives called in off-duty and auxiliary police officers to assist in directing traffic, but the congestion persisted in many areas of the city for several hours. Many motorists elected to treat each non-functioning signalized intersections as a four-way stop, greatly slowing the flow of traffic through the intersections. Emergency generators were later used to power some of the traffic signals, and most of the congestion had cleared from the downtown area by 6:30 p.m. Throughout the day on Friday, August 15, officials in Cleveland urged motorists to limit their driving due to the non-functioning traffic signals. By Friday afternoon, however, all but one percent of Cleveland's traffic signals were once again working.

Half of the 400-truck emergency fleet of the Cleveland-area American Automobile Association was rendered inoperable by the blackout, their in-cab computers unable to receive the data necessary to route the trucks to stranded motorists. The availability of fuel was also an issue in Cleveland in the hours immediately following the blackout, both for private motorists and for public vehicles. Cleveland personnel were able to supply fuel to public vehicles, including those of the Police and Fire Departments, within a few hours of the blackout by attaching backup generators to its fuel pumps.

Without power to run equipment and without needed materials and other supplies, several automobile-manufacturing plants in Cleveland ceased operations during the period of the blackout. The closure of the plants had a significant effect on commuting and other travel patterns in the Cleveland area in the days after the blackout, allowing many people to remain at home as the city gradually return to normalcy.

3.2.2. Transit

Following the blackout, Greater Cleveland RTA immediately lost power in portions of its system, forcing passengers to exit light rail vehicles and walk along the tracks to the nearest stations. Although Greater Cleveland RTA continued to retain power in portions of its system throughout the period of the blackout, all service was halted due to interruptions in the flow of power to the signal system. Those passengers who were evacuated from the light rail vehicles were met by Greater Cleveland RTA buses and four-wheel drive vehicles, which had been diverted from their normal routes in order to transport stranded commuters. Although the passenger evacuation was handled smoothly and quickly, many of the diverted vehicles were delayed in the downtown gridlock. Greater Cleveland RTA staff was also responsible for freeing individuals from trapped elevators on their property.

In preparing for the Year 2000 (Y2K) and based on their experiences from September 11, transit managers had developed a plan for the rapid establishment of an integrated operations center in case of emergency. Certain identified individuals know to report to the center in urgent situations, allowing them to coordinate their response activities there. This center was set up shortly after the loss of power on August 14 and helped to direct the Greater Cleveland RTA evacuation. In addition to freeing individuals from elevators and light rail vehicles, they used a retired diesel locomotive to push some of its disabled light rail vehicles into its rail yard. Greater Cleveland RTA had approximately 40 light rail trains running at the time of blackout. In addition to assisting at the agency's emergency operations center, their Chief of Security participated in the municipal-level emergency response to the blackout, working with other local agency heads to coordinate and streamline all response activities.

During the blackout, Greater Cleveland RTA experienced failures within its communication system until a backup diesel generator was connected. In particular, the repeaters used to strengthen and extend the signals produced by the agency's internal radio system failed during the blackout, and not all were connected to backup sources of power. Furthermore, the loss of a key radio tower in the far eastern section of Cleveland left the Greater Cleveland RTA without its global positioning system (GPS) network. Throughout the blackout, transit employees were able to use their mobile telephones and mobile radios. Traditional telephone service also worked, without break, during the blackout.

During the blackout, the agency continued to run limited bus service, followed by a minimal nighttime bus service. At 4:10 a.m. on the morning of Friday, August 15, power returned to the rail yard, allowing Authority workers to begin the process of restarting its operations. By 12:20

p.m. on Friday, Greater Cleveland RTA staff was able to restore power to the light rail system. The trains were working in time for Friday afternoon rush hour, although on a limited basis.

3.2.3. Waterways

Freight moving on the Cuyahoga River, which runs through the center of Cleveland, experienced difficulties because some of the river drawbridges were stuck in the down position during the blackout. A plan developed for Y2K directs that a generator will be moved from bridge to bridge in order to lift the bridges, but the Coast Guard gave its permission to leave the bridges down during the time of the blackout, provided the blackout remained limited. During the period that the bridges were down, river traffic did not become exceptionally congested.

3.3 Post-Event

By Friday morning, only about 150,000 Cleveland residents remained without power, compared to the 1.4 million without power on Thursday afternoon.

Since the blackout, Cleveland-area agencies have taken or planned actions:

- Invest in additional backup power to support entire facilities or additional equipment, such as radio repeaters (although some agencies post-event assessments resulted in the decision not to invest in costly generating capacity)
- Hardwire additional equipment to a backup power system
- Explore new locations for an EOC that is better equipped with generating power
- Assess public communications options
- Consider citywide HAR
- Consider consolidation of an EMC and a move to a suburban location
- Explore additional communications options such as cellular priority access and push-to-talk service

4. Findings

4.1 Advanced Preparations and Planning

Following the events of Y2K and September 11, 2001, advanced emergency planning has become crucial to the safe and effective management of the transportation network. Emergency preparation can include everything from the drafting of an emergency response plan to the stockpiling of certain emergency items to the rehearsal of particular crisis scenarios, all in the service of planning and training for an actual emergency. Advanced planning can greatly increase the effectiveness of emergency response, allowing individuals and agencies to work collaboratively and efficiently, in agreed-upon roles, to address a crisis situation.

Have an emergency response plan

Several representatives of the agencies interviewed cited the importance of formalized emergency response plans, plans that have been developed and practiced in advance of a real emergency. In particular, emergency response plans were valuable because they made it possible for agency staff members to know their responsibilities in an emergency and to easily and quickly step into their assigned roles, with a minimum of confusion and wasted time. Furthermore, many communities and agencies maintain multi-agency plans, detailing the ways in which multiple agencies will work together to coordinate a response to a multitude of potential emergencies.

Make plans that are specific and detail-oriented

Pre-event planning is important not only for establishing broad-brush responses but also for laying out the small details that make it possible to weather a crisis. Staff at the Ambassador Bridge of Detroit, for example, credited their advance Y2K preparations for encouraging them to keep both backup generators and bottled water on hand at all times. Likewise, the personnel at the Greater Cleveland RTA pre-positioned chemical light sticks, flashlights, and vests in their various district garages so that they will be ready in case of emergency.

Plan in concert with other agencies

Transportation agencies are interdependent, all working together to create an efficient transportation network. As a result, emergency response planning will be most effective if done in concert with the other agencies that make up that network, allowing the various agencies to work together smoothly during an emergency. This extends not only to transportation agencies, but also to other, non-transportation agencies involved in the provision of transportation services. For example, the Detroit-Windsor Truck Ferry staff is now working more closely with the U.S. Customs Service officers to better plan for emergencies that impact the crossing of freight between Canada and the U.S.

Rehearse emergency response plans

Emergency response plans are only as good as the preparations and support that go along with them. Several interviewees emphasized the importance of drilling staff members in the details of emergency response plans, of providing training and encouragement for emergency response planning, and of practicing various emergency response scenarios.

Review emergency plans after an event
Emergencies can be used as learning experiences, allowing agencies to pinpoint their vulnerabilities and better plan for future situations. For example, after the blackout, the Ohio DOT staff reviewed the performance of its emergency plan during the event. To be most effective, emergency response plans and their corresponding preparations should be continually updated.

Consider the emergencies needs of both people and equipment
During an emergency, people will need drinking water, food, portable toilets, flashlights, and battery-powered radios. To address equipment needs, Ohio Turnpike managers have put extensive effort into planning for the continued operation of its computer equipment in case of emergency. They purchased backup battery supplies, which last up to 10 hours, and generators that can then recharge the batteries. The agency even has a redundant data center to which they can shift full operations in less than 12 hours.

Insulate emergency response capacities from disruption and compromise
Emergency response preparations are subject to whatever emergency may be at hand. One interviewee experienced a loss of power in its emergency response facility – the facility was not connected to a backup generator – rendering the facility largely unusable. To be effective, emergency response centers must not rely upon only one source of power, emergency telecommunications systems must have redundancy built in, and emergency transportation procedures must provide for sufficient stores of fuel.

Plan for all types of emergencies—they can come in many forms
Some agency staff members indicated that they have developed a single emergency plan – often based upon emergency response to a large storm or other natural disaster – without tailoring it for other types of emergencies. There may be much overlap between types of emergency responses. For example, several organizations mentioned that their snow emergency plans were useful during the blackout. But it is valuable to be prepared for the ways in which different kinds of emergencies may vary. In the case of the blackout, Y2K preparations seemed more useful than actions taken in response to September 11. The most common examples of Y2K preparation included the purchase of generators and the preparation of backup plans should their systems shut down at the start of 2000. While September 11 did affect how agencies thought about security and communications issues, Y2K seemed be more influential. Like many agencies, the Ambassador Bridge and the Detroit–Windsor Tunnel managers purchased generators in preparation for Y2K. Michigan DOT staff reviewed their identification of key locations for backup generator capability. The RCOC personnel doubled the number of generators they had, from 10 to 20 in preparation for Y2K. The greater the types of events considered, the more likely an agency will be prepared for whatever happens.

4.2 Institutional Coordination

Just as emergency planning is vital to the management of a transportation agency, so is coordination with other agencies and institutions. Transportation officials can coordinate with representatives of other, partner agencies – including law enforcement, public utilities, emergency responders, public health officials, and others – to prepare for emergencies, to handle emergencies when they arise, and to evaluate emergency response after the fact.

Conduct a collaborative post-incident review
Following any kind of emergency, it is vital that the partner agencies that worked together to respond to the emergency find a way to review and evaluate their performance and cooperation during the emergency. Representatives of the Detroit & Canada Tunnel Corporation organized a debriefing with staff members from the Ambassador Bridge, U.S. and Canada Customs, and of local law enforcement to discuss their performance during the blackout.

Practice cooperation during normal times
A general lack of cooperation – caused by inadequate communication, institutional competition, or mutual distrust – will be exacerbated during emergencies, making it particularly difficult for agencies to work together during times of stress and crisis. One interviewee noted that its long-standing rivalry with another agency made it almost impossible for the two to collaborate in even a basic way, although their collaboration might have eased congestion during the blackout period.

Cooperate across agencies to share resources and equipment
Emergency equipment can be costly to purchase and store, and agencies cannot always predict what sorts of equipment they will need during an emergency. The establishment of mutual aid agreements in advance of an emergency can make it possible for agencies and communities to share equipment as necessary and possible. This helps to reduce the need for costly expenditures and inefficient searches for equipment at the heights of crises. Oakland County, Michigan, staff has developed these types of agreements with representatives of its towns to share resources in periods of crisis.

