



Transportation During and After Hurricane Sandy

Sarah Kaufman, Carson Qing,
Nolan Levenson and Melinda Hanson

Rudin Center for Transportation
NYU Wagner Graduate School of
Public Service

November 2012

Executive Summary

Hurricane Sandy demonstrated the strengths and limits of the transportation infrastructure in New York City and the surrounding region. As a result of the timely and thorough preparations by New York City and the MTA, along with the actions of city residents and emergency workers to evacuate and adapt, the storm wrought far fewer casualties than might have occurred otherwise.

The MTA and New York City Police Department, Departments of Transportation, Environmental Protection, and Sanitation worked quickly to pump water out of tunnels, repair infrastructure, enforce bus lanes, and clear debris. They also informed riders of service updates and the status of infrastructure, particularly with up-to-date maps, photos and videos provided by the MTA. The experience of Hurricane Sandy reinforced the importance of having multiple modes of transportation in the New York Region: subways, buses, bridges and tunnels, ferries as well as commuter rail systems in moving people in, through and out of the New York City and surrounding region.

Hurricane Sandy also highlighted key investments and policies that should be considered to assure the viability of our infrastructure during future disasters:

- Install backup power for subway pumps
- Consider the use of porous pavement for streets in flood-prone areas
- Locate building generators and fuel sources in flood prone areas on higher floors

Hurricane Sandy and its impact on transportation also provided a timely message to all New Yorkers that public transportation is essential to the economic and social well being of the people who live, work and visit here. During and after the storm, New Yorkers displayed impressive inventiveness to maintain their mobility. Individuals created new routes and combinations of modes to get to work, using a variety of systems: bus shuttles, bikes, shared vehicles with strangers, ferries, alternate work sites, and telecommuting. According to a survey conducted as part of this research, commuters suffered from the storm's transportation damage. Those who returned to work on November 1st and 2nd saw their typical commuting times double or triple, and reported high levels of frustration. But several discovered new methods of commuting, and others shared their workspaces. The importance of social media was also highlighted as an essential source of information for many residents lacking television service, but able to receive information on smartphones.

While transportation stoppages would have crippled other cities, New York was able to provide alternative services, and those residents who lived outside the severely damaged areas of the Rockaways, southern Brooklyn, and the south shore of Staten Island creatively adapted to conduct business, though under new constraints and conditions. It is this remarkable blend of ingenuity and persistence in the face of disaster that truly characterizes New Yorkers' behavior with regard to transportation.

Preparation Preceding Hurricane Sandy

During the past decade, flooding has forced the MTA to shut down New York City's subway system several times. On a typical day, 700 pumps located throughout the subway system drain 13 million gallons of water. Rain is not the only source: groundwater and water seeping from the city's sewers can also flow into the tunnels. Water is pumped up to street level, where it flows into storm drains. Pumps can process about 1.5 inches of rainwater per hour. Higher rates exceed the pumps' capacity, and result in flooding and drainage issues.¹

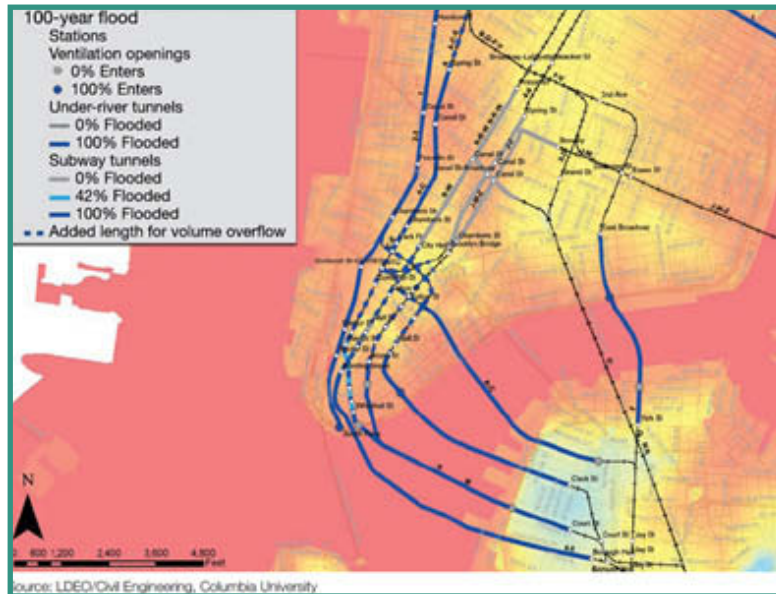
When excessive water enters the subway, the system must be shut down before the water comes into contact with the third rail. The 600 volts running through the third rail can cause the water to boil and set debris on fire.² Water also short-circuits electrical signals and switches. Seawater corrodes equipment, causing additional damage.

On average, New York City has about 50 inches of rain a year—about four inches a month.³ However, in September 2004, torrential downpours dropped more than two inches of rain an hour, causing subway closures. Similarly, in August 2007 a flash flood on August 8th dropped approximately 3.5 inches of water, quickly overwhelming the pumps and causing shutdowns during morning rush hour. Though the

1 Chan, Sewell. "Why the Subways Flood," August 8, 2007. <http://cityroom.blogs.nytimes.com/2007/08/08/why-do-the-subways-flood/>

2 Chan.

3 Monthly Averages for New York, NY. <http://www.weather.com/weather/wxclimatology/monthly/graph/USNY0996>



MTA was able to get much of the system running again within a few hours, the disorder during the storm showed the MTA was not well prepared for extreme weather in both infrastructure and communications inside and outside of the agency.

In response to the 2007 flood, Governor Eliot Spitzer commissioned a report to examine the storm response, and make recommendations for infrastructure and operational improvements. A task force, in the report "August 8, 2007 Storm Report," identified three primary problems:

1. Poor communications within the MTA resulted in a lack of coordination among employees;
2. Infrastructure to prevent water from entering the system and to pump it out was insufficient; and
3. Customers could not get reliable information, especially on subway platforms.

The MTA implemented many of the task force's recommendations, and by 2009, had completed more than \$30 million worth of projects to prevent flooding, including:

- Targeting the most flood-prone stations (as shown in image on previous page)
- Installing valves to keep pumped-out water from re-entering the subway
- Improving sewers to avoid future flooding
- Installing Doppler radar in each agency's operations center
- Creating an MTA-wide Emergency Response Center
- Raising entrances at 30 subway stations
- Raising or closing approximately 1,500 ventilation grates
- Replacing or modernizing pumps throughout the system.⁴



▲ Raised ventilation grate and bike rack. Photo credit: MAS.org.

MTA also developed operational strategies, including plans for pre-deploying portable pumps and personnel when storm conditions threatened to flood. Customer communications were improved with a re-designed MTA website, new e-mail and text message alerts, and installing cellular service and Wi-Fi to subway platforms (still in progress). Lastly, steps were taken to improve communications between operations centers and field personnel.

Anticipating heavy flooding from Hurricane Irene, the MTA suspended subway service on August 27, 2011. This was the first time public officials closed the system in preparation for a storm. Over the course of several hours, crews moved trains and other valuable equipment to higher ground. They blocked station entrances, covered vents, and positioned pump trains and emergency generators in locations where they could be immediately used after the surge.

Hurricane Irene hit New York City on August 28, 2012. Damages to the transportation system were initially estimated to total \$65 million.⁵ After the storm, Klaus H. Jacob, a research scientist at Columbia University's Earth Institute and a climate change adaptation advisor to NYC, estimated that the storm surge from Irene came "just one foot short of paralyzing transportation into and out of Manhattan." He predicted that a larger storm would render the subway tunnels under the Harlem and East Rivers "unusable for nearly a month, or longer, at an economic loss of about \$55 billion."⁶

4 MTA, "August 8, 2007 Storm Report," September 20, 2007. http://www.mta.info/mta/pdf/storm_report_2007.pdf

5 "MTA: Tropical Storm Irene cost agency \$65 million," August 28, 2012, ABC Eyewitness News. <http://abclocal.go.com/wabc/story?section=resources/traffic&id=8789084>

6 Navarro, Mireya. "New York Is Lagging as Seas and Risks Rise, Critics Warn," The New York Times, September 10, 2012. <http://www.nytimes.com/2012/09/11/nyregion/new-york-faces-rising-seas-and-slow-city-action.html>



▲ MTA worker covering subway ventilation grate, above; and the Bowling Green 4/5 station, below. Photo credits: NYMag.com and MTA.

MTA prepares for Hurricane Sandy

As a result of improvements made after the 2007 flood and Hurricane Irene, the MTA was far better prepared for the larger-scale Hurricane Sandy. On October 26th—three days before the storm hit—the MTA published a press release alerting the public about a possible transit shutdown. The press release outlined the agency’s hurricane plan, which calls for service suspensions if wind speeds exceed 39 miles per hour. Additional measures in the plan included:

- Moving buses and trains to higher ground;
- Covering subway entrances and ventilation grates with sandbags and tarps, as shown at right;
- Deploying crews to clear debris from all pumps and drains in subways, tunnels, and bridges;
- Activating and staffing the Incident Command Center to coordinate personnel and manage the response;
- Assuring all pump trains, portable pumps and emergency response vehicles are in working condition and ready to be deployed after the storm passes.⁷

New York’s public agencies followed this plan. They began clearing drains and covering vents days before the storm hit, and shut the system down completely the day before. Gear was put in place, and the city had crews ready to begin dewatering efforts immediately after the storm surges subsided.

