

Role of Public Transportation in a Natural Disaster State of Emergency Declaration

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Jodi Godfrey¹, Gennaro Saliceto¹, and Roberta Yegidis¹

Abstract

Destructive natural disasters such as hurricanes or other extreme weather events challenge many industries, especially the public transit industry. The 2017 hurricane season proved to be tumultuous, with three major hurricanes devastating the United States in less than 2 months. The challenges faced in Florida, in response to Hurricane Irma, precipitated best practices and lessons learned related to monitoring and reporting the status of transportation infrastructure, identifying temporary alternative solutions, and coordinating and communicating with emergency operations centers, state departments of transportation, and individual transit agencies. Sharing the lessons learned from recent firsthand experiences will undoubtedly improve the public transit industry's emergency preparedness, response, and recovery activities.

Public transit systems in the United States are tasked with providing safe and reliable transportation for their community. The expectation of safe and reliable transportation is critical during emergencies. FTA's emergency relief program defines "emergency" as "a natural disaster affecting a wide area (such as a flood, hurricane, tidal wave, earthquake, severe storm or landslide) or a catastrophic failure from any external cause, as a result of which the governor of a state has declared an emergency and the Secretary of Transportation has concurred; or the president has declared a major disaster under the Stafford Act" (1, Section 5324 of Title 49, Chapter 53).

Within transit agencies, any type of circumstance that disrupts service, natural or manufactured, could be considered an emergency, and require action on the part of public transit employees. FTA's *Immediate Actions for Transit Employees* lists several types of emergencies to which transit employees may have to respond (2). Examples of such emergencies include health emergencies (e.g., an individual collapsing or bleeding); accidents or collisions; suspicious items (e.g., unattended packages); suspicious behavior (e.g., belligerent or disorderly passengers); security threats and assaults including terrorist attacks and mass shootings; fires or explosions; and natural disasters (e.g., tornados, earthquakes, and blizzards) (2). Historically, public transit agencies and employees have exceeded expectations when called on to respond to past emergencies. A few examples are as follows:

- New York Metropolitan Transportation Authority transported first responders to ground zero during the 9/11 attack (3).
- Lynx provided extended service following the Pulse shooting (4).
- Houston Metro emerged as one of the heroes of Hurricane Harvey (5).
- Sonoma–Marin Rail Transit continued to operate full service, suspending fares to those in need, during the northern California wild fires (6).

For the purposes of this study, the focus will remain on emergencies associated with natural disasters. Natural disaster emergencies can be categorized as either predicted or unpredicted. Predicted emergencies are a set of expected events that can threaten the transit system and the community, posing serious impacts on regular transit operations. Natural events, such as hurricanes, tropical storms, or flooding are all examples of predicted emergencies. Unpredicted emergencies are events that happen suddenly or with short notice, like earthquakes, tornados, or mudslides. Transit agencies are expected to respond effectively to both predicted and unpredicted

¹Center for Urban Transportation Research at the University of South Florida, Tampa, FL

Corresponding Author:

Address correspondence to Jodi Godfrey: Jodis@cutr.usf.edu

events in a timely manner, which can only be accomplished through emergency preparedness. This response also requires seamless coordination with other emergency support functions, including communications, public works, firefighters, law enforcement, and so forth, throughout all phases of emergency management (7). This study will describe emergency phases and the importance of public transit during each phase. Perhaps of most value, this study will describe best practices and lessons learned from personal experience garnered from Hurricane Irma in Florida as a resource to be referenced for future events.

Before describing emergency phases and the role of transit during these phases, it is important to understand the necessity of this study as detailed in the background section .

Methodology

The research team performed a literature review and gathered lessons learned from the 2017 hurricane season from transit professionals across the state of Florida through discussions at the Florida Transit Safety and Operations Network, and its associated annual summit. The findings from the literature review and lessons learned were summarized to form this report.

Background

Since hurricanes were first tracked and named, in the early 1870s, more than 290 named storms have hit the United States (8). The Gulf Stream provides ideal environmental characteristics to produce enough thermal energy to sustain hurricane development. The shallow warmer waters of the Gulf of Mexico are ideal for increased strength hurricanes.