Establish emergency procedures that will be easy and efficient to implement
Some agencies reported encountering unexpected obstacles in the implementation of their emergency procedures, particularly obstacles centered on multi-agency coordination. In one case, officials from multiple agencies were required to give permission for the establishment of an emergency response center, greatly slowing its opening. In others, established chains of command among and between agencies proved to be cumbersome and inefficient, also reducing response time. Multi-agency response requires pre-planning that will establish clear chains of authority during emergencies.

Be aware of the importance of individual relationships
As important as official institutional emergency response plans and procedures are, the value of individual relationships was cited over and over again by the interviewees. Relationships established and nurtured during normal times can pay great dividends during emergencies, allowing individuals to efficiently and sometimes informally make contacts, accomplish tasks, and speed emergency response. One interviewee explained the ways in which his long-standing relationships with local officials allowed him to quickly obtain information and make important decisions during the blackout period.

Utilize technology to enhance institutional coordination
Several agency representatives identified the lack of interoperability between the communication systems of different agencies as a major obstacle to inter-agency coordination during the blackout. Other interviewees discussed the importance of having pre-established modes and protocols of communication – telephone, fax, or Internet – for agencies to contact each other during emergencies, with particular attention paid to ensuring redundancy in the systems.

Allow for a multi-agency response to any type of emergency as a part of an emergency response plan
Many communities and agencies maintain plans for quick-response EOCs, in which multiple agencies can come together to oversee and coordinate emergency response to a multitude of potential emergencies. This sort of coordinated response, when properly managed, can allow for an efficient and effective handling of a crisis situation. Representatives of several agencies in Cuyahoga County in Ohio, for instance, established a multi-agency response center in the early period of the blackout.

Consider cross-border coordination
The blackout covered both Canada and the United States, requiring staff of agencies in the two countries to cooperate on their response. Given their long history of collaboration on a host of border issues, agency contacts between the countries were well established and generally facilitated emergency response. Such cooperation is an important part of emergency response planning and drilling in any area that shares an international border.

4.3 Operating Decisions

Agencies may have to make a number of unusual operating decisions during an event, such as how to fill staffing needs, how to best serve constituents under the circumstances, and whether to continue operations at all. Since emergencies come in many different forms and may be difficult to predict, agencies should be prepared to make quick and accurate decisions as required during the incident.

Prepare for emergencies in advance to make day-of-event decisions easier
Because the Ohio Turnpike was well prepared for a power outage, managers were able to oversee seamless conversion to backup power systems with few decisions that deviated from protocol. They decided in advance which functions could continue, and which few would be suspended until the power returned, such as the kitchens of restaurants in the service plazas. Even for agencies that chose to shut down completely, advanced planning made those choices easier, such as the Detroit–Windsor Tunnel staff’s swift decision to close shortly after losing power. In contrast, the RCOC staff encountered the prospect of a countywide signal outage for the first time during the blackout. They had to make decisions about which intersections were most important to try to maintain with backup power and how to go about checking signals throughout the county as power was restored. Staffing was one issue that was particularly difficult for several organizations that did not have explicit agreements with bus drivers or maintenance crews, for examples, for what expectations would be during emergencies.

Empower the relevant staff to make decisions and to communicate them
Within any organization, it should be clear who is authorized to make what kinds of decisions under different circumstances, and how decisions are communicated. Agencies should consider the practicality of who the decision makers are. For example, the opening of an EOC in the Detroit area required one person's authorization, and that person happened to be on a plane when the blackout hit. A lesson learned for EOC staff was that other people should be authorized to open the EOC, when necessary. Depending on the organization, it may be useful to empower many people in the agency to make independent decisions. Education, training, and drills may help agency members make better decisions under unusual circumstances.

4.4 Role of Advanced Technology

Technology can play a crucial supporting role in aiding transportation decision makers during times of crisis. It can help agency personnel obtain information on which they can make better decisions as events unfold. Advanced technology allows agencies to better coordinate responses with other agencies. It also allows agencies to collect and distribute real-time information so that individuals can make decisions on when and how to travel. As many staffs discovered during the blackout, advanced technology is useless without emergency backup power. Many interviewees spoke of their dependency on Internet and electronic-based information and the realization that loss of power can critically affect their ability to function. The expanded use of ITS has made power redundancy considerably more important. Appendix B contains a summary of the installed ITS technology within key transportation agencies in the affected areas. The summary describes ITS technology installed, which equipment maintained operations capability during the blackout, and which equipment lost operations capability during the blackout. It also provides a set of pre-event preparations that an agency may have taken that allowed it to better respond to the event as well as a set of lessons learned from the event.

Establish reliable backup power to maintain normal ITS functions
The agencies that used advanced technologies during the blackout had acquired independent power sources to support their equipment. Many of these agencies, such as the Ambassador Bridge and the Ohio Turnpike, depend on advanced technologies for revenue collection. The Ambassador Bridge maintained transponder lanes and card swipes using generator power. The Ohio Turnpike maintained scales and toll collection equipment as well as traffic volume detection devices, all powered by backup generators. The SMART dispatch center also maintained all computer systems, including geographic information systems (GIS) that coordinate paratransit service and a website updated with transit information. Generators provided power and a holdover dialup modem filled in when the internet service provider (ISP) connection was lost. However, some agencies continued operating without their advanced systems. For example, an online reservation system and an advanced notification system for freight cargo, which notifies Customs of approaching cargo in advance to help streamline processing, was lost at one agency whose computers had no power. Staff had to operate using manual means.

Consider ITS functionality that could be particularly useful during an emergency
One official observed that equipment without backup power means that ITS data "go right in the wastebasket, during a time when you could ultimately use it the most." Some advanced technology proved to be useful in managing the crisis. For example, the Region 12 Ohio DOT's

incident management crews maintained radio communications and GPS data while on the road. Backup generators supported computers at the data center, helping to efficiently deploy the crews. The trucks are also equipped with VMS that were functional during the blackout. As another example, Oakland County's EOC staff manages an on-line event tracking system that many agencies shared during the blackout, although the event pointed to the need for more training using the software.

Interviewees also identified technologies that would have been useful during the blackout. When Detroit area freeways flooded, operational cameras would have helped the TMC personnel to monitor the event and advise state police on what resources were necessary to deploy. In addition, functioning VMS would have helped the TMC operators warn motorists about the incident. TMC staff also lamented the lost opportunity to record traffic volume data during what was essentially a full evacuation of Detroit on Thursday. Several interviewees suggested that route management supported by ITS might have helped alleviate traffic on Thursday evening, such as identifying alternative routes for passage to and from Canada. For example, the staff at the Niagara International Transportation Technology Coalition (NITTEC) have used their ITS to re-route traffic between Niagara-area bridges in case of congestion or closure at one bridge.

Allocate ample resources for the restoration of traffic signals and other communications devices
A plan that prioritizes restoration activities, with available staff resources and placing backup generators where they are most needed, would assist in this process. Representatives of the Michigan DOT and the RCOC mentioned the great amount of time involved in making sure that when power was restored, signals were actually working properly. Rolling blackouts also caused signals to be re-timed more than once.

4.5 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 when allocating resources and setting 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 a human response to make the decisions, it is important to have the proper technology to disseminate the information. Communications has both this 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. The blackout highlighted the need for emergency plans, both internal and external, that will address a catastrophic failure of routine communications.

Loss of communications capability was the single most consistent finding involving most of the Great Lakes agencies
Initially, it was the complete lack of information about the scope of what had actually happened. As blackouts of short duration are common in both the Detroit and Cleveland areas, the magnitude of the event went unrecognized for some time. That immediate lack of information was one reason everyone persisted in trying to leave work and get home, without realizing that all traffic signals were blackened, and gridlock was sure to ensue.

During the blackout, Greater Cleveland RTA staff experienced failures within its communication system until a backup diesel generator was connected. In particular, the repeaters used to strengthen and extend the signals produced by the internal radio system that were not connected to backup sources of power failed during the blackout.

For some agencies, such as the Michigan DOT, it was the inability to contact field people on any reliable basis. The RCOC's FAST-TRAC system went down, as did the MITS Center at the Michigan DOT. SMART supervisors, unable to contact their regular bus drivers because their radio system failed, had to cancel Friday's regular service and run only emergency, medically related paratransit trips. For some other agencies, all the phones were down, and the backup radio system was not working. In some instances, this condition lasted for just a few hours; others were plagued throughout the full length of the blackout.

The lack of interoperability between the communication systems of different agencies was a major obstacle to inter-agency cooperation during the blackout. Agency representatives discussed the importance of having pre-established modes and protocols of communication – telephone, fax, or Internet – for agencies to contact each other during emergencies, with particular attention paid to ensuring redundancy in those systems. In Cleveland, there is an effective 800 MHz system, but it is not interoperable with the suburban counterparts.

At the Ambassador Bridge, cell phones and two-way pagers connect all managers and supervisors. They lost communication with their partner agencies, and the availability of their cell phones was intermittent. Although the two-way radios continued to operate, a repeater went out immediately, and staff could not communicate with Canadian Customs. Use of cell phones allowed them better communication, although it was also spotty. Trucks going back and forth also allowed them to pass messages across either side of the border. The Detroit–Windsor Truck Ferry staff, while in radio communication with Canadian Customs, lost the ability to transmit information through their advanced notification and reservation system that normally facilitates the movement of cargo across the border.

Maintain reliance on "old technology," such as the "plain old telephone system" (POTS) and portable radios

Low-tech options are sometimes more reliable. A clear finding is that the more options the better. While many worked at certain times – fax, email, cell phone, pagers/text-messaging, short-wave radio – all of them worked sporadically. One consideration is whether in-house POTS can operate without local power. Some agencies found that text messaging was particularly effective for maintaining a communications link between the central office and maintenance people in the field. One of the problems with the blackout was that people did not have access to radio and TV. Only people with battery-operated radios in their homes were able to access any information. There are two options being considered in Cleveland as a potential solution to how to get the public information in times of emergencies. Reverse 911®), an automated telephone emergency broadcast system, is the first option. The second is a citywide or countywide HAR in the Cleveland area.

Communicating with the public was often misleading or problematic
The blackout occurred in the midst of the major construction season. The use of VMS by Michigan DOT crews and contractors before the blackout occurred was to broadcast construction-related lane-closure information. When the power came back on, the signs displayed messages based on pre-blackout assumptions and reported inaccurate lane closures. In the future one transit provider is going to budget for purchasing commercial airtime for emergency announcements, as the public service announcements were not sufficiently informational.