⁷ Metropolitan Transportation Authority, “MTA Prepares for Hurricane Sandy,” October 26, 2012. <http://www.mta.info/mta/news/releases/?agency=hq&en=121026-HQ1>

Hurricane Sandy Transportation Timeline

Date	Area	Event
Friday 10/26	STORM PREPARATION	New York City Mayor Michael R. Bloomberg activates New York City's coastal storm plan and opens NYC Office of Emergency Management's situation room.
Sunday 10/28	EVACUATIONS	Mayor Bloomberg orders mandatory evacuations for Zone A in New York City.
	SUBWAYS AND BUSES	MTA orders the start of the subway system shutdown at 7 p.m., with all services stopped by 3 a.m. Subway cars moved to higher ground, away from vulnerable areas. Buses make final departures at 9 p.m. PATH suspends all services at midnight.
	COMMUTER RAIL	Metro North and Long Island Rail Road make final departures at 7 p.m. NJ Transit starts shutting down services at 4 p.m., with all rail, bus, light rail suspended by 2 a.m. MTA personnel build makeshift dam in West Side Rail Yards to protect Penn Station facility from flooding
	AIRPORTS	John F. Kennedy (JFK), LaGuardia, Newark remain open. Decisions on flight cancellations are left to airlines' discretion. Airlines add Sunday flights in anticipation of cancellations over the course of the storm.
	TRAFFIC	Closures of major crossings determined on a "case by case basis" heading into Monday, but remain open during Sunday.
	FERRIES	NYCDOT suspends Staten Island Ferry services at 8:30 p.m. NY Waterway announces that all ferry and bus services will be suspended on Monday, October 29th.
Monday 10/29	DETERIORATING CONDITIONS	Hurricane Sandy makes landfall at 8 p.m. near Atlantic City, New Jersey. Rising storm surge at high tide in New York Harbor at 9 p.m. results in record flooding at the Battery (13 feet) and in low-lying coastal areas.
	POWER	Con Edison substations flood, malfunction, and plunge much of Manhattan south of 39th Street into darkness. Strong wind gusts and downed trees knock out power to millions across the Tri-State area. Backup generators fail at NYU Langone Medical Center in Manhattan, requiring the evacuation of 200 hospital patients.
	TRAFFIC	<p>Holland Tunnel and Battery Tunnel preemptively close at 2 p.m. due to vulnerability to flooding. Tappan Zee Bridge is closed at 4 p.m. due to worsening weather conditions. The FDR Drive closes at 6 p.m. from the Battery to 155th Street, and experiences major flooding due to storm surge, especially at the Battery Underpass.</p> <p>A partially collapsed crane at the top of a high-rise construction project in Midtown Manhattan forces the closure of nearby streets at 57th Street and 7th Avenue and evacuations of nearby buildings.</p> <p>Verrazano, Whitestone, Throgs Neck, Henry Hudson, George Washington, Brooklyn, Manhattan, Williamsburg, and Queensboro Bridges: closed to traffic at 7 p.m. as conditions deteriorate.</p> <p>At 9 p.m., storm surge breaches Hudson River, East River. Significant flooding reported as far east as 10th Avenue in Chelsea, streets in East Village, Lower East Side also become inundated.</p> <p>Queens Midtown Tunnel closes at 8:45 p.m. due to flooding. It was not initially closed because it was expected to be able to withstand severe flooding. Hugh Carey (Battery) Tunnel experiences severe flooding from end to end. Holland Tunnel also experiences significant flooding. By end of October 29, Lincoln Tunnel is the only Manhattan entry point that remains open.</p>

Date	Area	Event
	SUBWAYS	Following record storm surge flooding at the Battery, floodwaters enter the subway system after 9 p.m. Storm surge floods the East River subway tunnels connecting Manhattan with Brooklyn and Queens. Floodwaters also enter PATH stations in Hoboken, Jersey City, and World Trade Center, subway tunnel between Manhattan and New Jersey also flooded.
	COMMUTER RAIL	Flooding reported in both East River and Hudson River rail tunnels. Floodwaters also enter the West Side Rail Yards near Penn Station.
	AIRPORTS	Kennedy, LaGuardia, and Newark airports close and all flights are grounded. Storm surge floods runways at Kennedy and LaGuardia; Newark Airport loses power.
	FERRIES	Hoboken Ferry / Rail Terminal sustains severe flooding due to storm surge from the Hudson River.
	COMMUTER VANS	Even with New York City's transportation system largely shut down on 10/29, privately operated "dollar vans" stay in operation.
Tuesday 10/30	THE DAY AFTER	Much of New York City remains shut down. As conditions improve, damage city-wide becomes increasingly apparent, and the clean-up effort begins.
	SUBWAYS	Subways remain shut down indefinitely, and MTA Chairman Joe Lhota remarks that the damage from Sandy is the most devastating the MTA has ever experienced. All seven East River subway tunnels were flooded. Major damage and flooding reported at South Ferry / Whitehall Street, Bowling Green, Broad Channel subway stations, and at the rail yards at 207th Street and 148th Street uptown.
	COMMUTER RAIL	Downed trees, flooding, and debris are strewn across major suburban rail lines. Services remain suspended.
	TRAFFIC	New York City's East River Bridges reopened at 11 a.m.. Sections of major highways also re-open, but roadways that sustained significant flooding, such as the Battery, Holland, and Midtown Tunnels and the Battery Park underpass, remain shuttered.
	BUSES	Less than 24 hours after Hurricane Sandy made landfall, New York City's bus system resumes limited services with free fares.
	AIRPORTS	Kennedy, LaGuardia, and Newark Airports remain closed as clean-up and repairs continue.
Wednesday 10/31	TRAFFIC	<p>With no subways and commuter trains running, widespread traffic gridlock reported across New York City, especially in Midtown Manhattan and near major entry points and arteries such as the Lincoln Tunnel, the Brooklyn-Queens and Gowanus Expressways, the Long Island Expressway, and Queens Boulevard.</p> <p>The severe gridlock conditions prompt action by the State and City of New York. Governor Cuomo declares a transportation emergency, extending free MTA fares through November 2. Mayor Bloomberg announces the implementation of HOV3+ carpooling restrictions on most entry points to Manhattan, with the exception of the George Washington Bridge.</p>
	FERRIES	Limited NY Waterway services restored between Jersey City, Hoboken, and Weehawken to Manhattan. Ferries quickly become a popular travel alternative due to mass transit suspensions and heavy traffic gridlock in the NYC region.
	BUSES	MTA's New York City buses return to normal schedules with free fares. Significant crowding reported on buses, and passengers reported long wait times as buses were filled to capacity and skipped stops on occasion. Travel times were also exceptionally long due to heavy traffic gridlock on city streets and highways.
	COMMUTER RAIL	Limited commuter rail services on Metro North and LIRR restored in time for evening commute. NJ Transit services remained suspended.
	SUBWAYS	The city's subway system remained suspended on 10/31.
	AIRPORTS	Kennedy and Newark Airports reopen, but LaGuardia Airport remains closed due to runway damage.

Date	Area	Event
Thursday 11/1	SUBWAYS	For the first time since Hurricane Sandy, subway service is restored, primarily north of 42nd Street in Manhattan and in areas unaffected by the storm and its related power outages. Limited services were provided with free fares on 14 of 23 subway lines.
	BUSES	The MTA implements a system of “bus bridges,” or temporary shuttle bus networks, from Brooklyn to Manhattan designed as a substitute for subway lines that cross the East River. NYCDOT establishes dedicated bus lanes on the Manhattan and Williamsburg Bridges, 3rd and Lexington Avenues, and on the Bowery and Delancey Street to better serve subway shuttle buses connecting Manhattan and Northern Brooklyn. Long waits (1+ hour) reported for subway shuttle buses in Brooklyn. NJ Transit restores commuter bus services to the Port Authority Bus Terminal in midtown Manhattan.
	TRAFFIC	Traffic conditions in Manhattan improve, but worsen at major crossings, as checkpoints are established to enforce HOV3+ rule. Traffic backed up for miles in Brooklyn, Queens, and New Jersey; 4-hour backups reported at the Lincoln Tunnel.
	GAS	The post-Sandy transportation crisis in the New York City region worsens as less than 40% of gas stations in the NYC metro area remain operational due to power and supply shortages. Long traffic backups and wait times reported at or near open gas stations across the region. Some reports of physical confrontations.
	COMMUTING ALTERNATIVES	As transit and car commutes become inconvenient, commuters opt for travel alternatives, such as walking and biking across the East River bridges. NYCDOT reports nearly three times as many bicycle commuters as normal on East River Bridges.
	AIRPORTS	For the first time since Sandy made landfall, all three major NYC-area airports are open and handle incoming and outgoing air traffic.
	FERRIES	Service is restored on the East River Ferry.
Friday 11/2	TRAFFIC	Noticeably lighter traffic at major crossings during morning commute as HOV3+ carpool regulations continue to take effect. HOV3+ regulations lifted at 5 p.m. The Holland Tunnel reopens, but only for commuter buses.
	SUBWAYS	With major gaps in services into Manhattan, severe crowding is observed along functioning subway lines that enter and exit the Central Business District.
	COMMUTER RAIL	Limited NJ Transit rail services on the Northeast Corridor line are restored to New York Penn Station; services remain suspended on most other lines.
	COMMUTING ALTERNATIVES	Crowding at “bus bridge” locations in Brooklyn improves as commuters opt for alternatives and adapt to the ongoing transportation crisis. The East River Ferry becomes an increasingly popular option as word spreads on social media. The volume of biking and walking commuters remain unusually high.
	GAS	Gas crisis continues to intensify: wait times in the NYC metro region reportedly as long as 5 hours. Social media becomes an indispensable tool to find open gas stations, i.e. #nygas, #njgas.
	FERRIES	NYCDOT restores services on the Staten Island Ferry.
	POWER	ConEdison successfully restores power to most of Lower Manhattan for the first time since October 29.
Saturday 11/3	SUBWAYS	As power is restored to Lower Manhattan and more subway tunnels are cleared of floodwater, 80% of New York City’s subway system is operational, less than a week after one of the most devastating crises in the system’s history. 4/5 trains resume services between 42nd Street-Grand Central and Borough Hall, and the 7-train resumed services between Times Square and Queensboro Plaza.