The East Coast of the United States has historically been heavily struck by hurricanes and tropical storms. The 10 worst storms that hit the United States since 1900 all made landfall on the eastern coasts of the United States, which are inclusive of the Gulf Coast from Texas to Florida, and the Atlantic Coast. In August 2004, Hurricane Charley made landfall on the Florida coast as a Category 4 hurricane, leaving a path of destruction in its wake. Charlie was followed by three more major hurricanes in a 6-week period, all of which affected the state of Florida (7).

The overactive 2004 hurricane season, with four major hurricanes making landfall in Florida, prompted an analysis of the varying emergency planning efforts and emergency responses from public transit agencies throughout the state. This analysis included a survey sent to both fixed route transit agencies and community

transportation coordinators to gather information. Questions on the survey were related to service impacts experienced by each agency, the agencies' role during and after the storm, and hurricane-specific issues related to fuel and power sources. Some of the survey responses led to improvements in Florida transit agency's emergency management protocol.

The 2005 previous Florida study revealed that 60% of fixed route and 89% of community transportation coordinator agencies experienced communication problems, and most agencies had no plans in place to address those communication problems. Thirty percent of fixed route transit providers in the state of Florida did not maintain a telephone contact list as part of their emergency planning—a challenge that was found to persist in 2017. Additionally, the 2005 survey revealed that only 40% of fixed route and 22% of community transportation coordinator agencies maintain interlocal agreements with other transit agencies or local/regional governments detailing predetermined cooperation throughout the emergency management phases, an area with great room for improvement. Finally, many transit agencies realized that fuel is a very valuable commodity in major storms such as hurricanes, and alternative fuel sites, and alternative power sources to deliver that fuel, should be considered part of the agency's emergency management plan (7).

The TCRP Report 86, Volume 7, *Public Transportation Emergency Mobilization and Emergency Operations Guide*, provides typical components of a public transportation agency's emergency management plan, including goals and objectives of the plan (9). The TCRP Report also indicates that the owner of the plan should be identified with proper jurisdictional authority explicitly outlined (9). Other emergency plan components include interfaces to describe how the plan integrates with other safety documentation and external organizations; identification of outside participating agencies, including key personnel, agreements, and responsibilities; communication and coordination protocol; the transit agency's role in disaster planning; the steps required in incident management; and details of the postincident evaluation process (9). Furthermore, the plan should describe aspects of public relations, including what type of information should be shared with the media; American with Disabilities Act considerations; emergency preparedness drills; plan management, describing who and when the plan should be updated; and references needed to resolve emergencies (9).

The 2005 hurricane season was also active in Florida, with both Katrina and Wilma making Florida landfall (10). However, following hurricane Katrina in 2005, the hurricane seasons remained relatively calm until 2017.

Hurricane Irma

The summer of 2017 proved to be tumultuous, with three major hurricanes devastating the United States in less than 2 months. Eleven years without a major hurricane making landfall on the eastern United States resulted in many agencies failing to be actively prepared for emergency management. One example of agencies' failure to be actively prepared for emergency management were outdated contact lists. Lack of preparedness was one of the biggest challenges associated with Hurricanes Irma and Maria in 2017.

Hurricane Irma was the most powerful Atlantic hurricane in recorded history, with sustained winds of 185 mph for over 37 H, the longest ever recorded. Its coastal storm surges were 20 Ft above normal tide levels (11). Irma held 7 trillion watts of energy, which is twice as much as all the bombs used in World War II. Its force was so powerful that earthquake seismometers recorded it and it generated the most accumulated cyclone energy in a 24-H period (12). Hurricane Irma was also one of the most massive storms on record, measured at 400 mi wide and 800 mi long. It completely covered three southern states, Florida, Georgia, and South Carolina.