Communications throughout the Great Lakes region was very scattered. The Detroit–Windsor Tunnel used cell phones to call radio and TV stations to get the information out to the public regarding both the initial closure of the tunnel, and then its re-opening. In some instances, tunnel staff had to physically go to the radio stations with tunnel information because some stations were without phone service.

Explore the option of joining the Government Emergency Telecommunications Service and Wireless Priority Service
Emergency situations typically generate significant demand for telephone services, often overwhelming the capacity available within the national telecommunications network. The Government Emergency Telecommunications Service (GETS) and the Wireless Priority Service (WPS) are two government sponsored priority communications systems that provide pre-approved users with priority routing of landline (GETS) and wireless (WPS) calls during times of emergency and crisis, even during periods of peak demand.

GETS and WPS are available to federal, state, and local government agencies, as well as to private companies and organizations, with responsibility for national security or emergency preparedness. Users are given ranked priorities, based on the importance of their role in national security. Transportation agencies are granted a 4-level priority within GETS and WPS, as are other public utility agencies.

GETS was not heavily used during the period of the blackout, experiencing only 1,800 calls. This may be attributed to the inability to access GETS through wireless technology, or perhaps to electrical outages impacting crucial GETS equipment. More information on GETS can be obtained at http://gets.ncs.gov/.

4.6 Redundancy and Resiliency of Systems

Redundancy, having backup systems in place in case the primary system fails, is crucial to the day-to-day management and operations of a system. The need for redundancy is even more important during a crisis. While for some agencies the blackout demonstrated the importance of backup power sources, there are numerous types of equipment and processes that need redundancy, depending on each agency's needs and the type of event.

Have backup power
Alternative power sources are essential for any functionality that an organization would like to maintain throughout the extent of an event. A representative from NITTEC suggested, "Have as much backup as you can." He explained that having generators for the signal system is a key in

managing traffic flow since there is only so much you can do with field elements. NITTEC member agencies are equipped with backup generators, and they have a system for mobilizing the deployment of these generators to priority intersections in case of an outage.

Test and maintain backup systems
Backup systems are only reliable during an emergency if they are tested frequently and regularly maintained. A number of agencies interviewed had invested in generators, but found that they malfunctioned, required repairs, or even caught on fire when called upon for extended use during the blackout. Other agencies reported switching to backup power, simulating a load on their backup system on a weekly or monthly basis for 12- or 24-hour stints, and scheduling routine preventative maintenance. Testing during regular operations will reduce the likelihood of encountering unforeseen omissions during an actual event.

Connect backup power to the right systems
During the course of the blackout, many agencies discovered systems that were necessary aspects of partial operations had not been connected to the backup power supply. Some of these included HVAC systems that are essential for cooling computer equipment in hot weather, radio signal repeaters, and fueling sites - especially if the generators are expected to run on fuel extracted at the fueling site.

Maintain a variety of old and advanced communications options
During the blackout, many types of communications were employed and the extent of their availability varied considerably. One responder explained, “Nothing worked all the time.” Organizations reported using a little of everything, including telephones, fax, email, cell phones, pagers, text messaging, short-wave radio, and face-to-face contact. Sometimes the low-tech options were the most reliable. A Federal Highway Administration staff member explained, “With TV, phones, and cell phones either not working or extremely busy, it seemed that good radio communication was critical.” Several interviewees learned the lesson that even though landline telephone services were working, high-tech phone systems with no backup power rendered them useless.

Assess the needs of an extended loss of the primary system versus a temporary interruption
Agencies should consider the prospect of extended outages as well as short interruptions in power. Some agencies wished they had been more prepared for an extended outage, encountering the limits of their battery supplies and discovering that equipment such as HVAC and fuel pumps became important as the blackout continued. Others noted the value of more functionality during the first few hours only. For example, having just enough backup to sustain the signals that would regulate traffic flow through Thursday’s rush hour would have been very valuable to the RCOC and other signal operators in the Detroit area. For traffic signal equipment, sustainability of backup generating power is a relevant consideration when purchasing new equipment. The lower power requirements of LED display means they can be powered by smaller, cheaper, easier-to-install generators.

Be cautious when relying on neighboring agencies and contractors for redundancy
Agencies sometimes form agreements with neighboring agencies to assist each other in case of an emergency in either’s jurisdiction. Some may also execute contracts in advance for labor or

supplies that might arise in unusual circumstances. For example, rather than purchasing generators, one organization has a contract with a local construction company to provide generators in case of power failure at one of its facilities. While in many circumstances these strategies are cost effective, if an event such as the blackout covers a wide geographic area, parties that have agreed to assist may be unable to do so because they need to address their own set of problems or are spread too thin. During the blackout, for example, some transportation agencies that contract out for backup power had to go without in deference to needs at hospitals or other essential agencies.

Locate redundant facilities remotely
The blackout was an extremely widespread event. In cases like this, redundant facilities are less likely to be affected by the same events as the primary operations site the farther away they are located.

Consider the failure of even quadruple redundancy
The blackout showed that it was possible even for agencies that draw from four separate power grids to lose power. A resilient agency should plan for losing functionality even of redundant systems. For the Detroit–Windsor Tunnel, this meant declaring a tunnel emergency and shutting down the facility. For other agencies, it may mean drawing up a “no communications” plan for what to do if all communications fail.

Adopt a mindset of resiliency
Many of the agencies with reliable backup power and that aimed to maintain operations regardless of the situation depend on electronic equipment for revenue collection. For example, the Ohio Turnpike stepped up their backup systems in response to an external audit conducted annually for their bondholders. Moreover, managers at other organizations clarified that resiliency was simply part of their organizational culture. One representative explained, “We’re not going to be caught flat-footed. Customers are relying on us.”

5. Conclusion

Widespread emergencies test the people, procedures, and equipment established to manage them in different ways. While emergencies share certain similar characteristics, each is unique, and from each, new insight is gained into how to prepare, plan, and prioritize. The past five years have seen three large emergency preparation and response efforts – for Y2K, September 11, 2001, and the 2003 blackout – and the experience of each is adding to a growing base of knowledge on emergency response and planning. This section presents a set of conclusions for emergency planning and response based on the review of the Great Lakes Region as well as the companion review of the New York-New Jersey-Connecticut Metropolitan Area.

Advanced Preparations and Planning

The experiences of Y2K and September 11 encouraged many agencies to draft or revise their emergency response plans-plans that proved invaluable on the day of the blackout. No matter how smoothly an agency may usually operate, efficient and coordinated action during a crisis requires advanced planning and rehearsal. Emergency planning provides agencies with many advantages during a crisis including pre-determined roles, clear and understandable chains of command, availability and readiness of appropriate supplies, and advance identification and rectification of weaknesses in the emergency response. Good advanced planning should include not only planning for the immediate period of a crisis, but for recovery and restoration afterwards.

The accumulation and storage of necessary supplies is a particularly important element of advanced planning, and one that was crucial during the hours of the blackout. The process of advanced planning requires agencies to thoroughly review the resources on which it depends for its operation, and to prepare for the possibility of having to do without these resources during a period of crisis. Emergency supplies can range from the small – including flashlights and glowsticks – to large – emergency generators. Effective planning includes developing an inventory of available emergency resources, acquiring any missing elements, and prioritizing the use of limited resources during an emergency. Given the near impossibility of stockpiling sufficiently for every possible emergency, agencies should develop a strategy for the use of precious resources during a crisis and, when possible, for sharing with other agencies and jurisdictions.

A further advantage of effective advanced preparation is the development of plans for the communication of information, within an agency, with other agencies, with the public, with the media, and with elected officials. The importance of accurate, frequent, and calming communication can be forgotten in the height of a crisis, as emergency responders focus on managing the immediate demands of the situation. Communication is vital and can facilitate the resolution of the crisis by encouraging cooperation and discouraging panic. Advanced planning should include communication strategies and the creation of relationships with the media and other important avenues of information dissemination.

Lastly, all emergency response planning should be rehearsed, drilled, and reviewed on a frequent basis. Several interviewees for this case study commented that their agencies had prepared emergency plans and, more importantly, had practiced them, greatly increasing their effectiveness. Different emergency scenarios should be staged – either through table-top exercises or through in-field exercises – and rehearsed, allowing emergency response to be evaluated and perfected. Emergency drills are also an important way for different agencies to work together in advance of a real emergency, and to identify any preparations that – while sensible on paper – seem unrealistic or unnecessary in practice.

The development of comprehensive plans requires time and effort and the dedication of resources, all for something that may never be used. But, should the need arise, the benefits of having prepared in advance will dramatically increase the chances that an emergency can be managed with a minimum of panic, disruption, and loss.

Agency Coordination

Cooperation between agencies and organizations is vital to successful emergency response, allowing multiple agencies – sometimes covering multiple jurisdictions – to contribute their strengths and skills during a crisis. Without agency cooperation, emergency response can become fractured, with agencies unsure of how to relate to each other or how to jointly participate in a response and recovery operation. Based on the research for this case study, it seems that coordination between agencies during emergencies can exist on two levels: that of the institution and that of the individual. Many interviewees identified the importance of formal multi-agency cooperation during the blackout, but many also identified informal personal relationships as the most efficient and effective way to accomplish much-needed tasks. Both are discussed here.

As part of advanced emergency planning, agencies should establish formal cooperative arrangements with appropriate partner agencies, those agencies with which they would need to work in an emergency. These arrangements should clearly delineate the roles and responsibilities of each agency during an emergency, perhaps indicating that roles will shift as the emergency response moves from one phase to the next. Of particular importance, partner agencies should establish and agree to the use of particular chains of command during a crisis – most likely different from standard chains of command – in which it is clear how authority will be distributed and exercised throughout the duration of an emergency.

The role of personal relationships is harder to quantify but of equal importance during a crisis. It is vital for any individual who will be involved with emergency response to be acquainted with his or her appropriate counterpart at partner agencies, to be able to easily pick up the telephone and place a call to the correct person to request assistance or coordinate response, and to be known and respected by his or her peers in other agencies. All of these elements will combine to make it possible for individuals to cooperate, on behalf of their agencies, for more effective emergency response.

Lastly, it is important to cast as wide a net as possible in developing coordination strategies. Many crises are local – a major fire, for instance, or the break of a water main – but some are regional, with effects felt over a large geographic area. In such a circumstance, as in the blackout, agencies that do not cooperate under normal circumstances suddenly need to work together to manage the situation. The midst of an emergency is not the time to be establishing relationships and developing a multi-agency understanding of roles, responsibilities, and priorities. Whenever possible, work these elements out in advance.