Date	Area	Event
	GAS	In response to gas shortages across the NY/NJ region and severe traffic backups at open gas stations, Gov. Christie orders mandatory rationing, coordinating access to gas station by odd/even license plate numbers.
Sunday 11/4	SUBWAYS	Services on most subway connections between Manhattan and Brooklyn are restored, with the exceptions of the B, L and R trains.
Monday 11/5	SUBWAYS AND COMMUTER RAIL	In the first full day of work and school since Hurricane Sandy, severe crowding is reported on mass transit across the region with limited services, particularly on Long Island Rail Road and New Jersey Transit. NJ Transit forced to suspend services on the North Jersey Coast line due to severe crowding. While MTA's transit network has been largely restored, NJ Transit continues to cope with major service gaps. Many vital rail lines in suburban New Jersey remain suspended, and alternate commuting options such as driving and PATH continue to be hampered by gas shortages and service suspensions. NJ Transit provides emergency bus and ferry services to Manhattan to mitigate severe crowding in its system as ridership swells under limited service.
Tuesday 11/6	TRAFFIC	The Queens Midtown Tunnel partially reopens for the first time since Hurricane Sandy, but like the Holland Tunnel, it is only open to commuter buses.
	SUBWAYS	Limited PATH services are restored between New York and New Jersey, but only between Journal Square and Midtown. Services in Hoboken, Newark, and World Trade Center remain suspended.
Wednesday 11/7	SUBWAYS	G-train services connecting Brooklyn and Queens are restored. D, F, Q trains also return to Coney Island for the first time since Hurricane Sandy.
	TRAFFIC	The Holland Tunnel reopens to all vehicle traffic.
Thursday 11/8	SUBWAYS	L train service between Manhattan and Brooklyn is restored.
Friday 11/9	GAS	Gas crisis in New York/New Jersey region continues. New York City, Nassau County, and Suffolk County join New Jersey in implementing odd-even gas rationing as fuel shortages and long lines persist.
	TRAFFIC	The Queens Midtown Tunnel reopens to all vehicular traffic.
Sunday 11/11	SUBWAYS	The A train is restored to Howard Beach, Queens, but service to the Rockaway Peninsula remains indefinitely suspended, due to heavy track damage that requires long-term repairs. Timetable of service restoration could be as long as six months. Temporary free shuttle buses from Far Rockaway to Howard Beach are set up to replace the A train.
Monday 11/12	SUBWAYS	Additional PATH train services are restored, connecting Newark to Midtown Manhattan. Service remains suspended in Hoboken, Exchange Place, and World Trade Center.
	TRAFFIC	The Hugh Carey/Battery Tunnel is open but only for commuter buses.
Tuesday 11/13	TRAFFIC	The Hugh Carey/Battery Tunnel partially reopens to all traffic. One tube remains closed due to storm damage.
	GAS	Governor Christie ends odd-even gas rationing in New Jersey; policy remains in effect in New York City and Long Island.
Thursday 11/15	FERRIES	Ferries begin running between Beach 108th Street and Beach Channel Drive in the Rockaways and Pier 11 and East 34th Street in Manhattan, as a partnership of the New York City Economic Development Corporation and Seastreak.
Tuesday 11/20	SUBWAYS	H shuttle train service begins between the Far Rockaway-Mott Avenue and the Beach 90-Holland stations on old, unused tracks, connecting the Rockaways with access to the rest of New York City via a shuttle bus to the Howard Beach station.
Monday 11/26	SUBWAYS	PATH train service resumes between Newark and the World Trade Center.
	FERRIES	New temporary rush hour ferry service between Great Kills in Staten Island and Lower Manhattan begins.

Key Transportation Impacts

The transportation crisis in the aftermath of Hurricane Sandy was a powerful indicator of how much the New York City region depends on both the mass transit system of subways, commuter rail, and buses, as well as the bridges and tunnels that carry cars, trucks and buses. Most importantly, the crisis demonstrated the remarkable ingenuity that New Yorkers brought to the challenge of getting to work, relying on flexible modes like walking and biking, and a willingness to explore alternate routes of commuting.

- The exceedingly intense traffic gridlock that the city experienced on October 31 to November 1 while the city's transit system was shut down was reminiscent of scenes from Sao Paulo and Jakarta: emerging megacities that struggle to provide adequate capacity to accommodate rapid clustering of economic activity in their urban cores. This experience shows how vital the city's subway and commuter rail systems are to providing for intense uses of land that create a dense concentration of economic activity.
- The recent expansion in the city's bicycle infrastructure provided a contingency option for commuters in Brooklyn and Queens who were stranded at bus stops or struggled to find gas for their cars, resulting in 30,000 bike commuters on November 1 (triple the typical number).⁸
- The East River Ferry, a recent expansion in the city's multimodal transportation network, played an important role in a post-Sandy New York.
- The region's extensive network of privately run commuter vans also remained in operation throughout the storm, filling a key gap in the transportation system as other modes were shut down for long durations.

"Traffic gridlock on Tuesday made me appreciate the subways more than ever before."

Commuter Survey Respondent



▲ Riders line up for Bus Bridge vehicles to transport them from the Barclays Center in Brooklyn to Midtown Manhattan. Photo: Melinda Hanson, NYU Rudin

While a major gas shortage and long-term closures of key arteries would have led to a prolonged crisis in a more auto-dependent city, New York was able to leverage alternative modes of transportation, such as biking, walking, and ferries, to get to work efficiently and restore a sense of normalcy even during a "transportation emergency." The recovery process is discussed over the next several pages.

8 "New York City sees increase in bike commuters after Hurricane Sandy," Public Radio International, November 15, 2012. <http://www.pri.org/stories/politics-society/government/new-york-city-sees-increase-in-bike-commuters-after-hurricane-sandy-12105.html>

New York City Plans for the Storm: Evacuation of Zone A Ordered Three Days Before the Storm

Public agencies throughout the New York metropolitan region actively prepared for Hurricane Sandy. Coordination efforts among municipal agencies were systematic and strong. The New York City Office of Emergency Management (OEM) convened an October 24 coastal storm steering committee, including



▲ MTA Emergency Response Room. Photo Credit: MTA

Police, Fire, Health, Education, and Transportation Departments to bring these essential City and State leaders to the same table.⁹ This meeting allowed for extensive collaboration and preparation. All agencies collaborated on innovative solutions to the impending storm's unique transportation challenges.

Three days before Hurricane Sandy arrived, Mayor Bloomberg signed an Executive Order mandating the evacuation of Zone A, comprised of low-lying areas most prone to flooding and damage. Many residents evacuated to the 72 City-run shelters, which

were reachable by public transportation. However, the City provided additional bus service to assist in Zone A evacuations. The evacuation and transportation of these individuals preceding the storm demonstrated remarkable cooperation by public agencies and the MTA to ensure the safety of evacuees.¹⁰

During and after the storm, public safety and transportation agencies responded quickly, using any staff available, and assisting each other whenever possible. This coordination was remarkable. The following section highlights the key transportation efforts of public agencies.

Metropolitan Transportation Authority

Hurricane Sandy demonstrated the vital and central role of the Metropolitan Transportation Authority (MTA). Every day, nearly 10 million people rely on the MTA's regional network of subways, buses, commuter rail, and bridges and tunnels to travel to work and leisure activities.¹¹ When these services were unavailable, the region's economic activity suffers, forcing people to find alternative and more time-consuming ways to travel.