In Florida, over 6 million people were issued an evacuation order, and shelters hosted more than 77,000 people. These relevant facts about Hurricane Irma allow an understanding of the tremendous impact it had on the affected municipalities. The Federal Emergency Management Agency (FEMA) identifies transportation as the number one emergency support function (ESF) because of its imperative assistance during evacuations and declared or undeclared emergencies. As a part of ESF 1 respondents, public transit systems must serve their communities with higher safety and security standards than subsequent ESFs. As such, public transit plays a crucial role during the preparedness, response, and recovery phases of any type of emergency.

Emergency Phases

Emergency management is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters (13).

Risk avoidance is undeniably integral to the security of the daily lives of citizens. As such, it should be integrated into the daily choices decision makers should make, rather than being called on only in response to major disasters. With this in mind, and after several catastrophes, FEMA launched a new concept of emergency management called an "all-hazards" approach to risk mitigation in the 1990s. This notion does not mean that emergency managers have to plan for every possible outcome, it means, instead, that all possible hazards have to

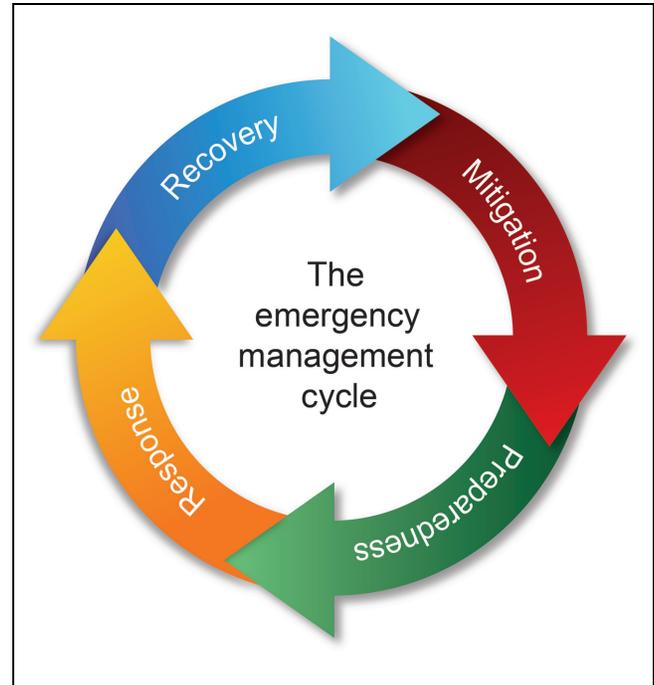


Figure 1. Emergency phases.

be considered. This "all-hazards" method has two main components: the risk analysis phase in which all possible dangers, threats, risks, and vulnerability have to be studied; and the development of the capacity phase in which responders will deal with the multiple hazards identified in the previous phase (14). As part of an "all-hazards" approach, FEMA transitioned from a reactive approach to a proactive approach and identified four phases in the emergency management process: mitigation; preparedness; response; and recovery, as shown in Figure 1.

Mitigation

Mitigation is the cornerstone of emergency management. It is the continuing effort to minimize the severity of the impacts that disasters have on people and property. Mitigation is defined as "sustained action that reduces or eliminates long-term risk to people and property from natural hazards and their effects" (15).

Mitigation efforts attempt to prevent hazards from developing into disasters and to reduce the effects of disasters when they occur. The mitigation phase of emergency management differs from the other phases because it focuses on long-term measures for reducing or eliminating risks, and it is a continuous activity. The implementation of mitigation strategies can be part of the recovery process if applied after a disaster occurs, but it can also be part of the preparedness phase to prevent occurrences. Mitigation measures can be structural or nonstructural. Structural measures use technological

solutions like flood protections. Nonstructural measures include legislation, land use planning (e.g., the designation of nonessential land, like parks, to be used as flood zones), and insurance. Mitigation is the most cost-efficient method for reducing the effect of hazards, although not always the most suitable.

Some key points of the mitigation phase are as follows:

- Takes place before and after the emergency occurs;
- Prevents emergencies from happening or minimizes their effects;
- Includes anything that can be done to minimize damaging effects, such as securing property, strapping down water heaters, anchoring bookshelves to walls, and buying insurance.