The Role of Advanced Technology

Technology plays a crucial supporting role in aiding transportation decision-makers during times of crisis. It helps agency personnel make better-informed decisions as events unfold and allows them to better coordinate responses with other agencies. It also allows agencies to both collect and distribute real-time information to people so that they can make individual travel decisions. As many agencies discovered during the blackout, advanced technology is useless without emergency backup power.

The need for the Internet and the use of electronic-based information has been closely woven into day to-day operations at many transportation agencies. The blackout showed these agencies that loss of power could critically affect their ability to function. Additionally, ITS equipment often requires power at both the control center and in the field: As many agencies found out, it is not sufficient to have backup power only at the control center. Backing up field equipment can be more difficult and expensive, but some agencies are exploring that as “a cost of doing business.”

For other types of technology, including traffic signal equipment, sustainability using backup power is an important consideration. Agency staffs should consider the power needs of equipment during the purchasing process and should provide for backup power whenever feasible. Furthermore, agency managers should also consider the restoration needs of the equipment in which they invest. The retiming of traffic signals, for instance, is a time-consuming and laborious process. Equipment that is capable of automated restoration can greatly reduce the burden of recovering from a crisis and can free individuals to attend to other, non-automated tasks. For those restoration tasks that require human action, the development of a plan that prioritizes restoration activities and places available staff where they are most needed will be of assistance.

Sustainability in a crisis is of particular importance for VMS and other types of technology that can communicate information to the public. During times of emergency, such equipment becomes a vital source of reassurance and instruction for the traveling public, communicating information about the crisis and recommendations for routes and modes of transportation.

Communications

The ability to communicate, internally and externally, is the most critical technological capability required in an emergency. When a crisis occurs, fast communication among all departments of an agency is crucial to stem anxiety, transmit instructions, and begin the process of response and recovery. Reliable communications technology is particularly important for transportation agencies, in which many employees may be working in the field, driving vehicles, or otherwise away from the central offices of the agency. Reaching those individuals with accurate information about a crisis allows them to take whatever action is necessary to protect themselves, their equipment, and the traveling public.

As with more general emergency planning, agency staffs should prepare and drill specifically for the failure of communications equipment. Some interviewees for this case study indicated their surprise that certain elements of their communications networks failed during the blackout, where extensive pre-emergency planning would likely have revealed the weaknesses that led to the failure. Furthermore, advanced planning can provide an opportunity to train employees to perform their responsibilities in an emergency without their standard communications equipment, including establishing communications procedures for times of reduced capacity.

To ensure that communications equipment has the best chance of operating in a crisis, agencies should maintain a mixture of communications technology, particularly a mixture of old and new technologies. In the case of the blackout, many agencies found that their landline telephones operated with minimal interruption, while the newer technologies of cell phones and two-ways were less reliable. Agencies should also do what they can to try to insulate their communications equipment from failure by installing backup power sources – generators or batteries – where appropriate.

Redundancy and Resiliency

The level of appropriate redundancy – for expertise, equipment, vehicles, and technology – will vary by agency. For all agencies, the concept of redundancy is continually being re-evaluated, based on the results of emergency response training and the experiences of actual emergencies. Some large-scale emergencies, like the blackout however, may always exceed the amount of available redundancy. Therefore, given financial and other constraints, managers must assume the most likely types of potential emergencies when planning for redundancy.

In planning for an appropriate level of redundancy, certain strategic decisions can be made that will help to increase the value of planned redundancy. From the experience of the blackout, it is clear that a source of backup power is the most important investment an agency can make. Backup power is crucial because most other systems – including communications, life-safety, and security systems – will operate so long as emergency power is available and sufficient. Without it, every other system will somehow have to be re-created or worked around, leaving agencies hobbled in many areas. Backup power sources must be tested and maintained, however, and must be connected to the appropriate systems. During the blackout, some agencies discovered that crucial operating systems were not connected to backup generators or batteries. In addition, an agency needs to explore the option of having off-site backup facilities. During an emergency that somehow incapacitated the headquarters, the off-site facility may be able to continue functioning.

Beyond backup power sources, agency managers must consider other important areas for the inclusion of redundancy. Based on the particular mission of an agency – to transport passengers, distribute transportation information, or oversee an international freight route – different elements will require redundancy. Whatever those elements may be, agencies should use the process of emergency response planning to categorize and prioritize their needs for redundancy and begin to accumulate the necessary equipment and expertise to ensure that all vital systems would have some type of backup in an emergency.

To manage localized emergencies, agencies should consider establishing mutual-aid agreements with partner agencies and neighboring communities. Such agreements make it possible for proximate communities to share resources and expertise during times of crisis, thereby reducing the amount of investment in redundancy that any one community needs to make. This strategy has its limitations, however, as was seen during the blackout; regional crises make it very difficult for communities to pool resources.

Lastly, agencies should prepare for the possibility of a long-term loss of power or other basic resources, a loss that will outlive the availability of backup power. Intense planning is required for such situations, in which agencies would have to learn to execute their responsibilities over an extended period with reduced resources and minimal technology. The demands of such a potentiality again underscore the need for advanced planning as the key to weathering a crisis with a minimum of disruption and loss.

Appendix A: Detailed Chronology

Thursday, August 14, 2003

12:05 p.m. Generators shut down at the American Electric Power plant in Conesville, Ohio.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

1:14 p.m. Generators shut down at DTE Energy's Greenwood power plant, north of Detroit.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

1:31 p.m. Generators shut down at FirstEnergy Corporation's Eastlake power plant in northern Ohio, along the southern shore of Lake Erie.
CBSnews.com, www.cbsnews.com/htdocs/blackout/
www.energy.gov

2:02 p.m. Due to a nearby brush fire, DPL's Stuart-Atlanta transmission line, which supplies power to the area south of Columbus, goes out of service.
Shaw Power Technologies, Inc.

3:05 p.m. FirstEnergy's Harding-Chamberlain line, running from eastern Ohio to northern Ohio, goes out of service.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

3:32 p.m. Extra power traveling through FirstEnergy's Hanna-Juniper line, which runs from eastern Ohio to northern Ohio, overheats the wires, causing them to sag into a tree, short-circuit, and fail.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

3:41 p.m. An overload on FirstEnergy's Star-South Canton line, which runs from eastern Ohio to northern Ohio, trips a breaker at the Star switching station, where FirstEnergy's grid connects with a neighboring grid owned by American Electric Power.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

3:45 p.m. FirstEnergy's Canton Central-Tidd line, which runs from eastern Ohio to northern Ohio, disconnects and reconnects 58 seconds later.

4:06 p.m. FirstEnergy's Sammis-Star line, located in northeast Ohio, disconnects.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

4:08 p.m. American Electric Power's Galion-Ohio Central-Muskingum and East Lima-Fostoria Central transmission lines disconnect, blocking the flow of power from southern and western Ohio into northern Ohio and eastern Michigan.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

4:09 p.m. Kinder Morgan's generating unit in Central Michigan is interrupted.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

4:10:38 p.m. The Perry-Ashtablua-Erie West transmission line trips, severing the path into northern Ohio from Pennsylvania.
www.energy.gov

4:10:40 p.m.–
4:10:44 p.m. Four transmission lines – Homer City-Watercure Road, Homer City-Stolle Road, South Ripley-Dunkirk, East Towanda-Hillside – disconnect between Pennsylvania and New York.
www.energy.gov

4:10:41 p.m. The Beaver-Davis Besse line, which connects the Cleveland and Toledo areas, disconnects, leaving Cleveland isolated from the Eastern Interconnection. Cleveland loses power.
www.energy.gov

4:10:42 p.m.–
4:10:45 p.m. Transmission paths disconnect between northern Ohio and New Jersey, isolating the northeast portion of the Eastern Interconnection. The Eastern Interconnection is now effectively split in half, with northern New Jersey, New York City and portions of New York state, New England, the Maritime provinces, eastern Michigan, the majority of Ontario, and Quebec all to the north of the dividing line. The areas south of this line remain unaffected by the blackout.
www.energy.gov

4:10:46 p.m.–
4:10:55 p.m. The New York power system splits east-west. New England, expect for southwestern Connecticut, and the Maritimes separate from New York and remain operational.
www.energy.gov

4:10:50 p.m.–
4:11:57 p.m. The Ontario system just west of Niagara Falls and St. Lawrence separates from New York. Southwestern Connecticut separates from New York and goes dark.
www.energy.gov

4:10 p.m. Power fails on the PATH transit system connecting New York and New Jersey. Power to the signal system, third rail system, fare collection equipment, station lighting, and tunnel lighting is lost.
PATH presentation at 2003 APTA Annual Meeting

4:11 p.m. New York City Transit subway operations cease as the system loses electrical power. A total of 413 trains with approximately 400,000 customers are in service and are affected by the blackout.
NYC Transit

4:11 p.m. INFORM, the transportation management center serving Long Island, loses connection to its closed-circuit cameras and signalized intersections.
INFORM

4:11 p.m. Most of Ontario blacks out and the remaining transmission lines between Ontario and eastern Michigan fail.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

4:11 p.m. New Jersey Transit loses power in portions of its service area.
Volpe Center notes

After
4:11 p.m. 300,000 users suddenly disconnect from America Online.
Washington Post 8.15.03, C. Mayer, page A08

After
4:11 p.m. Lines begin to develop at pay phones in New York City, as the cellular phone network becomes overwhelmed by the unexpected volume of calls and ceases to function.
Washington Post 8.15.03, C. Haughnery, page A10

After
4:11 p.m. The 11,000 signalized intersections in New York City lose power.
Enhancing New York City's Emergency Preparedness: A Report to Mayor Michael R. Bloomberg

4:13 p.m. The cascading sequence is essentially complete, with the blackout stretching from eastern Michigan and southeast Canada to New York state, New Jersey, and parts of New England. 3,700 square miles

are in the dark. One area remains in operation, mostly in western New York. This service was maintained by generating stations south of Lake Ontario, and formed the basis for the restoration of power.
CBSnews.com, www.cbsnews.com/htdocs/blackout/

4:15 p.m. The lights go out in the Office of Emergency Management of the Port Authority of New York and New Jersey (PANYNJ)
PANYNJ Situation Status Report

4:15 p.m. The tunnel between Detroit and Windsor, Ontario closes.
Volpe Center notes

4:15 p.m. The SMART transit system in Detroit loses power.
Volpe Center notes

4:20 p.m. The emergency power system at New York's JFK International Airport switches on.
New York Daily News 8.15.03, J. Lemire

4:20 p.m. NYC Transit determines that power will not be restored quickly and begins evacuation procedures for its subway system.
NYC Transit

