State of Good Repair in an Era of Climate Change

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in collaboration with the American Public Transportation Association (APTA)

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Room 283 - 285, Second Level, Convention Center
APTA Annual Meeting & EXPO 2011 New Orleans, LA

WORKSHOP AGENDA

Introductory Remarks: Therese McMillan, FTA Deputy Administrator

Keynote Speaker: Diana Ritter, Managing Director, New York MTA

Panel:

- Rob Hyman, Federal Highway Administration – U.S. DOT Gulf Coast Study
- David M. Springstead, Metropolitan Atlanta Rapid Transit Authority (MARTA) - incorporating weather and climate risks into asset management systems
- James Burke, National Disaster Preparedness Training Center, University of Hawaii – disaster preparedness training and climate adaptation in Hawaii
- Kate Mattice, FTA Deputy Associate Administrator for Budget and Policy - Moderator

Floods, heat waves, hurricanes, wildfires, and sea level rise threaten the state of good repair of transit assets and infrastructure. Weather records already show a worsening of these phenomena and robust climate science projects these trends to accelerate. Already struggling with bringing transit assets up to a state of good repair in the face of tight budgets, how do transit agencies respond to this threat? Come learn about state-of-the art risk management tools and what transit agencies in the lead are doing to respond. This is the second in a series of FTA workshops on climate change adaptation.

WORKSHOP HIGHLIGHTS

Welcome

Kate Mattice, FTA Deputy Associate Administrator for Budget and Policy, welcomed participants to the workshop. She explained that the panel would cover perspectives from research, practice, and training.

Introductory Remarks

Therese McMillan, FTA's Deputy Administrator, began her remarks with an example from a tour of the new streetcar line along Loyola Avenue that provided the opportunity to see different aspects of sustainability. It was telling for her to see the economic facet of sustainability as businesses are springing up in advance of the streetcar line's construction. A trip along the alignment that reaches into

the Ninth Ward pointed to another part of sustainability, the facet under discussion at today's workshop. Five years later, the impact of Hurricane Katrina is still evident. Stories from some of the poorest members of community are sobering and inspirational, showing resilience and reminding us that at the end of day, what we are talking about has direct effects on people.

Ms. McMillan stressed that it is important to be proactive on this timely and important issue; to adopt a well-grounded, risk-based approach to the challenges facing us; and to work with the transit industry to come up with solutions that can be integrated with existing policies and procedures. FTA is in the process of evaluating applications for a new climate change pilot program that will provide on the ground examples of what to do to prepare for climate impacts.

There's no question that changing climate patterns have the capacity to wreak havoc and devastation on transportation infrastructure. This past year alone brought tornados in Joplin, Mississippi River flooding, Hurricane Irene wrecking the East Coast, flooding in Vermont, and wildfires in Texas.

One of FTA's top priorities is bringing transit assets into a state of good repair—and cultivating best practices so that transit agencies can better manage and anticipate their maintenance and repair needs over time. The challenges are well documented. FTA's analysis shows an almost $80 billion backlog.

Throw in the stress of external climate factors and the challenge becomes even more significant. And transit equipment and facilities already in disrepair, or past their useful lives, are the most vulnerable of all.

Both science and common sense tell us we need to reduce greenhouse gas levels to lessen future climate impacts, while at the same time adapting to the climate impacts already being felt, as a result of past emissions.

Responsible risk management calls for adapting to reasonably foreseeable changes in climate conditions. Ms. McMillan said she wanted to hear from the panelists how they are beginning to do that at their agencies. She also stressed that there are opportunities to integrate adaptation strategies into asset management programs, the transportation planning process, and emergency preparedness plans.

As part of a larger DOT effort, FTA has recently issued policy communications clarifying its commitment to integrate climate change impacts and adaptation into planning, operations, policies, and programs. More resources and information on climate adaptation are available on FTA's website at www.fta.dot.gov/sustainability.

Ms. McMillan concluded that what those in the audience do informs what FTA can share with the rest of the country and that FTA seeks to work in partnership with the transit industry to adapt U.S. public transportation to climate change impacts.

Keynote Presentation

Diana Ritter, Managing Director for New York MTA, discussed MTA's efforts to mitigate the effects of New York City's changing climate on the public transportation system, explaining that some climate change impacts are already being felt.