Mitigation activities related to transit systems include establishing procedures and policies that promote a safe operating environment; determining and adhering to design codes and standards; and purchasing appropriate insurance coverage. In addition, vehicle and facility design considerations, training in safety procedures and standards, and the dissemination of materials, such as hurricane manuals, are vital actions to accomplish a successful mitigation phase.

Preparedness

Preparedness takes the form of plans or procedures designed to save lives and to minimize damage when an emergency occurs (16). According to FEMA's "all-hazards" approach, preparedness is a continuous cycle of planning, organizing, training, equipping, exercising, evaluating, and improving activities to ensure the effective coordination and the enhancement of capabilities to prevent, protect against, respond to, recover from, and mitigate the effects of, natural disasters, acts of terrorism, and other manufactured disasters. These activities ensure that when a disaster strikes, emergency managers and safety sensitive employees will have the ability to provide the best response possible. The preparedness phase includes drills and exercises carried out at least annually, to reduce complacency, especially in significant intervals between active seasons. In the preparedness phase, emergency managers develop plans of action to manage and mitigate their risks, and take action to build the necessary capabilities needed to implement such plans.

Common preparedness measures include the following:

- Updating all emergency contacts, at least annually;

- Maintaining interagency communication plans with easily understandable terminology and methods;
- Proper maintenance and training of emergency services;
- Developing and exercising emergency population warning methods;
- Preparing shelters and evacuation plans;
- Stockpiling, documenting inventory, and maintaining disaster supplies and equipment.

Emergency preparedness activities specific to transit systems should include establishing general emergency procedures such as communication/notification, situation assessment, evacuation from hazardous areas, and use of emergency equipment; hazard-specific procedures for severe weather, hazardous material spills, and other natural or technological disasters; and the establishment of a command and control structure. Moreover, it is important to establish mutual agreements with law enforcement and first responders at the county and city levels to assist during the emergency and during the preparedness phase, ensuring that drills and exercises are conducted at the highest practical level. The establishment of mutual agreements provides the opportunity for relationships to be made, which will improve the likelihood of beneficial communication occurring during a declaration of emergency. When a face is associated with the name, the chances of receiving a response, especially in an emergency, increases.

Response

The response phase includes the mobilization of the necessary emergency services and first responders in the disaster area (17). This emergency phase includes the active gathering of core emergency services such as firefighters, police, ambulance crews, and transit systems. Response is defined as the actions taken to save lives and prevent further damage in a disaster or emergency situation (18). Response puts preparedness plans into action. Response activities may include damage assessment, search and rescue, firefighting, and sheltering victims. The organizational response to any significant disaster is based on existing emergency management organizational systems and processes: the Federal Response Plan and the Incident Command System. In other words, the response phase is putting the preparedness phase into action.

Hurricanes are somewhat predictable, providing communities time to prepare and respond. However, even when an event is predicted, the precise path and the severity of the consequences are typically unpredictable. Maintaining communication with the public at all times—through the media, web pages, and other

means—is an important aspect of the emergency response phase. Additionally, information aids such as checklists and reference cards are imperative for transit agencies in the response phase. Continuous communication and the availability of cohesive guidance will help to ensure that all necessary actions are carried out, even in confusing and chaotic circumstances.

Recovery

The recovery phase includes all actions taken to maintain a level of safety that will ensure a return to normal life as soon as practical. Some actions in the recovery phase will be immediate—reducing detours and route deviations and resuming regular service. Other actions may be ongoing. For example, if a home has been damaged, it will need to be repaired or replaced and the person will need to start submitting claims on those items covered by insurance. The level of difficulty of the recovery phase is dependent on the severity of the emergency and the level of preparedness completed before the emergency. A person who has prepared well, with enough food, water, and other supplies, including things like having the proper insurance coverage, will fare much better than someone who has not prepared adequately.

Some key points of the recovery phase:

- Recovery takes place after the emergency is over.
- Goal of recovery is to resume normalcy as soon as possible, including resuming normal service.
- Recovery includes making repairs and filing insurance.
- Assessing mitigation, preparedness, and response phase actions, and refining them for next time are all part of the recovery phase.