4:30 p.m. The PATH transit system ceases efforts to restore power and a full evacuation of all trains and stations is ordered.
PATH presentation at 2003 APTA Annual Meeting

4:40 p.m. Two plumes of black smoke are visible on the New York City skyline.
PANYNJ Situation Status Report

4:54 p.m. Federal officials rule out terrorism as a cause of the blackout.
Newsweek, MSNBC 8.25.03, M. Hirsch

5:00 p.m. Four of Cleveland's water pumping stations and their backup systems – used to pump and clean drinking water from Lake Erie – lose power and fail.
The Cleveland Plain Dealer 8.16.03

As of
5:00 p.m. PATH, New Jersey Transit, New York City subway, Metro-North Railroad, and Long Island Rail Road – all serving the greater New York area – are out of operation. New Jersey Transit and New York City buses are running with delays, and the Port Authority Bus Terminal is closed.
Transcom 8.14.03

As of
5:00 p.m. The eastbound lane of the Lincoln Tunnel is closed. The Holland Tunnel is open and the Queens Midtown and Brooklyn Battery Tunnels are open for emergency vehicles only. The George Washington, Verrazano, Triboro, Bayonne, Outerbridge Crossing, Goethals, and Tappan Zee Bridges are open. The Manhattan-bound Brooklyn, Williamsburg, and Manhattan Bridges are closed.
Transcom 8.14.03

As of
5:00 p.m. The New Jersey Turnpike and the Garden State Parkway are both open and tolls are waived, due to the lack of power.
Transcom 8.14.03

Just after
5:00 p.m. The U.S. Department of Homeland Security mobilizes several emergency response teams to assist with telecommunications and other needs in areas impacted by the blackout.
Newsweek, MSNBC 8.25.03, M. Hirsch

Just after
5:00 p.m. North American Aerospace Defense Command (NORAD) orders two F-16 airplanes from Tyndall Air Force Base in Florida to patrol the East Coast.
Newsweek, MSNBC 8.25.03, M. Hirsch

5:20 p.m. All operations cease at the New York Marine Terminal of PANYNJ.
PANYNJ Event Log

5:45 p.m. Mayor Bloomberg of New York gives a press conference, describing the blackout as an "inconvenience rather than a crisis."
Washington Post 8.15.03, B. Gellman, page A01

6:00 p.m. Power begins to return in Toledo.
Washington Post 8.15.03, M. Weil, page A01

6:10 p.m. Trucks are exiting normally at the New Jersey Marine Terminal of PANYNJ and roadblocks are established to prohibit additional trucks from entering.
PANYNJ Event Log

6:12 p.m. PANYNJ staff work to stages buses outside the Port Authority Bus Terminal in order to transport commuters out of midtown Manhattan.
PANYNJ Situation Status Report

6:15 p.m. Operations cease at the Howland Hook Marine Terminal and the Red Hook Marine Terminal, both of PANYNJ.
PANYNJ Event Log

6:30 p.m. All PATH trains are successfully evacuated.
PATH presentation at 2003 APTA Annual Meeting

6:32 p.m. All railroad crossing lights are operational at the Port Newark Marine Terminal. The Coast Guard is not restricting inbound ships.
PANYNJ Event Log

6:42 p.m. The George Washington Bridge Bus Station, in upper Manhattan, is evacuated and secured.
PANYNJ Event Log

6:54 p.m. The George Washington Bridge is operating in both directions.
PANYNJ Situation Status Report

7:00 p.m. New Jersey Governor James McGreevey declares a state of emergency.
PANYNJ Event Log

7:00 p.m. Mayor Jane Campbell of Cleveland receives a call from the White House to assure her that the blackout does not appear to be related to terrorism.
The Cleveland Plain Dealer 8.16.03

By 7:00 p.m. New York LaGuardia, JFK International, and Newark Liberty International Airports resume limited operations.
cnn.com 8.14.03

7:09 p.m. The evacuation of the NYC Transit subway system is complete. Three minor injuries are reported system-wide.
NYC Transit

7:16 p.m. Power is restored to the central terminal at Newark Liberty International Airport.
PANYNJ Situation Status Report

7:52 p.m. New York LaGuardia, JFK International, and Newark Liberty International Airports institute “snow plans,” in which they prepare for stranded passengers to spend the night in the airports.
PANYNJ Situation Status Report

8:00 p.m. A few Amtrak trains move through Penn Station, using power from the New Jersey grid.
Washington Post 8.15.03, D. Phillips, page A08

8:00 p.m. Orange County, New Jersey imposes a curfew.
Washington Post 8.15.03, B. Gellman, page A01

By 8:00 p.m. Partial power is restored on the PATH system, as well as full traction.
PATH presentation at 2003 APTA Annual Meeting

8:12 p.m. New York Governor George Pataki declares a state of emergency.
PANYNJ Situation Status Report

8:23 p.m. Power is restored in some parts of Buffalo.
msnbc.com 8.14.03

8:28 p.m. Power is partially restored in New York, with the boroughs of Queens and the Bronx the first to come back on-line.
msnbc.com 8.14.03

8:30 p.m. Power is restored at the Port Newark Container Terminal.
Shipping News 8.18.03

8:38 p.m. The Marine Terminals at Port Elizabeth and Newark are accepting ships and allowing ships to depart.
PANYNJ Event Log

8:44 p.m. New York LaGuardia, JFK International, and Newark Liberty International Airports agree to accept some flights throughout the night.
PANYNJ Situation Status Report

8:45 p.m. Mayor Jane Campbell of Cleveland requests and receives a declaration of a state of emergency from Governor Bob Taft of Ohio.
Cleveland Plain Dealer 8.16.03

8:45 p.m. Power is restored in most areas of Pennsylvania affected by the blackout.
CBSnews.com 8.15.03

As of
8:45 p.m. PATH, New York City subway, Metro-North Railroad, and Long Island Rail Road rail services – all serving the greater New York area – are out of operation. New Jersey Transit rail service is running very limited service. New Jersey Transit and New York City buses are running with delays, and the Port Authority Bus Terminal remains closed, but passengers can be picked up outside the station and taken to a staging area at the Meadowlands Sports Complex for transportation to areas around the region.
Transcom 8.14.03

As of
8:45 p.m. The eastbound lane of the Lincoln Tunnel is closed. The Holland Tunnel and the Queens Midtown Tunnel are both open, and Brooklyn Battery Tunnel is open with suspended tolls. The Henry Hudson, Throgs Neck, Bronx Whitestone, George Washington, Verrazano, Triboro, Bayonne, Outerbridge Crossing, Goethals, and Tappan Zee Bridges are open, some with suspended tolls. The Verrazano Bridge is operating without lights. The Manhattan-bound Brooklyn, Williamsburg, 59th Street, and Manhattan Bridges are open to emergency vehicles only.
Transcom 8.14.03

As of
8:45 p.m. The New York State Thruway is open without incident.
Transcom 8.14.03

Evening New York Waterway, which operates private ferry service in New York City, carries 170,000 people during the afternoon and evening, 140,000 people more than on a typical day.
Enhancing New York City's Emergency Preparedness: A Report to Mayor Michael R. Bloomberg

9:00 p.m. NBC airs a videotaped message from President Bush, who reiterates that terrorism was not a factor in the blackout.
msnbc.com 8.14.03

9:00 p.m. The Cyber Division of the FBI announces that computer hacking does not appear to have played a part in the blackout.
msnbc.com 8.14.03

9:30 p.m. Amtrak restores limited service in the tri-state area of New York, New Jersey, and Connecticut.
wnbc.com 8.14.2003

9:30 p.m. Municipal officials in Cleveland impose a curfew for anyone under the age of 18.
msnbc.com 8.14.03

9:30 p.m. Mayor Bloomberg of New York holds a press conference, and urges residents to take care of themselves and their neighbors. Mayor Bloomberg also announces that all of the New York City subways have been evacuated safely, as have most of the elevators in the city. He estimates that approximately 10 to 15 percent of the power in New York City has been restored, and that the majority will be operational by 1:00 am EST.
msnbc.com 8.14.03

9:30 p.m. Power returns to portions of Long Island.
cnn.com 8.14.03

9:34 p.m. The emergency power system at New York LaGuardia Airport fails.
New York Daily News 8.15.03, J. Lemire

9:45 p.m. PATH service is restored between Journal Square and 33rd Street.
PATH presentation at 2003 APTA Annual Meeting

9:45 p.m. TRANSCOM, the collaborative transportation operations center serving the New York region, experiences a generator fire. The facility is evacuated.
PANYNJ Situation Status Report

By 9:45 p.m. Power has been restored to 650,000 customers in New Jersey, leaving 350,000 without power.
msnbc.com 8.14.03

9:48 p.m. Power is restored at Teterboro Airport in Teterboro Borough, New Jersey.
PANYNJ Situation Status Report

9:55 p.m.	The Lincoln and Holland Tunnels are open eastbound to buses and westbound to buses and cars. *PANYNJ Situation Status Report*
10:15 p.m.	PATH service is restored between Newark and Exchange Place. *PATH presentation at 2003 APTA Annual Meeting*
10:15 p.m.	The tunnel between Detroit and Windsor, Ontario re-opens. *Volpe Center notes*
10:24 p.m.	New York LaGuardia, JFK International, and Newark Liberty International Airports are all accepting limited arrivals and supporting limited departures. *PANYNJ Situation Status Report*
10:24 p.m.	The Port Authority Bus Terminal is officially secured. *PANYNJ Situation Status Report*
10:24 p.m.	The Holland Tunnel has one lane open to automobiles in each direction. *PANYNJ Situation Status Report*
11:00 p.m.	New York Governor George Pataki holds a press conference, and announces that there have been no serious injuries or deaths related to the blackout. *Washington Post* 8.15.03, B. Gellman, page A01
11:00 p.m.	The final person is freed from a Cleveland elevator. *The Cleveland Plain Dealer* 8.16.03
By 11:00pm	Only 250,000 New Jersey residents remain without power, out of 1 million originally in the dark. *cnn.com* 8.14.03
11:04 p.m.	PATH is running normal service. *PANYNJ Situation Status Report*
11:31 p.m.	The Federal Emergency Management Agency establishes a Regional Operations Center for the New York area.
11:41 p.m.	Traffic in the Holland Tunnel is light in both directions. *PANYNJ Event Log*
Overnight	New York City officials log 800 elevator rescues and 80,000 calls to 911. *Newsweek*, MSNBC 8.25.03, M. Hirsch
Overnight	About 10,000 New York City policeman are on duty, one-third of the total force. *Washington Post* 8.17.03, D. Von Drehle
Overnight	New York City Fire Commissioner Nicholas Scoppetta reports that EMS crews answer more than 5,000 calls, twice the typical number. *Washington Post* 8.17.03, D. Von Drehle
Overnight	Cleveland police make 19 arrests, fewer than half the summer average of 50. Cleveland deploys twice the typical number of officers. *Washington Post* 8.17.03, D. Eggen, page A01