First, Ms. Ritter provided a quick overview of MTA, the largest transit agency in the United States, with over 5600 track and route miles serving 8.5 million riders daily. MTA has an extraordinarily large amount of assets to operate, maintain, and replace in the face of climate change and must develop and implement strategies to protect these assets.

The forecast is quite compelling, she explained. According to a Columbia University study, New York summers will be hotter; in fact 2010 was the hottest summer on record in New York City and 2011 was the second hottest ever recorded in the United States. Precipitation intensity is increasing, as is the intensity of hurricanes and sea surface temperatures. These trends will continue and have huge implications for transportation infrastructure. Hotter temperatures can affect customers, employees and equipment – including rolling stock, track and electrical equipment. It also means increased energy consumption, increasing the possibility of blackouts and fluctuations in voltage. Like other transit agencies, MTA assets are particularly vulnerable to flooding because many of them are in low lying areas or below sea level. Increases in coastal flooding and storm surge threaten assets not built to withstand saltwater conditions.

Ms. Ritter showed a timeline of a number of significant storms since 1990, including the rain storm of August 2007, which had a peak intensity of 2.2 inches per hour, and the blizzard of December 26-27, 2010, with a snowfall intensity of three inches per hour and wind gusts of over 40 mph. These events can flood tunnels and streets, bringing transportation to a standstill and having disastrous effects on assets. Images of damage from recent storms illustrated her point. Photos of the August 2007 flood showed rising floodwaters entering the system and overwhelming the capacity of drains and pumps during the morning rush hour. Images of the December 2010 snow storm, which was particularly pronounced because of poor forecasting and low availability of employees on the day after Christmas, showed vehicles stuck in deep snow. Hurricane Irene in August 2011 was predicted to pass through New York as a Category 1 storm with high winds and storm surge. In response, for first time in its history, MTA coordinated a system-wide shutdown. Hurricane damage was extensive. Damage to the Port Jervis commuter line for instance is expected to take many months to years to totally repair. Images of storm damage available on MTA's website show a Metro-North station submerged under water, significant track damage, flooding of tracks and yards in the subway system, and coastal flooding. MTA estimates costs at $13.9 million in lost revenue alone and $ 7.7 million in preparation and response costs.

Ms. Ritter then turned to what she called the most important part, MTA's response. The response is twofold, involving both adaptation and mitigation. Adaptation modifies assets and operations to better protect against the expected impacts of climate change. Mitigation strategies reduce contributions to the causes of climate change by reducing energy use and emissions.

MTA has undertaken a number of activities to respond to climate change, such as partnering with Columbia University under the Blue Ribbon Commission on Sustainability, retrofitting the system to better respond to flooding, and introducing sustainable design elements. MTA also developed and continues to update the agency's inclement weather plans, including the flood plan, winter operation plan, and hurricane plan. Debriefings after each weather event are intensive, and staff spend weeks analyzing operations and the condition of assets so as to better plan for future events. MTA also undertakes risk assessment as an ongoing process. For example, after the August 2007 storm, the agency issued a flood report with priorities for remediation. In fact, the locations identified as the highest priorities have now been retrofitted to control the amount of water that enters the system. Examples of interventions include raising ventilation grates and raising station entrances. Since 2007, 25 locations have been retrofitted and $89.9 million allocated. In addition, some stations in the MTA system drain directly into the city's sewer system with no pumping mechanism. These locations are particularly prone to flooding when the city's sewer system is overwhelmed. Since MTA is unable to increase the capacity of the sewer system, which is currently only designed to accommodate a two-year storm, the only defense is to prevent the backflow of water into MTA facilities. As such, MTA has installed check valves that prevent the back-up of water onto the tracks in the event of a combined sewer overflow. This is, however, intensive capital work.

Preparation before storms is key to making sure assets have limited exposure to damage. Maps in MTA's hurricane plan show areas particularly prone to flooding under Category 1, 2, 3, and 4 storm scenarios. Thirty percent of MTA bus facilities are at or below sea level. Moving assets out of harm's way is crucial. In preparation for storms, MTA stores vehicles in parts of the system not prone to flooding, builds flood walls in the most vulnerable areas, covers ventilation grates with sheeting, and removes vital electrical equipment for storage in dry areas.

Fast and efficient recovery after the storm ends is the next step. Equipment and employees have to be staged and mobilized to inspect assets and return the system to service. After the complete system shutdown for Hurricane Irene, it took MTA only two and half hours to get the system up and running again. Transit employees and leadership worked together to pull off this miraculously quick recovery and media coverage was positive.