9 Chaban, Matt.

10 "Mayor Bloomberg Issues Order for Mandatory Evacuation of Low-Lying Areas as Hurricane Sandy Approaches," NYC.gov, October 28, 2012. <http://www.nyc.gov/html/om/html/2012b/pr377-12-static.html>

11 "The MTA Network," <http://www.mta.info/mta/network.htm>

Preceding the storm, realizing imminent threats to the city and its infrastructure, Governor Andrew Cuomo announced that subways would be shut down on Sunday, October 28 at 7:00 p.m. and buses would suspend service at 9:00 p.m. to allow the agency enough time to make preparations for the storm. Based on the MTA's experience with Hurricane Irene, "the Transit Authority needed twelve hours for the subways, the buses needed eight hours" to shut down service.¹²

As a result of the MTA's preparations, the storm caused no damage to the rolling stock; buses were back in service on Tuesday, October 30 at 5:00 p.m., and some subway service returned on the morning of Thursday, November 1. Both transit modes ran free of charge for riders through Friday, November 2.

Despite these successes, there were unexpected challenges, including the flooding of the Hugh L. Carey Brooklyn-Battery Tunnel and Queens-Midtown Tunnel. Trees and other debris lay along Metro-North (MNR) and Long Island Railroad (LIRR) tracks.

Infrastructure Cleanup, Dewatering, and the Return of Rail

The MTA was effective in assessing the damage to infrastructure and instituting a cleanup plan. Inspectors examined every stretch of impacted rail and electrical infrastructure to ensure their functionality. One of the most challenging aspects of the storm repair is the 108-year old subway system, which has unique and outdated parts that require extensive time and costs to replace.

The subway system was severely affected by the flooding of its tunnels. MTA employees used their three pump trains to remove water from the tunnels as soon as possible.¹³ They received some aid from the "unwatering team" of the Army Corp of Engineers, but most of the pumping was done by MTA. Workers put in double shifts on consecutive days to get the pumping done. The subway does have its own pump system for normal drainage, but it cannot function without power and therefore could not work during the hurricane.¹⁴



▲ Subway Pump Trains. Photo Credit: MTA

Different tunnels were impacted in different ways, according to MTA New York City Transit (NYCT) President Tom Prendergast, depending on the mix of salt water from the ocean and fresh water from the Hudson River. Salt water creates a challenge in the cleanup efforts

12 Chaban, Matt.

13 Metropolitan Transportation Authority (MTA) Press Office

14 Kolker, Robert. "How Did the MTA Restore Subway Service in Time for Monday's Rush Hour?", New York Magazine, November 15, 2012. <http://nymag.com/daily/intel/2012/11/how-did-the-mta-restore-subway-service.html>

because it leaves salt deposits that can corrode equipment. These salt deposits cannot always be cleaned on site, which requires the equipment to be taken elsewhere for cleaning, or to be replaced entirely.¹⁵ Salt is also conductive, which means that improperly cleaned equipment could cause short circuits and fires.¹⁶

On Wednesday, October 31, Governor Cuomo and the MTA announced that subway service would resume the following day, primarily north of 42nd Street in Manhattan and into the Bronx, east of downtown Brooklyn and Williamsburg, and in parts of Queens. The F and N trains (between Manhattan and Queens) were the only trains crossing the East River, which created massive crowding issues. Limited Metro-North service between Grand Central and White Plains began, and limited Long Island Railroad service between Jamaica Station and Penn Station and Atlantic Terminal resumed as well.¹⁷ The MTA worked tirelessly to get the system back in order, opening lines as they became ready and power was restored.



▲ *Subway Rides Free in the Days After the Storm.*
Photo Credit: Nolan Levenson

On Saturday, November 3, 80% of the subway system was back in operation, including the first of the East River subway tunnels, the Joralemon Tunnel of the 4/5 trains.¹⁸ This tunnel experienced significantly less flooding than the others because its entrances on both the Brooklyn and Manhattan side are at relatively high elevations. This was an important repair because the 4/5/6 line is the highest capacity transit corridor in the country.¹⁹

By Monday, November 5, commuter rail service had been mostly restored. On the

MNR lines east of the Hudson River, almost all of the lines were operating, with those that travel through New Jersey west of the river still without service. By Thursday, November 8, almost all LIRR service was back. Shuttle buses supplemented missing service where possible in both MNR and LIRR service areas.

15 MTA Press Office

16 Kolker, Robert. "How Did the MTA Restore Subway Service in Time for Monday's Rush Hour?", *New York Magazine*, November 15, 2012. <http://nymag.com/daily/intel/2012/11/how-did-the-mta-restore-subway-service.html>

17 "Governor Cuomo Declares Transportation Emergency," *New York State Governor's Office*, October 31, 2012. <http://www.governor.ny.gov/press/10312012transportationemergency>

18 Goldmark, Alex. "NYC Subways Run Under East River for First Time Since Storm, System 80% Operational," November 3, 2012. <http://transportationnation.org/2012/11/03/nyc-subways-run-under-east-river-for-first-time-since-storm-system-80-operational/>

19 Grescoe, Taras. "Excerpt: 'Straphanger: Saving Our Cities and Ourselves from the Automobile'," *The Takeaway*, April 24, 2012. <http://www.thetakeaway.org/blogs/takeaway/2012/apr/24/excerpt-straphanger-saving-our-cities-and-ourselves-automobile/>

By November 16, 2012, nearly all subway lines were fully operating, with the exception of the R train between Brooklyn and Manhattan, and the A train between Howard Beach and the Rockaways. MNR east of the Hudson River was back to regular service. MNR lines west of the river in New Jersey and extending to Rockland and Orange counties were either not in service or have partial service with supplemental shuttle buses. LIRR was almost at full operation, although there continues to be limited service on some lines such as Long Beach, which must operate with diesel trains because of damage to power substations.²⁰

Region-wide Repairs

The MTA was committed to getting the entire system running again, and not just focused on Manhattan. This is highlighted by a valiant effort to restore subway service to the Rockaways. Hundreds of feet of track and the signal system along the Broad Channel Bridge were permanently damaged. On Sunday, November 11, the A train was extended to Howard Beach, and a free shuttle bus was set up between the Howard Beach station and Far Rockaway / Mott Avenue. The MTA, however, says that it will be months before subway service is restored between the Rockaway Peninsula and Howard Beach.²¹

To restore transit service within the Rockaways peninsula, the MTA brought subway cars on flatbed trucks and placed them on unused tracks to run a shuttle, the 'H' train, between the Far Rockaway-Mott Ave. and Beach 90th Street stations. From Far Rockaway, riders can take a bus shuttle to Howard Beach to regular A train service.²² To provide alternative transportation, a ferry service is running between the Rockaways and Manhattan.²³ These transportation developments mark an essential development in providing Rockaways residents with modes to return to work, and removing their isolation from the city.



▲ Damaged and debris-strewn A train tracks, above; Transporting subway cars to the Rockaways, below. Photo Credits: MTA

20 "Cuomo: LIRR service returns to hard-hit Long Beach," Bloomberg Businessweek, November 13, 2012. <http://www.businessweek.com/ap/2012-11-13/cuomo-lirr-service-returns-to-hard-hit-long-beach>

21 MTA. "Rebuilding the Rockaways After Hurricane Sandy." <http://mta.info/nyct/service/RebuildingRockawaysAfterHurricaneSandy.htm>

22 MTA, "Free H Shuttle Provides Rockaway Service," November 20, 2012. <http://mta.info/news/stories/?story=878>

23 Chaban, Matt. "Ferry Service Returns to the Rockaways to Shuttle the Stranded, Along with Flying Subway Cars," November 9, 2012. <http://observer.com/2012/11/ferry-service-returns-to-the-rockaways-to-shuttle-the-stranded-along-with-flying-subway-cars/>

Bridges and Tunnels

All bridges and tunnels were closed before the storm in preparation for the high winds and flooding. Although most bridges were able to re-open in a short amount of time, the two tunnels—Hugh L. Carey Brooklyn-Battery and Queens Midtown Tunnels experienced significant flooding.

Even with significant preparations, the Authority did not expect the tunnels to experience the quantity of flooding that they did. This forced the MTA to be flexible in their recovery plan and address unexpected issues.