If transit service has been altered or suspended during the emergency, it should be restored as soon as is feasible. Therefore, it is important to follow some general guidance:

- Determine critical service and prioritize needs; for example, providing transportation to return citizens from the shelter back to their homes.
- Assess damage and determine required resources.
- Communicate to appropriate authorities.
- Implement critical services.
- Assess feasibility of restoring normal operations, and the specific tasks necessary to do so.
- Perform trial runs of normal operations to determine if a route is safe to resume operations.
- Communicate with employees to establish shifts when they will return to work, if necessary.
- Resume all scheduled service on all routes.

Depending on the nature and the severity of the emergency, other activities may have a fundamental role in the recovery phase. Those activities include clearing debris from roadways and transit facilities, repairing damage to vehicles and transit centers, and replenishing supplies such as fuel.

Lessons Learned

Hurricane Irma posed several challenges for the local transit systems in Florida. Coordinated by the Florida Department of Transportation (DOT), the transit agencies in Florida responded spectacularly to the hurricane, and were recognized nationwide for their efforts. However, a few things could have gone better, had more preparation been completed before the onset of the hurricane season. Before 2017, Florida had not been struck by a hurricane since 2005, which means 12 years passed without a major meteorological threat. The lack of hurricane activity in the state allowed Florida transit systems, and Florida DOT, to focus their attention on other priorities, leaving emergency management and hurricane preparation as secondary targets. One reason Florida's transit systems responded so well to the threat of one of the worst hurricanes in modern history was because of the strong safety backbone promoted at all levels throughout each agency. Florida transit agencies have solid safety policies and procedures coordinated by Florida DOT and other contracted agencies. In addition, through programs sponsored by Florida DOT, like the Florida Transit Safety and Operation Network and its safety subcommittees, most of the agencies communicate regularly and have well-established relationships. These professional relationships allow for succinct timely communication and coordination throughout the state. Therefore, the mitigation phase in Florida is routinely exercised at many transit agencies and ever-present in their daily activities.

Florida's population is 35.8% native as of 2016, according to the U.S. Census Bureau's American Community Survey, meaning most people in Florida came from somewhere besides Florida. With more than 26.2% of the Florida population aged 60 and older, and 41.8% of Florida's population aged 16 and older not in the labor force (19), it is clear that many retirees choose to live in Florida. Additionally, many people are retired from geographical areas where hurricanes have never made landfall. Lack of familiarity with hurricanes causes some to underestimate the risks related with this type of meteorological occurrence. This lack of hurricane familiarity was noticeable during the 2017 hurricane season. Transit systems employ safety critical personnel that must be ready to report to work immediately after the declaration of the emergency. This can only happen

efficiently if those essential employees have been advised of their critical function during the hiring process and reminded before the onset of each annual hurricane season. All transit agency employees should have a plan in place to ensure their family's protection, otherwise they will not be available when needed, or they will not be focused on necessary tasks. At least 3 months before the official start of the hurricane season, it is imperative that transit agencies ensure that essential employees understand their commitment and have a plan in place. This plan should have the option for the employee and their family to evacuate, if needed, to a local shelter; to a transit facility with the ability to shelter in place; to other areas not affected by the emergency. Furthermore, the plan should indicate how the employee and their family will reach the designated location. If the decision is made to shelter in place, it is crucial to ensure all the necessary supplies (generator, gas, cash, water, food, etc.) are available. A plan should also be ready for pets, if the family has any. This preparedness will allow critical employees to be ready to report to duty, once the emergency arises, knowing that their families will be safe and protected.

Another lesson Hurricane Irma taught is the importance of having an updated statewide contact list. The contact list should be updated no later than May of each year. Transit agencies throughout the nation are challenged with employee turnover, including emergency personnel, and, as such, it is important that the contact information be updated within the transit agency and shared with Florida DOT to ensure seamless coordination and communication when emergency situations arise. Before Hurricane Irma, Florida DOT administrators, thanks to their vision and past experience, tasked the Center for Urban Transportation Research safety team with updating the emergency contact list for each agency within the state. Surprisingly, the list had not been updated in the past 5 years, and most of the emergency personnel listed had retired, changed positions, or changed organizations. If Florida DOT had not taken action, requesting an updated emergency personnel list, recovery actions in Florida would have been delayed, likely by several days. The emergency personnel directory allowed the state to have a detailed status report from each agency in Florida in real time, and permitted the prompt deployment of personnel and resources precisely where they were needed. In addition, having the updated contact information available afforded the state the opportunity to understand the exact fuel needs agencies had, allowing Florida DOT to prioritize assistance and restore services in a timely manner.