General	17 General Motors plants, located in Lansing, Pontiac, Detroit, Toledo, Parma (Ohio), and Ontario, are closed. 23 Ford plants, located in southeast Michigan, Cleveland, and Ontario, are closed. 14 DaimlerChrysler plants, located in southeast Michigan and Ontario, are closed. *Washington Post* 8.15.03, J. Porretto
General	Starbucks closes all of its shops in areas without electricity.
General	New York City opens emergency shelters for stranded commuters. *Washington Post* 8.15.03, B. Gellman, page A01
General	Authorities in Cleveland relocate approximately 100 prisoners from the city jail to more secure facilities in Youngstown, Ohio. *cnn.com* 8.15.03
General	The MGM Grand Casino in Detroit closes for the first time since its opening in 1999. *Washington Post* 8.15.03, B. Gellman, page A01

Friday: August 15, 2003

12:00 a.m.	The NYC Transit subway system resumes partial service. *NYC Transit*
12:45 a.m.	Lights inside the Cleveland Terminal Tower flicker, signaling the beginning of restoration of power to downtown and other parts of Cuyahoga County. *The Cleveland Plain Dealer* 8.16.03
2:00 a.m.	The North Bergen, Little Ferry, and Kearny rail freight terminals of CSX – all located in New Jersey – resume operations. *Shipping News* 8.18.03
3:00 a.m.	Power is restored at the Howland Hook Container Terminal on Staten Island. *Shipping News* 8.18.03
3:00 a.m.– 6:30 a.m.	Metro-North is able to run several trains, using diesel locomotives, from Grand Central Station to the suburbs of New York and Connecticut. *wnbc.com* 8.15.03
3:23 a.m.	The Lincoln Tunnel is closed eastbound. *PANYNJ Situation Status Report*
4:00 a.m.	Partial power is restored to INFORM, the transportation management center serving Long Island. *Volpe Center notes*
4:10 a.m.	Power returns to the rail yard of the Greater Cleveland Regional Transit Authority. *Volpe Center notes*
4:31 a.m.	Power is restored to portions of the southeast Bronx, Manhattan, Brooklyn, Westchester County, and Staten Island. *Con Edison Press Release* 8.15.03

5:40 a.m.	The Holland Tunnel is open with one lane in each direction and is collecting tolls, but reporting some ventilation problems. *PANYNJ Situation Status Report*
Early Morning	New York City buses run on schedule and are free to all passengers. *wnbc.com* 8.15.03 and *New York Daily News* 8.16.03, P. Donohue.
6:20 a.m.	Staten Island Railway service is restored. *NYC Transit*
6:30 a.m.	The Lincoln Tunnel is open with two lanes in each direction. *PANYNJ Situation Status Report*
7:23 a.m.	Cleveland Hopkins International Airport regains power and resumes limited passenger operations. *The Cleveland Plain Dealer* 8.16.03, A. Garrett
7:40 a.m.	Full power is restored at New York LaGuardia Airport. 400 stranded passengers are reported to be on-site. *PANYNJ Situation Status Report*
8:00 a.m.	The Federal Aviation Administration suspends all operations at New York LaGuardia Airport until 12:00 p.m. *PANYNJ Situation Status Report*
8:45 a.m.	Power is restored at Brooklyn Marine Terminal but Terminal employees have not reported for work. *PANYNJ Situation Status Report*
9:00 a.m.	Metro-North restores limited service from Grand Central Station to the northern suburbs of New York and Connecticut, using diesel locomotives, but halts service shortly thereafter due to a failure in the signal system. *wnbc.com* 8.15.03
9:00 a.m.	Power is completely restored to Staten Island. *Con Edison Press Release* 8.15.03
10:00 a.m.	Complete power is restored to INFORM, the transportation management center serving Long Island. 80 percent of the INFORM closed-circuits cameras return to operation. *INFORM*
10:03 a.m.	Con Edison reports that rolling blackouts are affecting all of Staten Island. *NYC Transit*
10:15 a.m.	The first flight since the blackout departs from Cleveland Hopkins International Airport. *The Cleveland Plain Dealer* 8.16.03, A. Garrett
10:32 a.m.	Power is restored to the #6 NYC Transit subway line. No customer service is in operation. *NYC Transit*
Morning	The Long Island Rail Road resumes limited service from Jamaica Station. *wnbc.com* 8.15.03
Morning	Airlines resume near-to-normal operations from Newark Liberty International, Cleveland Hopkins International, Albany International, Buffalo Niagara International, and Montreal Airports. *New York Daily News* 8.16.03, J. Marzulli

Morning	150,000 Cleveland residents remain in the dark, out of 1.4 million without power on Thursday afternoon. *CBSnews.com* 8.15.03
Morning	130,000 Michigan residents remain in the dark, out of 2.1 million without power on Thursday afternoon. *CBSnews.com* 8.15.03
Morning	Responding to a question about the lack of cellular service, a spokeman from Nextel explains that cellular towers require electricity in order to function. Most towers have back-up systems that can run for 3-6 hours only. *MSNBC.com* 8.15.03
11:00 a.m.	Con Edison New York elects to reduce power to parts of its service area – New York City and Westchester County – in order to avoid volatile fluctuations. Customers are asked to turn off appliances. *Con Edison Press Release* 8.15.03
Mid-Morning	20,000 New Jersey residents remain without power. *CBSnews.com* 8.15.03
Late Morning	Power is restored to the Norfolk Southern rail freight terminals in Bellevue (Ohio), Toledo, Buffalo, Cleveland, and portions of the New York City region. *Shipping News* 8.18.03
Late Morning	Power is not yet restored to Penn Station. *wnbc.com* 8.15.03
12:20 p.m.	Greater Cleveland RTA restores power to its light rail system *Volpe Center notes*
2:00 p.m.	The parking lots at New York LaGuardia Airport are completely full; officials announce that they may begin limiting automobile access to the airport. *Washington Post* 8.16.03, S. Goo, page A08
3:10 p.m.	Power is restored to the third rail on selected portions of the IRT tracks (portions of Lexington Avenue, 7th Avenue, and Eastern Parkway) in New York City. No customer service is in operation. *NYC Transit*
4:05 p.m.	Power is restored to the Port Authority Bus Terminal. *PANYNJ Situation Status Report*
Day	Amtrak resumes limited service between Washington, DC and New York. *wnbc.com* 8.15.03
Day	Without electricity to operate their pumps, most gas stations in New York City are closed. *NY1* 8.16.03, J. Ramirez
Day	A spokesmen for Verizon Communications reports that the use of landline telephones was 300 percent greater than typical during the period of the blackout. *MSNBC.com* 8.15.03

Afternoon	In a press conference, Governor Pataki announces that power has been restored to most of New York state, including 85 percent of New York City. *Washington Post* 8.15.03, D. Cohn
5:00 p.m.	Over the next several hours, power is restored to portions of the NYC Transit subway system. No customer service is in operation. *NYC Transit*
Early Evening	FirstEnergy Corporation declares that full service has been restored to the Cleveland area. *Newsweek* 8.25.03, J. Adler
Evening	Most flights in and out of Cleveland Hopkins International Airport are running on schedule. *Washington Post* 8.16.03, S. Goo, page A08
6:36 p.m.	Power is restored to New York LaGuardia Airport. *PANYNJ Situation Status Report*
7:00 p.m.	Con Edison restores power through the New York feeds into the Lincoln and Holland Tunnels. *PANYNJ Situation Status Report*
7:40 p.m.	Full power is restored in the passenger terminals at JFK International Airport. *PANYNJ Situation Status Report*
9:02 p.m.	Power is restored at cargo buildings at JFK International Airport. *PANYNJ Situation Status Report*
9:03 p.m.	Power is completely restored to all areas of New York City and Westchester County. *Con Edison Press Release* 8.15.03
10:15 p.m.	The Office of Emergency Management of the Port Authority of New York and New Jersey is deactivated. *PANYNJ Situation Status Report*
11:00 p.m.	Sixty-three of the major NYC Transit bus lines are operating fare free, and will continue to operate without fares until subway service is restored. *NYC Transit*
Overnight	City officials report that six people are arrested in Detroit for incidents related to the blackout. *Pittsburgh Post-Gazette* 8.17.03
General	During the 29 hours of the blackout, 132,000 calls were logged by the New York City 911 system. This represents a 187 percent increase over the same period during the previous year. *Enhancing New York City's Emergency Preparedness: A Report to Mayor Michael R. Bloomberg*
General	During the 29 hours of the blackout, the Emergency Medical Service of New York City transported 133 percent as many patients as is typical. *Enhancing New York City's Emergency Preparedness: A Report to Mayor Michael R. Bloomberg*
General	During the 29 hours of the blackout, 150,000 calls were logged by the New York City 311 Citizen Service Center. *Enhancing New York City's Emergency Preparedness: A Report to Mayor Michael R. Bloomberg*
General	The ports of Toronto, Detroit, and Cleveland are without power. *Shipping News* 8.18.03

General	American Stock Exchange spokesman Robert Rendine reports that the Stock Exchange opened for only 15 minutes on Friday, in order to set closing prices for the day before. *Washington Post* 8.19.03, G. Schneider, page E01
General	Amtrak reports operating 80 percent of its scheduled service. *Washington Post* 8.16.03, S. Goo, page A08
General	The NYC Transit subway system remains out of service all day. *Washington Post* 8.16.03, S. Goo, page A08
General	The public bus system in Detroit remains out of service all day. *Washington Post* 8.16.03, S. Goo, page A08
General	Traffic signals in New York are out of service. *Washington Post* 8.16.03, S. Goo, page A08
General	Peter Pan Bus Lines runs 2-3 times their regular service into and out of New York City. *Washington Post* 8.16.03, S. Goo, page A08
General	The Long Island Rail Road commissions 100 school and tour buses to transport 40,000 stranded commuters from Manhattan to Queens and Long Island. *Washington Post* 8.16.03, S. Goo, page A08
General	Most shuttle flights between Washington, DC and New York are cancelled. *Washington Post* 8.16.03, S. Goo, page A08
General	American Airlines delays or cancels nearly all of its outbound flights from JFK International Airport. *New York Daily News* 8.16.03, J. Marzulli
General	Officials in Cleveland and Detroit urge motorists to limit their driving due to non-functioning traffic lights. *Washington Post* 8.16.03, S. Goo, page A08
General	Mail delivery is limited in Detroit. *Washington Post* 8.16.03, R. Pierre, page A01
General	New York City closes its public beaches due to concerns about water quality. *NY1* 8.19.03
General	A spokesman for the NASDAQ reports that 80 percent of the 270 firms listed on the NASDAQ exchange were open for business. The NASDAQ itself was able remain operational due to an off-site generating facility. *Washington Post* 8.19.03, G. Schneider