Working hard to pump the tunnels, the MTA was able to accommodate rush hour traffic in one direction as quickly as they could for the Hugh Carey tunnel, opening one tube at a time—Manhattan-bound in the morning, Brooklyn-bound in the evening. The Queens-Midtown Tunnel was able to open partial service starting Friday, November 8, and returned to full operation on Friday, November 16.²⁴ On Monday, November 12, limited rush-hour service for buses reopened

in the Hugh L. Carey Tunnel in the Manhattan-bound tube. On Tuesday, November 13, the tube was opened to car traffic as well, with one lane for buses and one for cars.²⁵



▲ MTA Subway Recovery Map, November 1, 2012.
Source: MTA

Communication and Clarity

Once it was announced after the storm that the subways would reopen in some parts of the city, the MTA was quick to adjust its service map as routes became functional. The map featured a stripped down version of the normal subway map, featuring operational routes in full color, and non-operational routes in gray. Typical map features, such as parks and neighborhood names, were removed for clarity, so users could easily interpret which routes were open.²⁶

- 24 Fermino, Jennifer. "Queens-Midtown Tunnel reopens to all traffic," *New York Post*, November 16, 2012. http://www.nypost.com/p/news/local/manhattan/queens_midtown_tunnel_re_opns_tomorrow_K0OVvJJKCY60t1oZKNhYkI
- 25 MTA. "MTA Service Info: Hugh L. Carey Tunnel," November 13, 2012. <http://mta.info/status/serviceStatus.html>
- 26 Hinds, Kate. "How NY's MTA Restore Service...to the Subway Map," *Transportation Nation*, November 8, 2012. <http://transportationnation.org/2012/11/08/work-in-progress-how-nys-mta-restored-service-to-the-subway-map/>

To communicate this information, all updates to bus, subway, commuter rail, and bridge and tunnel service were posted on the MTA’s website, Twitter, and Facebook. The map was posted and updated numerous times per day as routes opened, again highlighting the responsiveness of the agency. This multi-channel information push was essential at a time when the audience did not necessarily have access to television, internet or cell phone service; by posting information in a multitude of places, the MTA was sure to reach a large proportion of the population.

The MTA also conveyed images of the storm damage by posting photos and videos online, which helped the public comprehend the extent of the flooding in the system.²⁷ It is likely that this active transparency led to great goodwill toward the agency; as one respondent to the NYU Rudin Center’s survey noted, “The MTA has done a great job at working to get the transportation back to normal.”

New York City Department of Transportation

Bus Bridges

The commuting challenges forced officials from the New York City Department of Transportation (NYC DOT) and MTA to create a bold and innovative transportation solution: impromptu Bus Rapid Transit. Janette Sadik-Khan, commissioner of NYC DOT said:

You had issues everywhere, you had no subways coming across from Brooklyn to Manhattan, so we needed to set up a new surface subway system. We worked with the MTA—we’d set up the bridges, so why not some bus bridges?—and the NYPD got their people out there to enforce that.²⁸



▲ Loading Buses at Atlantic Avenue. Photo Credit: MTA

27 Flickr: <http://www.flickr.com/photos/mtaphotos> and YouTube: <http://www.youtube.com/mtainfo>

28 Chaban, Matt.

Between Brooklyn and Manhattan, 330 buses ran to replace missing subway service.²⁹ The agencies instituted New York's first truly exclusive busways over the Manhattan Bridge between Jay Street and Atlantic Avenue/Barclays Center and Midtown Manhattan. Buses also traveled across the Williamsburg Bridge (although not in exclusive lanes) from the Hewes Street station to Midtown Manhattan. In Manhattan, the buses traveled on bus priority lanes on Lexington Avenue, East 23rd Street, Third Avenue and Bowery. This effort required extensive coordination between the DOT and MTA.

On the first day of this operation, Thursday, November 1, people swarmed to these stations, causing overcrowding and confusion. MTA NYCT President Thomas Prendergast acknowledged the challenges of running the buses. "If the bus bridge did anything," Prendergast said, "it helped underscore for people how our rail system has a lot more utility than our bus system."³⁰ By Friday morning, 3,700 people boarded the buses per hour, with three buses loading simultaneously, and rode into Manhattan on dedicated lanes.

Lines to board buses were still packed on Friday, but the system was functioning much more efficiently. The agencies were once again able to coordinate and solve some of the issues by being adaptable and proactive.

"Smoother than expected. Only frustration was with the lack of organization at the shuttle stop at Jay St. No sense of a line, just a big mass of people pushing on and MTA employees yelling for them to stay on the sidewalk. Need barricades and an organized line."

Commuter Survey Respondent

29 "MTA Chairman: Service To Be Restored For Straphangers, Half of Metro-North Customers," October 31, 2012. <http://newyork.cbslocal.com/2012/10/31/city-traffic-thicker-on-2nd-morning-after-superstorm-sandy/>

30 Kolker, Robert. "How Did the MTA Restore Subway Service in Time for Monday's Rush Hour?", New York Magazine, November 15, 2012. <http://nymag.com/daily/intel/2012/11/how-did-the-mta-restore-subway-service.html>

Emergency Ferry Service

To provide an alternative transportation mode, NYCDOT in coordination with the Mayor's Office implemented ferry service to areas particularly hard-hit by the storm. On November 9th, a ferry service that runs between the Rockaways and Manhattan was announced.³¹ The city's Economic Development Corporation worked quickly to construct a temporary landing to make the service possible.³² Residents and local officials applauded these efforts. "It changes everything in terms of the whole experience of this past two weeks. It really is positive. Very happy about it," Rockaways resident Emer Casey said in an interview with New York 1 News.³³

On November 20, the city announced a new ferry to serve the southeastern neighborhoods of Staten Island, including Great Kills, Midland Beach, and Tottenville, where residents are experiencing long and stressful commutes to Manhattan.³⁴ Commissioner Sadik-Khan said:

For those Staten Islanders rebuilding their homes and their lives, every minute counts. With this new Staten Island ferry service, we're doing our part to get New Yorkers back on their way and providing a new and faster commuting option to some of the city's hardest-hit neighborhoods and making that daily trip to work or school easier and faster.³⁵

To implement this service, the city constructed a new ferry landing at Great Kills, highlighting the efforts of the city agencies to mitigate transportation issues. They intend to run this service for eight weeks. Both ferries from Staten Island and the Rockaways will run during morning rush hour to Manhattan and evening rush hour from Manhattan. The fare is \$2.00 each way, providing an affordable option for commuters.

31 Chaban, Matt. "Ferry Service Returns to the Rockaways to Shuttle the Stranded, Along with Flying Subway Cars," November 9, 2012. <http://observer.com/2012/11/ferry-service-returns-to-the-rockaways-to-shuttle-the-stranded-along-with-flying-subway-cars/>

32 Chaban, Matt. "Ferry Service Returns to the Rockaways to Shuttle the Stranded, Along with Flying Subway Cars," November 9, 2012. <http://observer.com/2012/11/ferry-service-returns-to-the-rockaways-to-shuttle-the-stranded-along-with-flying-subway-cars/>

33 Clark, Roger. "Rockaway Ferry Bridges Transit Gap For Weary Commuters," NY1, November 12, 2012. <http://www.ny1.com/content/transit/172182/rockaway-ferry-bridges-transit-gap-for-weary-commuters>

34 Office of the Mayor, City of New York. "Press Release: Mayor Bloomberg and Transportation Commissioner Sadik-Khan Announce Commuter Ferry Service From Great Kills to Lower Manhattan to Aid Staten Island." November 20, 2012.

35 Office of the Mayor, City of New York. "Press Release: Mayor Bloomberg and Transportation Commissioner Sadik-Khan Announce Commuter Ferry Service From Great Kills to Lower Manhattan to Aid Staten Island." November 20, 2012.

Non-emergency ferries also saw heavy usage. The East River Ferry, which connects midtown and lower Manhattan with Brooklyn’s neighborhoods of Williamsburg, Greenpoint and DUMBO, saw record-high ridership after Hurricane Sandy. On November 1, more than 7,400 commuters used the ferry, double the typical ridership for the season. When L train service resumed, ferry ridership returned to average seasonal numbers.³⁶

Warming Buses

To accommodate New York City residents without heat, NYCDOT and MTA provided “warming buses” at six locations throughout Staten Island, among other locations across affected areas, as places for people to get out of the cold. The City distributed blankets and other supplies at these locations. While the warming buses were only available during the day, they also helped transport residents to local shelters for nighttime, when the risk of hypothermia was higher.³⁷ The cooperation among public agencies resulted in a safer population.

Mobile Medical Vans

The City of New York sent vehicles staffed with physicians and stocked with common prescriptions to the Rockaways, Coney Island, Staten Island and Red Hook. These vans remained through the day to provide necessary health assistance free of charge, and volunteers traveled door-to-door to check on residents. New York City’s Human Resources Administration partnered with FEMA and several non-profit organizations to determine high-risk households likely needing medical care.³⁸

36 Short, Aaron. “With Subway Stuck, Sandy Was Boon For Ferries,” City and State, November 23, 2012.

37 Carse, Kathryn. “City opens daytime warming stations on Staten Island, provides night time buses to shelters.” November 3, 2012. http://www.silive.com/news/index.ssf/2012/11/warming_stations_open_on_state.html

38 Office of The Mayor. “Mayor Bloomberg Announces Mobile Medical Vans are Providing Medical Care and Prescription Drugs at Locations in Coney Island, Rockaways, and Staten Island,” November 5, 2012. <http://www.nyc.gov/html/om/html/2012b/pr393-12-static.html>

New York Police Department

The New York Police Department (NYPD) helped enforce the new bus system. This creative Bus Rapid Transit initiative could not have operated without the NYPD's active support, further demonstrating the cooperation among public agencies. Police were stationed at the various hubs, set up cones, and controlled traffic.