Florida has a unique peninsular geography, meaning three-quarters of its boundaries are touched by waters. The Atlantic Ocean covers the full eastern coastline, and the Gulf of Mexico touches all the West Coast. Further,

Florida has many little islands and unique keys as well as more than 11,000 mi of rivers, several lakes, and other water masses. Hurricanes are characterized by strong winds and heavy rains, which have the potential to cause widespread catastrophic flooding. Additionally, rural areas are often difficult to reach during the recovery phase. Therefore, it is important that people deployed to assist first responders and emergency personnel have the necessary equipment to rescue those individuals in need of immediate help. Hurricane Irma was particularly aggressive on the Florida Keys, causing U.S. Route 1, the only road that connect the keys to the mainland, to be impassable at several locations. In certain road segments, the asphalt was completely destroyed. Once military personnel restored circulation for emergency vehicles, Florida DOT deployed more than 150 workers to aid in the cleaning operations. The deployment required buses to assist in transporting those workers to the areas where debris accumulated. Florida DOT used transit system vehicles for this purpose. However, the drivers and the transportation coordinator did not have proper Florida DOT identification (ID), resulting in challenges and delays when passing through the checkpoints. Moreover, residents attempting to return home were queued at these checkpoints, making it very difficult for the buses to maneuver through the traffic congestion. Another lesson learned is the importance of ensuring emergency response personnel have proper ID available and ready to speed up the documents review at the checkpoints. Another suggestion from the transit first responders is to have law enforcement available to escort buses that are transporting DOT crews. A law enforcement escort could have reduced waiting times at the checkpoints, resulting in cheaper and more efficient emergency response operations. Certain areas of the Florida Keys also had communication challenges as mobile phone towers were damaged. The restoration took a long time, and the buses were not equipped with satellite phones. The lack of satellite phone availability left first responders without means of communication when traveling down to the keys. In the case of an emergency, such as a flat tire, there would have been no way to alert Florida DOT officials of the issue. Transit buses, when involved in emergency services, should have satellite phones that allow them to communicate any type of issue that could arise.

Once the immediate threat from Hurricane Irma had subsided and residents were allowed to return home from the shelters, the work of the transportation coordinators remained vital. Many of the residents with disabilities and immobile residents who required transportation to shelters also needed to be transported back to their places of residence. One specific lesson learned was related to the need to ensure that those residents still

have a safe place to return to. Transporting the most fragile population to a residence that is uninhabitable wastes valuable time and resources and contributes to additional stress for all persons involved. To avoid this pitfall in the future, the condition of the homes should be assessed before the release of populations with disabilities and older populations from the shelters.

Lastly, a standardized reporting system is crucial for keeping records of activities conducted. Transportation coordinators involved in emergency response and recovery need to track personnel hours, the fuel they used during the activities related to the emergency, miles traveled, vehicle identification for maintenance purposes, and all other related information. This information is required by federal agencies like FEMA to file for reimbursement. Furthermore, the reporting system should be standardized to allow all the necessary information to be communicated clearly and effectively. During Hurricane Irma, emergency transportation agencies in Florida mostly spoke directly with Florida DOT's central office. However, sometimes personnel were busy with other emergency activities, and the information could not be delivered in a timely manner. This issue could have been avoided if a centralized communication system had been established before the hurricane season. The model established by FEMA-NIMS (National Incident Management System) recognizes six main points in communication during emergencies. These principles are as follows (20):

- **Interoperability:** personnel should be able to communicate within and across agencies' and jurisdictions' communication centers.
- **Reliability:** communication should be able to function in the context of any kind of emergency.
- **Portability:** communication should be built on standardized radio technologies, protocols, and frequencies.
- **Scalability:** suitable for use on a small or large scale as the needs of the incident dictate.
- **Resiliency:** alternate methods of communication in the event that radio service is lost or there is damage to the communication infrastructure.
- **Redundancy:** alternate communications methods should be available if primary systems go out.