Internal and external communications strategy is critically important. During Hurricane Irene, incident command centers facilitated decision-making and communications, MTA coordinated heavily with city and federal agencies, and press conferences and the MTA website kept the public informed.

While Ms. Ritter's presentation mostly discussed adaptation, she also briefly addressed MTA's mitigation efforts, including solar panel arrays, green roofs, hybrid buses, rain garden catchments and wash water recycling. While making changes and doing its part, mitigating climate change is much larger than MTA and requires action on a much broader level.

Ms. Ritter concluded her presentation by recommending that transit agencies seeking to improve their resilience to a changing climate 1) pursue partnerships with research centers and universities, 2) identify and address vulnerabilities in their systems, 3) build and procure assets to higher standards, and 4)

develop and refine weather plans - including strategies for predicting events, preparing and protecting assets, internal and external communications, and recovering and restoring service.

Panel Presentations

Rob Hyman of the Federal Highway Administration (FHWA) discussed the U.S. DOT Gulf Coast Study, a multi-modal study that FHWA manages on behalf of the U.S. DOT Climate Change Center and participating agencies, including FTA. The effort is a study of the risks and vulnerabilities climate change poses to transportation infrastructure in the Gulf Coast region. It has two phases. Phase one was completed in 2008 and provided an overview of climate impacts on transportation infrastructure in the entire central Gulf Coast. Phase 2, underway now, is a more focused study, using Mobile, AL as a case study. It is intended to result in tools that other jurisdictions can use in assessing vulnerabilities.

Phase I was one of first large scale studies on climate impacts on transportation. The results were eye opening, showing a large portion of infrastructure to be vulnerable. Gulf Coast region infrastructure vulnerable to four feet of relative sea level rise includes 24% of interstate miles, 28% of arterial miles, all New Orleans transit assets, 72% of freight port facilities, 9% of rail miles, 20% of rail freight facilities, and three airports. Infrastructure vulnerable to an 18 foot storm surge (for comparison, Katrina had about a 25 foot storm surge) include 51% of interstate miles, 56% of arterial miles, most transit authority facilities, 98% of port facilities, 33% of rail miles, 43% of freight facilities, and 22 airports.

The broad overview provided by Phase I proved useful as a first snapshot, but had limitations that indicated a need for a more detailed assessment. Some limitations may have resulted in overestimates of vulnerability: the analysis of impacts was based on land elevation rather than the height of facilities; and the analysis does not consider the presence of possible protective structures (levees, sea walls, etc.). Other limitations may have resulted in underestimates: for instance, a small flooded segment may render a larger portion of the infrastructure inoperable, due to the connectivity of the intermodal system; and many transportation facilities depend on local roads which are not elevated. To overcome these limitations, the Phase II analysis was scoped to be much more detailed, on a more focused study area. Phase II also has a larger budget.

The methodology for Phase II follows the conceptual model that FHWA designed to help state and local entities scope vulnerability and risk assessments. The framework has the flowing steps: 1) develop inventory of infrastructure assets; 2) gather climate data; 3) assess vulnerability and risk of assets to projected climate change; 4) analyze and prioritize adaptation options; and 5) monitor and revisit. Phase II focuses on the first three steps.

Inventorying assets and identifying critical transportation systems is particularly applicable to today's session on state of good repair. The Gulf Coast Study delineated important assets by developing a scoring summary based on available data. It required significant engineering judgment to fill data gaps. In addition, what is "critical" will vary by community. FHWA found in Mobile that after a methodical engineering analysis, Mobile stakeholders asked why a seafood port was not included which was important to them for identity and economic activity but had not ranked highly according to the study criteria.

As part of the criticality analysis the study mapped the transit assets in the region (including the two bus facilities and the fixed-route bus service) overlaid on locations with high proportions of low income and minority residents.

Identifying the relative sensitivity of each asset to climate effects comes next. For instance, what wind speeds would stop operations, or what water levels would cut off access to the entrance ramps?