NYPD officers were also assigned to bridges to enforce the "HOV3," or carpooling rule, instituted by Mayor Bloomberg, Governor Cuomo, the Port Authority, and MTA, which required vehicles entering Manhattan to have three or more passengers to use the Lincoln Tunnel, and the Henry Hudson, Robert F. Kennedy, Queensboro, Williamsburg, Manhattan, and Brooklyn Bridges.³⁹ This policy, in combination with the bus bridges and a lack of gas, was extremely effective in reducing traffic congestion. Like the Bus Bridges, this would not have been possible without⁴⁰ enforcement from the NYPD.

The NYPD and other local law enforcement agencies were also critical in maintaining order at gas stations during shortages. When gas lines were at their peak, fights broke out throughout the region. Police were called in and made arrests. Eventually, police officers were placed at every gas station in the city to prevent fighting and regulate orderly lines.⁴¹



▲ *Police Regulate Gas Lines. Photo Credit: Nolan Levenson, NYU Rudin*

-
- 39 Miller, Stephen. "Bloomberg Announces Carpool Rule for Manhattan-Bound Drivers," *Streetsblog*, October 31, 2012. <http://www.streetsblog.org/2012/10/31/bloomberg-announces-carpool-rule-for-manhattan-bound-drivers/>
- 40 Saul, Michael Howard. "Gas Rations Put in Place in New York," *The Wall Street Journal*, November 9, 2012. <http://online.wsj.com/article/SB10001424127887324439804578107512842789702.html>
- 41 Kaleem, Jaweed and Lucas Kavner. "Fighting, Unruliness Hinder Hurricane Sandy Recovery In New York, New Jersey," *Huffington Post*, November 2, 2012. http://www.huffingtonpost.com/2012/11/02/fighting-unruliness-hinders-hurricane-sandy-recovery_n_2067813.html

Port Authority of New York and New Jersey

The Port Authority of New York and New Jersey (PANYNJ) operates a wide array of services, including commuter rail (PATH trains), airports, bridges, tunnels, a major bus terminal, and the ports. PANYNJ's tunnels, particularly the Holland Tunnel and PATH train tunnels, experienced significant flooding. This led to severe gridlock on other routes to Manhattan from New Jersey, particularly in the Lincoln Tunnel. John F. Kennedy, LaGuardia and Newark Airports were all closed during and the day after the storm, but all opened within two days of the storm. PANYNJ, like the other public agencies, was impressive in its efforts to reopen services that are vital to the region.

Due to serious damage, it took much longer for PATH trains to resume service. Partial PATH service began again on Tuesday, November 6.⁴² Several stations still remain closed at the time of writing, and will likely remain closed for a considerable time due to flooding and damage to both tunnels and rolling stock. PATH continues to work to restore service. The Port Authority reopened the Holland Tunnel at first exclusively to buses on Friday, November 2, and then to all commuter traffic on Wednesday, November 7.^{43,44}



▲ Hoboken PATH Station Flooding. Photo Credit: ABC News

The Port Authority adopted a different communications approach than the MTA or NYCDOT, which were extremely proactive about their communication and outreach, posting photos and information in many formats. PANYNJ's homepage features only a small clickable icon about "inclement weather," which directs users to their information about the impacts to services. The alerts posted are all in text format, with no images to clarify the information or illustrate the damage. The PATH train's website, however, features a new map

that highlights limited service and clearly displayed frequently asked questions and answers. In addition, @PATHTweet, PATH's Twitter account, has actively answered riders' questions about service.

42 PATH Twitter Account. <https://twitter.com/PATHTweet/status/265681201321365505>

43 Gelsi, Steve. "Holland Tunnel opens for buses after Sandy," Wall Street Journal, November 2, 2012. <http://www.marketwatch.com/story/holland-tunnel-opens-for-buses-after-sandy-2012-11-02>

44 Fermino, Jennifer and Rosenberg, Rebecca, "Holland Tunnel reopens," New York Post, November 7, 2012. http://www.nypost.com/p/news/local/holland_tunnel_reopens_WAgZe2zet-2FHD9HwVP0OuO

New Jersey and NJ Transit

With a large portion of NJ Transit rail cars and engines damaged, the state agency struggled with meeting demand and restoring service.⁴⁵ The agency had shut down service pre-emptively, and moved trains to less flood-prone areas in preparation of the storm, but the storm still caused significant damage. Like the subways, there are many custom-designed parts on NJ Transit trains. While the agency was able to restore bus service relatively quickly, with loaned buses from SEPTA and USDOT,⁴⁶ NJ Transit has restored only limited rail service. Free shuttle buses are replacing train service in some areas, particularly focusing on routes that connect to ferry ports.⁴⁷

During the days immediately after the storm, NJ Transit began offering free park-and-rides, shuttle buses and ferries into Manhattan to help mitigate some of the congestion on the open bridges and tunnels.⁴⁸ Information was and is still displayed prominently on their website, and updates were also posted on Twitter, Facebook, and through the “My Transit” e-mail alert system.

Throughout New Jersey, there were long lines at gas stations for many days following the storm. To address this issue, Governor Christie instituted a gas rationing system, where vehicles with license plates that end in an odd number can fill up their tanks on odd numbered dates, and vehicles with license plates that end in even numbers can fill up on even numbered dates.⁴⁹ New York also experienced this issue, however it took more than a week after the storm for Mayor Bloomberg and Long Island counties to establish a similar policy.

45 Frassinelli, Mike. “Despite rails returning, commuters still sore over NJ Transit’s Sandy Response,” *nj.com*, November 13, 2012. http://www.nj.com/news/index.ssf/2012/11/despote_rails_returning_commut.html#incart_m-rpt-1

46 Tri-State Transportation Campaign. “Wednesday Winners (and Losers),” *Mobilizing the Region*, November 7, 2012. <http://blog.tstc.org/2012/11/07/wednesday-winners-and-losers-17/>

47 NJ Transit. “NJ TRANSIT Implements ADDITIONAL Emergency Trans-Hudson Access Plan,” November 14, 2012. http://www.njtransit.com/sa/sa_servlet.srv?hdnPageAction=CustomerNoticeTo&NoticeId=2310

48 NJ Transit, “Christie Administration Implements Emergency Trans-Hudson Access Plan Starting Monday Morning,” November 4, 2012. http://www.njtransit.com/tm/tm_servlet.srv?hdnPageAction=PressReleaseTo&PRESS_RELEASE_ID=2806

49 Walsh, Michael. “NJ Odd/Even gas rationing plan in effect,” November 4, 2012. <http://www.nydailynews.com/new-york/n-odd-gas-rationing-plan-effect-article-1.1196416>

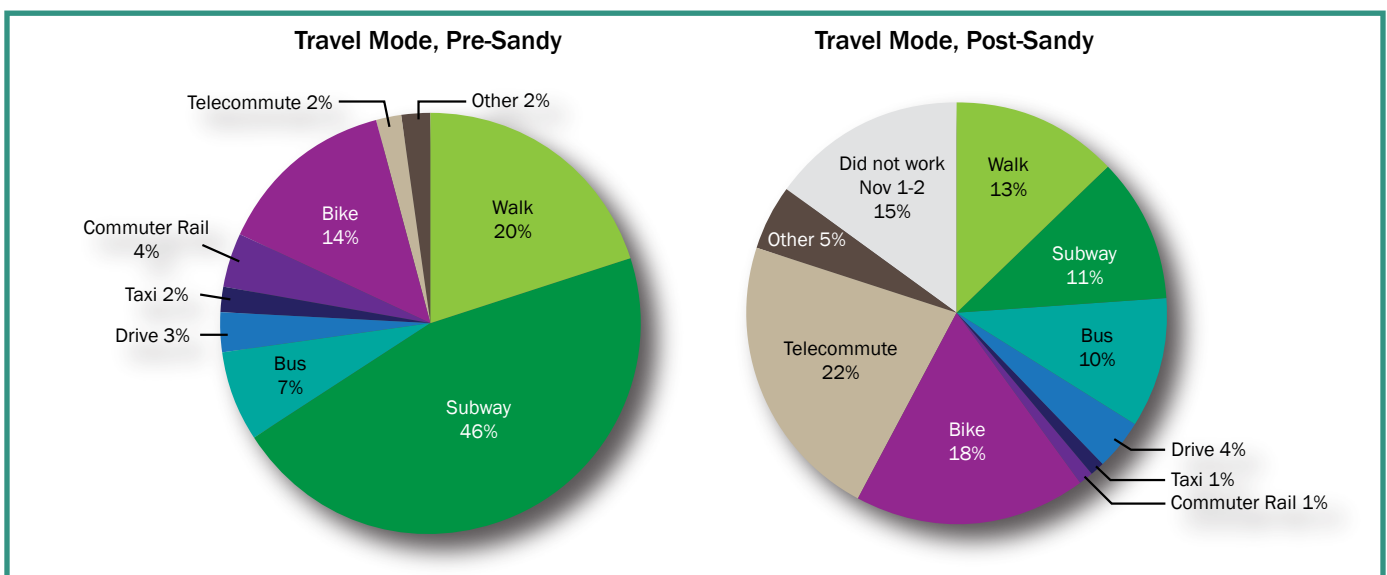
Public Agency Resilience

Whether it was distributing bottled water, directing street traffic, or pumping out water from tunnels, the public employees in the New York metropolitan area deserve credit for the recovery of the region. Public agencies were able to restore almost all of its transportation services in a prompt manner through extensive coordination and hard work, a feat that many initially thought would take months to accomplish given the magnitude of the storm. Without the trains, buses, ferries, bridges, tunnels, and roads that citizens use daily, the region and its economy simply cannot function.