In other words, transit personnel involved in field operations should report to a centralized unit that collects the information, analyzes it, and transmits the essential information to the pertinent authorities, such as the DOT's central office. Centralized reporting would ideally be managed remotely as a website, possibly with mobile phone applications to allow for data input, plus a set of paper forms to collect and document the pertinent information when electricity is not available. Although there

is not a current centralized reporting system to share as a template, the lack of centralized reporting is one weakness that was identified following the 2017 hurricane season.

As transit professionals, it is important to learn from past experiences. This gained knowledge is not limited to personal experience but can be gleaned from others' shared experiences as well. Through attending presentations, many overall lessons were also learned in this study. The resounding lesson is that relationships and agreements should be in place long before an emergency arises. One specific example of the benefits of establishing agreements was apparent following the 2017 hurricane season when Hurricane Harvey made landfall in Texas. Houston Metro released the now famous photo of 120 empty transit buses lined along the closed express lane on Highway 59 in preparation for the flooding that was associated with Hurricane Harvey. This preplanned execution of storing the buses on high land, knowing that the bus yards were subject to flooding, resulted in Houston Metro only losing two of its approximately 1,230 bus fleet (21). Considering the area collected more than 50 in. of rain in 5 days, that outcome was considerably better than the alternative of leaving the buses in areas that were ultimately completely under water.

Key Takeaways

It is important to share the lessons that were learned in Florida from the Hurricane Irma landfall. The key takeaways are highlighted by emergency phase in the subsequent sections.

Mitigation Phase

Transit managers should ensure that their key personnel have a personal plan in place 3 months before the onset of hurricane season, to avoid last-minute actions. If there is not a plan in place to ensure their families are safe, employees will not put their work above their family well-being in an emergency situation. Transit agency risk managers should check the insurance coverage before the onset of hurricane season, verifying that all necessary information is updated and accessible. Transit agencies are also strongly encouraged to establish memorandums of understanding (MOUs) with any outside agency that may be able to assist in an emergency. One example of a mutually beneficial agreement is between the transit agency and local first responders. Establishing well-maintained relationships with local first responders will allow for seamless communication in times of emergency. One MOU that proved especially beneficial for Houston during Hurricane Harvey allowed the transit agency to park their buses along the high-occupancy

vehicle (HOV) lanes of a closed down overpass. Houston was aware that their bus yards were located in areas that were susceptible to flooding, thus prompting the establishment of the MOU that had been in place for nearly a decade (22). Stand-by, pre-arranged contracts with private sector vendors would also be beneficial for services such as oil cleanup, food services, or possibly even fuel services, to ensure the agency has access to the resources and services necessary when the recovery phase ensues. Finally, it is recommended to establish a centralized reporting system with each state DOT to allow for seamless communication and transferability of pertinent data before, during, and after the emergency.

Preparedness Phase

In the preparedness phase, transit agencies should ensure that the statewide emergency contact list is up to date for communication purposes. Accommodations for assets, like buses, are not typically available without prior agreements in place. Transit agencies should also be prepared to feed and shelter all employees that are expected to be available. The Florida transit responders indicated that having a temporary ID available for checkpoint access would have reduced some of the delays that were experienced when transporting workers to the disaster zones. In this phase, it is recommended that supervisors ensure that employees know how to use a centralized reporting system if one is in place.

Response Phase

The updated contact lists will be used in the response phase, and all previous efforts to keep that list up to date will pay off in this phase. In the response phase, clear constant communication, especially with shelters, is extremely important. This communication should include understanding the times that the shelter opens, what shelters accept pets, and which are full to capacity. Satellite phones would be beneficial on transit vehicles that are used to transport workers to the hardest hit areas, because downed lines make cellular communication impossible. Moreover, having an escort to get the buses through the lines of traffic once the areas are reopened to the public would reduce the delays that were experienced in Florida. Finally, if there is a centralized reporting system in place, the response phase is when it will be used.