Gathering the climate data follows. The study developed the needed climate data in partnership with the U.S. Geological Survey (USGS). One challenge in generating data useful for transportation is that the data from the global climate models is on a very large geographic scale. The models create outputs for each grid cell, which typically cover an area 50 to 300 miles wide, making it of less use to specific metropolitan areas. As such, the study developed statistically downscaled data. This was done using a regression model to compare the output of global models to regional conditions. Researchers ran the global model for historic time periods, compared the outputs to actual historical data, developed a regression model that quantified the relationship between global outputs and actual data, and then used the model to generate future projections. An advantage of downscaled projections is that they are good for showing local variability and extremes. Information on extremes is more important to transportation engineers than annual averages. For instance, the number of days above 95 degrees is important for predicting rail buckling, and the exceedance probability for precipitation across two and four consecutive days is important for culvert size.

The temperature data generated for the study found large increases in the number of very hot days, with implications for track maintenance, paratransit demand, and worker and customer health. While current summers in Mobile typically have ten to twenty days above 95°F, by to 2070-2099, that number is projected to increase to 50 to 90 such days, depending on emissions scenario.

The precipitation results are less clear. The range of multiple model results show both positive and negative values, meaning some models indicate precipitation increasing and others decreasing. Precipitation is much more difficult to model because of complex interactions in the atmosphere.

For sea level rise and storm surge, the study used a scenario approach rather than climate model outputs, since the models do not typically focus on these variables. The study team used the literature to determine a reasonable expected range for sea level rise and storm intensification. The team then used sophisticated modeling, incorporating the topography of the Mobile region and wave dynamics, to analyze how the storm would come ashore. The analysis also included subsidence data. The sea level rise results include maps showing 30cm, 75cm, and 200cm of sea level rise. 200cm floods a large portion of downtown Mobile. The high end scenario could be looked at as either a less likely scenario, or as a longer term scenario. The team tested the storm surge model against actual data from Hurricane Katrina and found that the model performed well. The team developed scenarios with different variables for sea level rise, paths, and storm intensification. Mr. Hyman showed maps indicating flooded areas under different scenarios. In combined storm surge and sea level rise scenarios, storm surge is the larger factor in flooding. The study is due to be completed 2013 and study deliverables will be uploaded to the website as they are completed.

DOT has already learned a number of lessons from the study: 1) Site-specific climate projections are difficult to find. Downscaling global models is a complex activity. Universities are often important players in developing this data and have been partners in many assessments. Some national-level downscaled data is available, such as climatewizard.org. 2) Transportation asset inventory data is time consuming to assemble. There are many different sources even within one agency in many different formats. LIDAR data does not capture all needed details, such as man-made sea walls. 3) Interdisciplinary cooperation is key, with a need to include science information, engineering specifications, planning processes, etc. However multi-disciplinary stakeholder communication is not easy and requires understanding existing decision-making processes and frameworks. 4) Impacts and concerns will vary by region. There are no one-size-fits-all answers. 5) Practitioners must be comfortable with range of climate projections. Not all climate trends are clear. Transportation engineers often want a single answer, but that is often not possible.

David M. Springstead of the Metropolitan Atlanta Rapid Transit Authority (MARTA) discussed opportunities for incorporating weather and climate risks into MARTA's asset management systems. Mr. Springstead began his presentation by showing photographs of flooding damage to transportation infrastructure. He then gave an overview of MARTA assets and operations, which include 338 rail cars, 120 track miles, 530 buses on 92 routes, and 175 paratransit vehicles.

MARTA's vision for asset management includes a solid, accurate database, a process for the asset management plan to feed the capital improvement plan, and a systematic program to prioritize projects in the long-range capital improvement plan. Asset management systems must balance a broad range of factors and influences, including climate change impacts in addition to more traditional areas such as safety assessment and project life cycle management. MARTA's asset management system takes a three-pronged approach, encompassing a condition assessment process, asset analysis tools, and asset management decision-making. The project team structure involves departments from across the agency. MARTA's condition assessment methodology uses updated and scrubbed asset data, third party assessors, randomly generated asset samples, and statistically significant data. As the result of an earlier study in 2005, MARTA had already loaded over 41,000 assets into the system. However, asset information was complete for only 18% of the items. This included information on physical Location, value, priority, condition, estimated useful life, and asset breakdown structure. Climate change was not considered in 2005. Over the past year, MARTA staff have added over 10,000 additional assets. Now 99% of the assets have complete information and more assets may be added. MARTA matches the level of detail of the asset (whether to specify by component or system) to the level of granularity used for procurement and safety.