The Adaptable New Yorker: Commuting, Working and Communicating After Hurricane Sandy

New Yorkers managed to reach their places of work in impressively large numbers following Hurricane Sandy, not only as a result of transportation providers' major efforts, but also through residents' own adaptability and ingenuity.

In the absence of subways, which typically transport 5.3 million people daily, commuters fanned out to buses, taxis, bicycles, and telecommuting. In the NYU Rudin Center's survey of 315 commuters, where approximately half had typically taken subways to work, patterns shifted significantly to allow for a diversity of modes: buses, walking, bicycling and telecommuting, as shown in the charts below:



“On November 1 I drove through Brooklyn picking up co-workers (5 total) and drove us all to work over the Williamsburg bridge. I biked on October 31 and telecommuted on 10/29 and 10/30.”

Commute Survey Respondent

These figures represent the remarkable multi-modal transportation supply and user adaptability seen in few cities outside of New York. In many U.S. cities, which are limited to cars, buses or other singular transportation modes, the disruption caused by Hurricane Sandy would have, at least temporarily, crippled the economy.

Even further, the November 1-2 commutes often took twice or three times as long, and frustration levels were self-reported at an average of 3.35 out of 10, but the return to work was palpable on November 1-2, the days immediately following the Hurricane. It should be noted that the frustration levels were highest in Staten Island (7) and New Jersey (5.7), the surveyed areas most geographically separated from the operating offices of midtown Manhattan. The travel times and frustration index for those reporting to a workplace (not telecommuting) on November 1-2 is shown below:⁵⁰

Residence Location	Pre-Sandy Commute Time (minutes)	Commute Time Nov. 1-2 (minutes)	Average Frustration Level
Brooklyn	42	86	3.93
Manhattan	29	52	2.97
Queens	45	47	3.00
Bronx	41	63	2.14
Staten Island	84	240	7.00
New Jersey	52	69	5.67
Northern Suburbs	73	61	2.40
Long Island	85	85	2.00

“Tried to take the ferry, but the lines were crazy. Feeling stranded.”

Commute Survey Respondent

To travel to work, New Yorkers embraced the High-Occupancy Vehicle restrictions on bridges by connecting with other drivers and passengers through neighborhood networks, picking up strangers at landmarks like Brooklyn’s Borough

Hall, and sharing taxi rides, negotiating ad-hoc rates with drivers. On the Park Slope Parents email network, more than 50 emails were exchanged for ride-sharing needs. New York’s DOT made the unprecedented recommendation that drivers pick up strangers waiting on bus lines before driving over bridges. Commute times by private car for survey respondents nearly tripled, from an average of 47 minutes pre-Sandy to an average of 115 minutes post-Sandy. Several survey respondents found more unusual modes of transport to work, including employer-run vans, relocated company offices, running, and staying in homes closer to offices.

⁵⁰ Note that the numbers of commuters on November 1-2 dropped significantly, as many offices were closed, and many workers telecommuted. As such, the November 1-2 commute time figures may not provide a representative number of commuters.

Local businesses, particularly neighborhood delis, opened their doors on November 1st and 2nd, some without lights or heat, many maintaining operations with a skeleton staff. Some restaurants, unable to broadcast music, hired musicians; most were unable to accept credit cards and acted on a cash-only basis. Several news outlets reported that the small, local businesses were more likely to open than the larger chains, because the former tend to have staff that live nearby and a lack of bureaucracy to decide whether to open for business.⁵¹

Even in the face of detrimental circumstances, New Yorkers' businesses maintained operations, showcasing the extreme adaptability of their operations, finances and creativity.

The information economy adapted to the closure of offices with innovative tools like the Sandy Coworking Crowdmap, which posted locations of powered businesses willing to share space with those businesses lacking functioning workspaces. The map was crowdsourced, or powered by individuals posting information individually, rather than an explicit government or private-sector project, again demonstrating New Yorkers' ingenuity.⁵²

“Worked in a different company office on 10/31. Could have done the same on 11/1 and 11/2 but didn’t have the gas to drive.”

Commute Survey Respondent

Other innovative public-private partnerships emerged during crisis management, including an alliance between New York City government and AirBnB, which helped displaced New Yorkers find temporary housing.⁵³

Several websites, including gasbuddy.com/sandy and Waze’s gas information site, were quickly launched to display locations of gas stations with adequate supplies, an essential resource during the shortage.

New Yorkers also remained on top of social media; in a geographic analysis by Floating Sheep, the most common tweeting location was Midtown Manhattan, even during and after the power outages. In fact, social media communications in areas without power continued throughout and after the storm, many centering around the collapsed crane on 57th Street. While few postings emerged from areas heavily struck by the storm, the continuous distribution of tweets throughout the city meant New Yorkers were informed and sharing information, even during the crisis.⁵⁴ Nearly two-thirds of survey respondents reported getting transportation information via social media (the second most popular choice), and 85% from official websites, indicating that locals were continually plugged in to sources of web-based information, even without power and internet access at home.

51 Ramey, Corinne. “Unlike the Chains, Local Businesses Stay Open in Sandy’s Wake,” *Next American City*, November 1, 2012.

52 Sandy Coworking: <https://sandycoworking.crowdmap.com/>

53 Brustein, Joshua. “New Tools for Disaster Aid,” *The New York Times*, November 9, 2012.

54 “The Urban Geographies of Hurricane Sandy in New York City,” Floating Sheep, October 31, 2012. <http://www.floatingsheep.org/2012/10/the-urban-geographies-of-hurricane.html>

These adaptations in the face of crisis are uniquely New York, in that the population quickly adapted to alternate and substitute transportation modes, new norms of local business practices, flexible, temporary workplaces, and continuous communications.

“It’s understandable the things are going to be at a halt due to one of the worst natural disasters to hit NYC. Not expecting everything to be back to normal overnight. Bloomberg and Christie are both doing an exceptional job. Never prouder to be a New Yorker. We got through Sept 11, we’ll get through this too.”

Commute Survey Respondent

Recommendations

Hurricane Sandy brought the New York Region together in an admirable show of preparation, collaboration, response, and adaptability, among both public agencies and individuals. In advance of the next major storm, which could result in even more flooding and damage, additional infrastructure improvements and policy changes should be implemented:

Infrastructure Upgrades

Physical infrastructure, commercial and residential buildings and transportation facilities must be evaluated with regard to their vulnerability to flood and water damage. Based on this initial report, we recommend the following:

Buildings

Building codes and engineering standards: New York City regulations require building generators to be housed in basements or on bottom floors; this made it impossible for many buildings to activate backup power during the larger outage due to flooded generator systems. Weather proofing the generators would involve moving generators to higher floors, away from flood-prone areas.

Subways

Install backup power for pump systems: When power outages knock out subway pumps, subway flooding is exacerbated, and the potential for infrastructure damage is much greater. Backup power is an essential addition to the subway pump system so that tunnels may be cleared of water more quickly.

Install flood gates and raised entrances at flood-prone stations: Several major transit systems, including those in Bangkok, Thailand and London, feature elevated subway entrances and built-in floodgates to allow the system to continue operations even during floods. These infrastructure upgrades, if implemented in New York, would significantly lessen the effects of flooding and damage to equipment during future storms.

Consider installing subway “plugs:” Currently under development by the Department of Homeland Security, the “plug”—which looks and works like a big balloon—helps prevent water from entering subway tunnels, and can inflate in just a few minutes. These plugs could help prevent significant damage due to tunnel flooding.

Buses

Maintain bus priority lanes on bridges and major streets: The large numbers of buses traveling from the outer boroughs to Manhattan in lieu of subway service showed the potential for a long-term alternative to over-crowded subways. If buses continued to have priority on bridges and throughout the major arteries of Manhattan and the outer boroughs, large numbers of people could move through the city more efficiently.

Increase BRT use for subway service issues: The MTA’s Bus Rapid Transit should be expanded and regularly implemented in situations where subways are non-functioning to better accommodate travelers throughout the city.

Streets & Sidewalks

Porous pavement should be considered in flood-prone areas: Specialized pavement that allows for draining of floodwaters back to the nearby bodies of water could help prevent the standing water that remains after the storm, and assist in the recovery of neighborhoods and streets that are especially hard-hit by floods.

Consider sidewalk vents with elevated vents that double as street furniture: Following the 2007 subway flood, New York City began installing elevated vents that doubled as street furniture, such as benches and bicycle racks. This program should be considered throughout the city to reduce flooding through ventilation grates system-wide.

Evaluate the use of closeable ventilation ducts: While elevating sidewalk ventilation ducts helps in many cases, vents in the most flood-prone areas should be closeable to prevent floodwaters from entering the subway system.