Saturday, August 16, 2003

12:00 a.m.– 1:00 a.m.	Partial to full customer service is resumed on the following NYC Transit lines: 6, 7, 2, 4, 5, 1, J, A, L, M, W, Q, A shuttle, R, D, and N. *NYC Transit*
1:00 a.m.– 3:00 a.m.	Partial to full customer service is resumed on the following NYC Transit lines: F, E, and G. *NYC Transit*

5:00 a.m. NYC Transit reinstates fares on the bus system.
NYC Transit

6:00 a.m. The NYC Transit subway system resumes full service.
NYC Transit

Morning 450 Connecticut customers, down from a peak of 278,000, remain without power. 50,000 Michigan residents are still in the dark, as well as 5,000 New Jersey residents.
cnn.com 8.16.03

Day All 24 of the New York City subway lines are operational.
cnn.com 8.16.03

Late Evening Power returns to the SMART system in Detroit.
Volpe Center notes

General Amtrak restores regular service between Boston and Washington, but cautions that service is still limited or delayed in Michigan.
Washington Post 8.17.03, S. Goo, page A15

General Detroit Mayor Kwame Kilpatrick announces that public transportation will be free for all passengers throughout the weekend.

Sunday, August 17, 2003

Late Afternoon The North American Electric Reliability Council announces that the power grid is operating reliably again, with all but one transmission line back in service.
Washington Post 8.18.03, J. Glanville

Night The New York City Traffic Department finishes the task of inspecting all traffic signals.
Inside ITS 9.15.03

General The SMART system in Detroit is running almost normally.
Volpe Center notes

General Air travel returns to near normal after three days in which airlines canceled more than 1,700 flights.
Washington Post 8.17.03, S. Goo, page A15

Monday, August 18, 2003

Morning Metro-North and the Long Island Rail Road, serving the New York suburbs, both announce that they are running on or near to schedule.
Washington Post 8.18.03, J. Glanville

Morning General Motors, Ford, and DaimlerChrysler resume manufacturing operations.
Motortrend 8.1.8.03

9:00 p.m. 3,000 Staten Island customers lose power. It is restored two hours later.
NY1 8.19.03

General Air traffic controllers at New York LaGuardia Airport, JFK International Airport, and Newark Liberty International Airport lose contact with all airplanes following a loss of power at the Federal Aviation Administration's control center on Long Island, most likely an after-effect of the blackout. A back-up system switches on after 30-45 seconds.
New York Daily News 8.18.03

Tuesday, August 19, 2003

General New York Stock Exchanges and major Wall Street firms said that they have little cleanup work to do and that the emergency backup plans they put into place after the attacks of September 11, 2001, had worked well.
Washington Post 8.19.03, G. Schneider, page E01

General New York City businesses lost about $800 million in products and services and another $250 million from spoiled food and perishables, said a spokesman for the city comptroller, William C. Thompson, Jr.
Washington Post 8.19.03, G. Schneider, page E01

On-Going

October 21 Officials from the Federal Reserve, the U.S. Treasury Department, and the Security and Exchange Commission testify before Congress that there was no evidence of panic or disruption in the banking system during the period of the blackout.
The Boston Globe 8.21.03

Appendix B: Summary of Installed Intelligent Transportation Systems (ITS)

Agency:	**Detroit International Bridge / Canada Transit Company**
Facility:	Ambassador Bridge
Location:	Connects Detroit (I-75, I-94, I-96, and Jefferson Avenue) with Windsor, Ontario (Highway 3, Highway 401, and Wyandotte Street)
Responsibility:	9,200-foot bridge with toll plazas

ITS Technology Installed

- Electronic toll collection (ETC)
- Weigh in motion (WIM) system
- Closed circuit television (CCTV) system
- Advanced border processing system
- Advanced traveler information system (ATIS) – Internet site, automated telephone system

Operations Capability Maintained during the Blackout

- ETC and WIM systems, supported by backup generation
- Two-way radio, with limited range
- Intermittent cell phone service

Operations Capability Lost during the Blackout

- Communication with partner agencies
- Short-wave repeater, limiting radio communications to a half-mile range (not as far as the Canada side of the bridge)

Pre-Event Preparation

- Comprehensive backup generating capability
- Bottled water on hand in case of emergency
- Coordination with emergency management personnel to facilitate sharing of information among first responders, local and state authorities, and U.S. and Canadian Customs

Lessons Learned

- Emergency preparations for the year 2000 and September 11 paid off, such as provision of generators and bottled water and the cultivation of relationships that turned out to be very helpful (such as with law enforcement, water board, public lighting, and U.S. and Canadian Customs officials)
- Need to relocate radio signal repeater so that it can function during future power outages
- Need to assess whether additional generators are warranted to service needs of the bridge

Agency:	**Detroit and Canada Tunnel Corporation**
Facility:	Detroit–Windsor Tunnel
Location:	Spans the Detroit River, connecting Detroit, Michigan, and Windsor, Ontario
Responsibility:	One-mile tunnel and toll and inspection plazas

ITS Technology Installed

- Variable message signs (VMS) – 1
- Closed circuit television (CCTV) system – 32 cameras
- Electronic toll collection (ETC) – tied to scales for commercial carriers
- Highway advisory radio (HAR) system – 1 station
- Lane-use control signals

Operations Capability Maintained during the Blackout

- Spotty communications via cell phone and radio

Operations Capability Lost during the Blackout

- All power, and therefore all ITS technology
- Landline phones

Pre-Event Preparation

- Quadruple redundancy in power source: four feeds, two from each country. Full operations can sustain on any one of the power feeds (but in the blackout, all four failed)
- Small generators to support things like the radio system

Lessons Learned

- Quadruple redundancy is not foolproof
- Regular generator maintenance should be scheduled into the standard operating procedure
- More generation capability is warranted for the phone system and the internal two-way radio. Also considering backup generation to support U.S. and Canadian Customs and life-safety systems in the tunnel
- Backup communications plans are necessary, such as a plan for how to contact the police and media when the usual systems are unreliable
- Need a dial-around option for phone systems that have an electricity-dependent switch
- A cooperative plan for diverting automobile traffic from the bridge to the tunnel might have helped relieve the heavy congestion on the bridge

Agency:	**Detroit–Windsor Truck Ferry**
Facility:	Ferry service
Location:	Detroit River, linking Detroit and Windsor, Ontario
Responsibility:	Ferry fleet, docking areas, onsite U.S./Canadian Customs processing, communications center

ITS Technology Installed

- Advanced reservation and border processing system

Operations Capability Maintained during the Blackout

- Continued operations with manual processing through customs
- Radio system

Operations Capability Lost during the Blackout

- Advanced notification system and online reservation system
- Phone system

Pre-Event Preparation

- Many drills and frequent training focused on safety and considered the loss of communications

Lessons Learned

- Need backup generation so that computer-dependent systems can continue to function
- Need upgraded radio and telephone systems
- Need network redundancy: wireless network as usual, plus dial-up and DSL capability
- Diverting some freight to the ferry might have helped relieve congestion in other areas

Agency:	**Greater Cleveland Regional Transit Authority**
Facility:	Bus and rail system serving Cleveland metro area
Location:	Cleveland
Responsibility:	Stations, maintenance facilities, communications center, 35 miles of one-way track

ITS Technology Installed

- Automatic vehicle location (AVL) system
- Computer-aided dispatch (CAD) system
- Variable message signs (VMS)
- Mobile data terminals (MDT) – buses only
- Electronic fare collection – magnetic strip
- Advanced traveler information system (ATIS) – internet site, automated telephone system

Operations Capability Maintained during the Blackout

- Communications center, including radio and computers system for bus operations (after emergency power was restored)
- Mobile radios (450 MHz system) for transit police force and rail operations
- Trunked 900 MHz bus system after emergency power restored at communications center
- AVL, CAD, MDT after communications center power restored
- Fare-collection equipment
- Telephone systems in facilities with emergency power available
- Cell phones

Operations Capability Lost during the Blackout

- Temporarily lost power at communications center, until generator was repaired, including AVL, CAD, mobile data terminals, and bus radio system
- Air conditioning was not a part of backup power system
- Radio signal and global positioning system (GPS) data for a large area due to a non-functioning repeater
- Short-range portable radios due to non-functioning repeaters
- Telephone systems (once backup batteries expired at facilities without emergency power)

Pre-Event Preparation

- Cultivation and maintenance of good relationships citywide
- Backup generation capability at central facility, on some in-field equipment such as repeaters, and on trains for lights and radio

Lessons Learned

- Relationships are key
- Generators need regular maintenance
- Compressed natural gas (CNG) compression system for refueling of vehicles is not able to work off of generators

- Managers at the communications center may have been forced to shut down communications and technological equipment if the outage had of lasted longer due to a lack of air conditioning to cool the equipment
- Need a stronger regional response plan

Agency:	**Michigan Department of Transportation**
Facility:	Michigan Intelligent Transportation Systems (MITS) Center with freeway and incident management systems and a traveler information system
Location:	Detroit, Michigan
Responsibility:	ITS along 180 miles of the state freeway system in the Greater Detroit area

ITS Technology Installed

- Closed circuit television (CCTV) system – 170 cameras
- Variable message signs (VMS) – 64
- Vehicle detection devices – 1600 inductive loops
- Fiber optic, coaxial cable, microwave, and radio communications network
- Integrated software includes device control, incident management, and ATIS capabilities.