Recovery Phase

The recovery phase could be improved most dramatically with the previously mentioned centralized reporting system. That system would allow for the pertinent information to be shared with all agencies, like the state DOT, which will require this information for all response

efforts. Other key takeaways include a recommendation to assess home conditions before releasing populations with disabilities or older populations from shelters, as returning them to uninhabitable locations is stressful to both the operator and the displaced individual.

Conclusion

The role of public transportation during declared emergencies continues to be at the forefront of transit safety discussions. Transit agencies across the United States face several emergencies, such as security incidents, internal crisis, terroristic attacks, and meteorological phenomenon, like hurricanes, that disrupt daily operations.

The previously cited report that resulted from a survey performed in response to the 2004 hurricane season revealed 23 best practices as a result of their postincident surveys (7). Many of these best practices align with the lessons learned from the response efforts associated with the 2017 hurricane season.

Good emergency plans should include key personnel contact lists, detailed checklists, and timelines for all emergency phases. MOAs are useful in establishing authorized assistance from nontransit local agencies; this was particularly useful in the case of Houston Metro and its ability to temporarily relocate its bus fleet away from flood-prone areas. Other bus parking strategies may include using buses as wind shields to help protect susceptible buildings, especially garage doors, when they are not located in flood-prone areas. Additional relationships that are beneficial in emergency situations include coordination with the local school board and other volunteers who may be called on to assist with evacuation efforts. This assistance may include providing school buses, drivers, and possibly even fuel. Education of both employees and their families, staff training with mock drills, including clearly defined expectations, are all imperative to ensure a successful response to an emergency situation. Another best practice is to establish a maximum wind level policy that allows for a clear understanding of when service must halt, considering the increased risk associated with the large bus side profile coupled with high sustained winds.

One best practice outlined in the 2005 report was the advice to fuel the bus fleet and staff vehicles before the storm event (7). The challenge that was faced in the 2017 hurricane season was the lack of fuel availability for extended periods of time leading up to Hurricane Irma's landfall. The challenges for finding fuel began nearly a week before the storm was scheduled to make landfall, and the shortage was exacerbated by the number of Florida residents evacuating long distances because of the ever-changing uncertainty of the hurricane's path.

Several other best practices are related to the preparation for disruptions in both communication systems and

power. Satellite phones, batteries, and power generators are worthwhile investments in areas that are prone to these types of natural disasters.

Best practices learned from past hurricane seasons highlight the importance of having several types of policies in place, including fare suspension policies, homeless and transient population evacuation procedures, and evacuation routes defined with bus assignments. These all help to ensure timely and effective responses to evacuation orders.

Events like Hurricane Irma, and the response Florida DOT coordinated with individual transit agencies, highlighted the preparation that Florida transit systems planned and executed to prepare for these types of emergencies. Hurricane Irma also underlined some gaps that, through the feedback and evaluation of lessons learned, can be closed, making the response to natural emergencies more effective with reference to costs and better use of equipment.

The 2017 hurricane season tested transit systems throughout Florida, reaffirming the imminent cyclical threat. Between June and November, hurricanes may strike this area and result in devastating damages. Transit agencies perfectly understand that a crucial key to being prepared is training. Training should be effective and focus on emergency phases.

This report focuses on the role of transit agencies during natural emergencies, like hurricanes, but it is important to recognize that the lessons learned and described in this paper highlight some weaknesses that can be corrected to improve the response in future events. Moreover, transit agencies face many other emergencies that can pose significant problems to their operations. This is a topic that warrants further examination. There is no doubt that many of the findings that result in recommendations will require budgeting adjustments and possibly funding beyond what is currently available to many transit agencies. Although this research did not focus on the cost of implementation, transit agencies could greatly benefit from future research that does.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: JG, GS; data collection: JG, RY, GS; analysis and interpretation of results: JG, RY, GS; draft manuscript preparation: JG, GS. All authors reviewed the results and approved the final version of the manuscript.

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