Bike Lanes

Continue to improve bicycle infrastructure: Bicycles became an especially popular mode of transportation during and after the storm. Biking during transit service outages should be recognized with extra infrastructure, particularly dedicated lanes in heavily congested areas.

Evaluate the deployment of bike & pedestrian access across the Verrazano-Narrows Bridge: With many Staten Island residents stranded without gas to power their cars, the ability to walk or bike across the Verrazano Bridge would allow them to reach locations with existing transit resources.

Ferries

Increase ferry service within New York City and the surrounding region: When many inter-borough transit routes are unavailable, ferry service helps connect far-flung areas and reduce bus, car and bike congestion.

Overall, New York City and State must recognize and strengthen its multi-modal transportation options, both during extreme situations like Hurricane Sandy, and on a day-to-day basis to improve the flow of people and goods.

Lessons learned and recommendations

Several lessons were learned from the experience of Hurricane Sandy, the vulnerability of key transportation infrastructure and the way in which innovative transportation systems were deployed. We recommend the following policies be considered to strengthen the transportation systems and services of the New York region.

Funding

Improve state and federal support for the MTA: The MTA is one of the city's and region's greatest assets, contributing in innumerable ways to the economic productivity of the city, region, state and nation. New York State cannot function without a strong and reliable mass transit and commuter rail system, and it warrants major public investment in storm recovery and for long-term system upgrades.

Communications

Improve social media and transparency by transportation providers: Hurricane Sandy highlighted the importance of social media during a crisis situation, when many New Yorkers lacked cell phone service, television, or other outlets for information; posting information on a multitude of channels,

including official websites, social media, television, radio, and print media helps reach a large population with an inconsistent variety of resources. During the Hurricane, the Port Authority and NJ Transit provided remarkably limited information throughout and following the storm about their service, especially when compared with the MTA's consistent service updates on multiple channels, and with photo and video content. More information and customer service should be available to Port Authority and NJ Transit customers.

Maintain adaptable MTA map function: The MTA's adaptable map, which showed service as it changed in the days following the storm, should be maintained as a regular function of the Authority to inform riders of outages, construction work, and detours. In addition, MTA and all transportation providers should make maps and schedules available through GTFS for wider dissemination across information sources and smartphones.

Increase secondary languages for information: Most of the transportation information provided through agency websites and social media was exclusively in English. In order to reach a greater portion of the city's population with necessary safety news, agencies should work to translate their notices into multiple languages.

Workplace

Foster the capability of remote work: With millions of New Yorkers working in information intensive firms, workplaces should consider contingency plans that allow their employees to work from home or co-working spaces so that they may avoid potentially hazardous commutes.

Hurricane Sandy highlighted the great benefit of Manhattan's multiple modes of transportation on and off the island. Because Manhattan is connected throughout the length of its nine miles by both bridges and tunnels, it remained possible to move on and off the island as needed, and populations could move throughout the city. Had Manhattan lacked either bridges or tunnels, and had an area lacked connectivity to an outer borough or New Jersey, the area may have been harder-hit by traffic congestion or an inability to evacuate the necessary locations. In preparations for future storms, it is essential that New York continue to maintain its aboveground infrastructure of bridges and elevated roadways as a means of transporting people and goods in the event that tunnels are flooded again.

However, New York could not have emerged from this disaster without the disaster planning and preparation of the City of New York and the MTA, the efforts of its public workers, and the innovative adaptability of its population.

Appendix: Commuter Stories

The Northern Suburbs Commuter Who Learned from Irene

As a resident of Orange County, New York, I commute to midtown Manhattan on a daily basis via the Metro-North Railroad (MNR) Port Jervis Line. Each morning, I drive a short distance to the Salisbury Mills-Cornwall train station. After an approximate 70 minute train ride, I transfer at Secaucus Junction and board another train to New York Penn Station. From here, I can walk to my office. Door to door, my commute takes me about two hours each way. These two hours can be longer during service disruptions; however, over 90 percent of the time, the line maintains its on-time performance.

My first experience with long-term service outage occurred as a result of Hurricane Irene. The Port Jervis suffered 14 miles of mangled and washed away tracks. Trees were toppled, parts of the signal system were carried downstream, and railroad bridges were battered. As reported in the New York Times, the damage was so extensive that when Jay H. Walder, the chairman of the Metropolitan Transportation Authority, visited the tracks, he rested his hands on his hips, let his jaw drop, and said quietly, "This is something. In nearly 30 years, I've never seen anything like it." Early estimates noted the repair could take months and cost tens of millions, if not hundreds of millions of dollars.

During this time the Metro-North expanded bus service options for Port Jervis customer and cross-honored Port Jervis monthly tickets on the Hudson Line. I avoided the cumbersome interim train-bus-train service, and took advantage of the latter option. This four-seat ride, including the Newburgh-Beacon Ferry, MNR train, Shuttle, and 1,2,3 Line, took me an additional 30 minutes, extending my total commute to two and a half hours – each way. Both the ferry and MNR train were covered with my regular monthly train ticket; however the travel from GCT to my office near One Penn Station added an additional \$5 per day. After three months of this alternate commute, the Port Jervis line was restored in late November. I had never appreciated my 'normal' commute more!

The importance of transportation redundancy was again apparent during the more recent service outage associated with Hurricane Sandy. The MNR commuter train lines were devastated, suffering power losses as fallen trees and other debris littered the system. My office was closed Monday during the storm, as well as Tuesday and Wednesday. But by Wednesday evening, upon receiving news that the office would re-open on Thursday, I began to investigate my options on how I would get to work. I had two options: drive to the Meadowlands park and ride in New Jersey and connect with one of the NJ Transit bus routes; or take the Short Line bus from Central Valley. I chose the Short Line, as it was a shorter drive and used less fuel. Not knowing how quickly the park-and-ride filled up or how traffic conditions would be, I left my house early – by 4:15 a.m. The trip in was a breeze until the bus approached the Lincoln Tunnel. Travel was backed, due to the roadside checks for the minimum three-passengers per vehicle. Nevertheless, I was to my office by 6:30 a.m., which is only a bit longer than my normal commute.

As of today, the Port Jervis Line is operating, but on a limited schedule. Therefore, for the past month I have continued to take the bus. The bus has some advantages, particularly noted during the morning commute. The bus makes less stops, and the dimmed lights make it easy to sleep. However, the evening commute is slowed, due to congestion. Also, the bus is more crowded, which makes it difficult to catch up on work – something I did regularly when taking the train. I plan to return to the train once service is fully restored.

The Brooklyn-Manhattan Car Commuter

Evan Frushtick

Driving from Carroll Gardens into Manhattan during the week is never normally difficult. I'm not due in until 10 and I work up in Times Square, so if I give myself 45 minutes, it's a safe bet I'll be at my desk on-time. I choose to either come up the BQE to the Brooklyn Bridge or if I'm feeling sassy and want to drop some Washingtons via my EZ Pass, I'll cruise through the Battery Tunnel and hit the West Side Highway in no time.

After Sandy, when driving was the only option, I figured I should give myself at least double the usual time to get to the office. The Battery Tunnel was out but my experience driving up Hicks street which follows the BQE until my entrance, has always been easy. That morning it was a parking lot! Un-timed lights that are usually not an issue on the weekends were major time-suckers.

I had also volunteered to take a co-worker to the office that day, so after I bailed on Hicks early, it was a pretty easy commute until Park Slope.

The larger issue was finding my way down Flatbush to get to the Manhattan bridge. That span from 7th Ave until the entrance lasted roughly 90 minutes in the sort of traffic usually reserved for a beach bridge to the Jersey Shore on the Fourth of July.

Overall, that's where the major hassle ended. There was some slow-downs in Manhattan at major crossings (14th / 23rd / 34th) with the lights still out and cops struggling to hold directional traffic but the traffic moved quickly. The frightening moment of my day was driving home from Times Square after dark and crossing 34th street into blackness. The entire trip down 7th Ave and then over to the Brooklyn Bridge was a bad carnival haunted house, never knowing if some car would decide to make a quick break across the busy avenue as I flew past dark stop lights.

About the Rudin Center for Transportation

The Rudin Center for Transportation at NYU's Wagner Graduate School of Public Service school aims to strengthen our understanding of transportation and infrastructure. The Center draws upon faculty, students, and visiting scholars at NYU. Current research include:

- The flow of people, goods and information in and through New York City
- Information technology and transportation systems
- Infrastructure planning, investment and development
- Aviation and economic development
- Mobility and the mind

The Rudin Center for Transportation was named in recognition of a gift from civic leader Lewis Rudin and receives support from foundations, public agencies, and leading firms in transportation, finance, and communications. Mitchell L. Moss, Henry Hart Rice Professor of Urban Policy and Planning, is the Director of the Rudin Center for Transportation.

www.nyurudincenter.com

Contact the Rudin Center for Transportation

Twitter: @nyurudin

Facebook: facebook.com/NYURudinCenter

Email: rudin.center@nyu.edu

Report designed by Scott Hong