Operations Capability Maintained during the Blackout

- Spotty two-way radio system
- Co-located state police dispatch center and satellite newsroom were powered by backup generation

Operations Capability Lost during the Blackout

- All ITS capabilities, including all cameras, data-collection devices, VMS, and computers at the central facility
- Landline phones (there are two places in the building to access the phone lines without requiring electricity, but there were no phones hooked up)

Pre-Event Preparation

- Had no plan for this type of event; had no backup generation capability

Lessons Learned

- The ITS technology that was missed the most were the cameras, especially those located near a flooded freeway
- The lost data on traffic volumes was a lost opportunity to document what was essentially a evacuation of Detroit
- Installing backup generation at the center, as well as at one or two carefully selected remote sites along the fiber optic ring could restore a significant amount of capability
- Loss of communications was the most frustrating loss; having landline telephone connections ready would be an easy preparation that would have made a big difference
- Text-messaging capability would be useful for future situations where the communications network is busy or intermittently available
- Restoration was more cumbersome than was anticipated; establishing a plan for what the expectations are for human resources would have been useful
- Could have better leveraged their connection with the media (via a co-located satellite newsroom) to disseminate transportation information to the public

Agency:	**New York State Thruway Authority**
Facility:	New York Thruway
Location:	Crosses New York State
Responsibility:	641-mile toll way

ITS Technology Installed

- Traffic management center (TMC)
- Electronic toll collection (ETC)
- Closed circuit television (CCTV) system – 30 centerline miles – 31 cameras
- Vehicle detection devices – loop detectors (44 centerline miles); probe readers using ETC tags (31 centerline miles); acoustic detectors (1 centerline mile); microwave radar (1 centerline mile); video imaging detector (1 centerline mile)
- Variable message signs (VMS) – 42
- Highway advisory radio (HAR) – 92 centerline miles
- Advanced traveler information system (ATIS) – Automated telephone system, Internet site

Operations Capability Maintained during the Blackout

- Backup generation supported most operations, including TMC, toll collection, radio system, and service plazas

Operations Capability Lost during the Blackout

- Some field equipment not supplied with backup power
- Some maintenance yards, which are also fueling sites, did not have backup generation Fueling was a problem for state police and others that depend on these facilities - They were shifted to alternative locations
- Air conditioning in the TMC was not connected to backup system
- In one case, fuel resources as the Service area ran out for a short period due to hoarding – Refuel occurred within hours and maximum fuel purchase was instituted until peak purchases slowed down

Pre-Event Preparation

- Comprehensive backup generation; all the toll plazas and critical systems for business were pre-tested and available - some battery supplies and portable generators are available for field equipment such as VMS

Lessons Learned

- Ability to maintain operations and, specifically, toll collection, led to less traffic congestion and acted as a self-metering device for the road system. Large volumes of traffic were handled with few customers aware of the blackout until they left the Thruway.

Agency:	**Niagara International Transportation Technology Coalition**
Facility:	Traffic operations center
Location:	Buffalo, New York
Responsibility:	Traffic operations in the Western New York and Southern Ontario region, coordinating 14 agencies whose territory includes four international border crossings

ITS Technology Installed

- Traffic operations center (TOC)
- Closed-circuit television (CCTV) system – 57 cameras
- Highway advisory radio (HAR) – 7 stations
- Variable message signs (VMS) – 24 permanent signs, plus 30 portable signs
- Road weather information system (RWIS) – 7 locations
- Advanced traveler information system (ATIS) – Internet site
- Traffic signals – 1,800
- Vehicle detection devices – loop detectors supporting ATMS cover 35 percent of the system, using TRANSMIT E-ZPass transponder technology
- Electronic sharing of data with emergency management agencies

Operations Capability Maintained during the Blackout

- Traffic operations center
- Most field equipment
- Area traffic signals, which either never lost power or were supported by portable generators

Operations Capability Lost during the Blackout

- None

Pre-Event Preparation

- Backup generating capability at operations center
- With partner agencies, identified critical intersections throughout the region that are to receive backup power in case of an outage
- With partner agencies, secured portable generators to be able to cover reasonable portion of the signalized intersections in the region
- Developed system for mobilizing generators to key intersections, with help of area agencies such as fire departments
- Practiced regional coordination for many types emergency response, including a process for diverting traffic from one bridge to another

Lessons Learned

- The ability to maintain a signal system is key; freeways will operate fine even without power. In addition, having generators and a plan for how to mobilize them can help free up emergency responders to do other things
- Have as much backup power as is feasible

Agency:	**Ohio Department of Transportation, District 12**
Facility:	District office with freeway and arterial management systems
Location:	Garfield Heights, Ohio
Responsibility:	ITS along 180 miles of the state freeway system in the Greater Cleveland area

ITS Technology Installed

- Networked television system
- Automatic vehicle location (AVL) system
- Variable message signs (VMS) – on fleet vehicles
- Traffic signals – 80
- Highway advisory radio (HAR) system

Operations Capability Maintained during the Blackout

- Two-way radios, AVL, and other computer systems at the central facility supported by backup generation
- VMS powered by the vehicles
- The cameras and the HAR were working, although not utilized.

Operations Capability Lost during the Blackout

- Traffic signals
- Landline phone service, cell phone service, and pagers were spotty

Pre-Event Preparation

- Comprehensive backup generation to power central facility and radio systems
- District incident response plan, which was used during the blackout

Lessons Learned

- Reduced communication capability was the biggest obstacle
- There could have been a larger role for ITS in managing traffic during the event

Agency:	**Ohio Turnpike Commission**
Facility:	Ohio Turnpike
Location:	Northern Ohio from Pennsylvania to Indiana
Responsibility:	241 miles of tollway and 16 24-hour service plazas

ITS Technology Installed

- Traffic management center (TMC) - the Ohio Turnpike Commission Dispatch Center and Ohio State Highway Patrol District 10 are co-located and perform as a TMC
- Weigh in motion (WIM) system
- Variable message signs (VMS) – controlled by cellular telephone.
- Advanced traveler information system (ATIS) – Internet site, automated telephone system
- Road weather information systems (RWIS)
- Electronic sharing of data with law enforcement, fire, and emergency management agencies

Operations Capability Maintained during the Blackout

- All ITS elements, including scales and toll collection facilities
- All gas stations at the service plazas as well as HVAC, vending machines, lights, janitorial services, and most food operations

Operations Capability Lost during the Blackout

- Some vendor kitchens in service plazas did not receive backup power at the vendor’s option
- Some administrative computers did not receive backup power, according to plan
- At some older facilities, generators did not perform according to specifications requiring frequency adjustments

Pre-Event Preparation

- Comprehensive backup generation, fueled by natural gas, tested for 1-2 hours weekly or monthly depending on location
- Completely redundant data center, tested with a month of use
- Independent fiber optic lines and a microwave system to run the phone system

Lessons Learned

- Preparation process is never complete; it is an ongoing process

Agency:	**Road Commission for Oakland County**
Facility:	Traffic Operations Center with an arterial management system
Location:	Oakland County, Michigan
Responsibility:	2,600 miles of county roads and 230 miles of state roads, including 1,200 traffic signals

ITS Technology Installed

- Closed circuit television (CCTV) system – 4 cameras, plus access to 150 Michigan Department of Transportation cameras
- Vehicle detection devices – 2,000 video cameras and 1,500 loop detectors
- Automatic vehicle location (AVL) system – for snow plow trucks
- Traffic signals – 1,300 (with 575 coordinated) plus 200 other electrical devices such as sign flashers and school flashers
- Advanced traveler information system (ATIS) – Internet site
- Road weather information systems (RWIS) – 3 sensors

Operations Capability Maintained during the Blackout

- Backup generation sustained partial functionality at operations center, including critical computers, some lights, and co-located police operations
- Up to 20 traffic signals supported by portable generators

Operations Capability Lost during the Blackout

- All traffic signals, save those that were later supported by portable generators

Pre-Event Preparation

- Two generators at central facility; 20 generators to use in the field

Lessons Learned

- Data collected through ITS equipment are useless without power, since no data could be used for traffic control or system status
- Generators need regular maintenance
- Need to have a response plan ready on priority intersections in advance of any incident occurring, based on an evaluation of safety, sight distance, and traffic volumes at each intersection; also assess in advance which generator-supported signals can be co-supervised by the same crew (because they are close enough to each other)
- For traffic signal equipment, sustainability on backup generating power is a relevant consideration when purchasing new equipment (the lower power requirements of LED displays means they can be powered by smaller, cheaper, easier to install generators)
- Just eight hours of battery backup on all traffic signals would have made a big difference for the rush hour the night of the blackout (but that technology does not yet exist)

Agency:	**Suburban Mobility Authority for Regional Transportation**
Facility:	Transit control center with a fleet management system
Location:	Detroit, Michigan
Responsibility:	Fixed route and demand responsive service in Macomb County and parts of Oakland and Wayne Counties

ITS Technology Installed

- Mobile data terminals – with interagency functionality
- Automated vehicle location (AVL) system
- Computer-aided dispatch (CAD) system
- Real-time monitoring of vehicle components
- Advanced traveler information system (ATIS) – Internet site

Operations Capability Maintained during the Blackout

- Control center
- AVL and CAD systems
- Website used to broadcast information about service

Operations Capability Lost during the Blackout

- Lost voice/data radio system because transmit sites had no backup capability (as a result, ceased bus operations except for emergency paratransit service)

Pre-Event Preparation

- Backup generation supplied to control center and fueling sites (though fueling generators malfunctioned during the blackout)
- Control center generators tested weekly and given preventative maintenance twice a year

Lessons Learned

- More backup generation capability may be necessary at radio transmit sites
- Backup generators should receive regular maintenance and testing

Appendix C: List of Acronyms

AVL	automatic vehicle locator
ATIS	automated traveler information system
CCTV	closed-circuit television
CAD	computer-aided dispatch
DOT	department of transportation
DSL	digital subscriber line
EMS	emergency medical services
EOC	emergency operations center
EMC	emergency management center
ETC	electronic toll collection
FAST-TRAC	Faster And Safer Travel Through Routing and Advanced Controls
FHWA	Federal Highway Administration
GCRTA	Greater Cleveland Regional Transit Authority, Greater Cleveland RTA
GETS	Government Emergency Telecommunications Service
GIS	geographic information systems
GPS	global positioning system
HAR	highway advisory radio
HVAC	heating, ventilation, and air conditioning
ISP	Internet service providers
ITS	intelligent transportation system
MDT	mobile data terminal
MITS	Michigan Intelligent Transportation Systems
NITTEC	Niagara International Transportation Technology Coalition
OTC	Ohio Turnpike Commission
PANYNJ	Port Authority of New York and New Jersey
POTS	plain old telephone system
RCOC	Road Commission for Oakland County
RTA	regional transit authority
SCATS	Sydney Coordinated Adaptive Traffic System
SMART	Suburban Mobility Authority for Regional Transportation
SOV	single occupancy vehicle
TMC	traffic management center

TTI	Texas Transportation Institute
VMS	variable message signs
WIM	weigh in motion
WPS	Wireless Priority Service
Y2K	Year 2000