Mr. Springstead shared the table below, listing opportunities to incorporate climate change adaptation considerations into asset management systems.

Element of Asset Management System	Opportunity to Incorporate Climate Change Adaptation
Goals and Policies	Incorporate climate change considerations into asset management goals and policies; these could be general statements concerning adequate attention of potential issues, or targeted statements at specific types of vulnerabilities (e.g., sea-level rise).
Asset Inventory	Map infrastructure assets in vulnerable areas, using GIS where possible; inventory critical assets that are susceptible to climate change impacts.
Condition Assessment and Performance Monitoring	Monitor asset condition in conjunction with environmental conditions (e.g., temperature, precipitation, winds) to determine if climate change affects performance; incorporating risk appraisal into performance modeling and assessment; identification of high risk areas and highly vulnerable assets. Use of "smart" technologies to monitor the health of infrastructure assets.
Alternatives Evaluation and Program Optimization	Include alternatives that use probabilistic design procedures to account for the uncertainties of climate change; possible application of climate change–related evaluation criteria, smart materials, mitigation strategies, and hazard avoidance approaches.
Short and Long Range Plans	Incorporate climate change considerations into activities outlined in short- and long-range plans; incorporate climate change into design guidelines; establish appropriate mitigation strategies and agency responsibilities
Program Implementation	Include appropriate climate change strategies into program implementation; determine if agency is actually achieving its climate change adaptation and monitoring goals**.**
Performance Monitoring	Monitor asset management system to ensure that it is effectively responding to climate change; possible use of climate change–related performance measures; "triggering" measures used to identify when an asset or asset category has reached some critical level

Source: Michael D. Meyer, Adjo Amekudzi, and John Patrick O'Har entitled, "Transportation Asset Management Systems and Climate Change Adaptive Systems Management Approach."

Mr. Springstead gave the example that three years ago, tremendous rains hit Atlanta. In some areas, complete houses were underwater. MARTA was able to manage the storm by rerouting buses. Rail service never stopped.

He stressed the importance of monitoring systems such as temperature alarms and water level alarms. MARTA had an experience in which after a primary pump failed, the redundant pump worked as planned until it too failed, at which point, the third rail flooded and MARTA had to shut down that segment. If they had had a water level monitor, that would not have happened.

Evaluating climate risks (location, probability vulnerability hazards, etc) could be incorporated into MARTA's assessment approach. MARTA is teaming with GeorgiaTech and recommends that other transit agencies also partner with universities.

MARTA is currently partnering with software provider AssetWORKS to upgrade its enterprise asset management system. Planned upgrades to software to include planning and capital project prioritization based on a number of factors (which may include climate change and other non-traditional factors).

James Burke of the National Disaster Preparedness Training Center at the University of Hawaii discussed disaster preparedness training and climate adaptation in Hawaii.

The mission statement of the National Disaster Preparedness Training Center at the University of Hawaii is to develop and deliver disaster preparedness lessons and recovery training to governmental, private, and non-profit entities, incorporating urban planning with an emphasis on community preparedness and vulnerable at-risk populations. The Center is part of a consortium of centers funded by the Federal Emergency Management Agency (FEMA), but is the only one focused on natural disasters, which affect more people than terrorist attacks.

Hawaii is particularly vulnerable to climate change, especially sea level rise and hurricanes. Mr. Burke showed a photograph of the main highway on Oahu, which rings the island. The photo shows the road within only a few feet of the ocean.

Earlier this year, when the island experienced a very high tide, Honolulu Transit planned to have bus operators record where water seeped up into road as this could give an indication of areas particularly vulnerable to sea level rise. Unfortunately it rained, so Honolulu Transit was not able to perform the test.

A map of Waikiki showing one meter sea level rise shows much of this high economic value tourist area under water, including roads with bus routes. This is the shock factor showing why Hawaiians are concerned.

Honolulu Transit began planning the Middle Street Intermodal Center and Paratransit Facility a few years ago. The selected site was in the 100-year floodplain. The U.S. Army Corps of Engineers recommended a five-foot high flood wall to mitigate flooding risk. City planners however wanted a smaller wall, at only two feet. As such, Honolulu Transit filled in the site with three feet of earth and built a two foot flood wall. This took the site out of the 100-year floodplain. Still, when there is a tropical storm or hurricane, the agency must relocate 160 paratransit vehicles. The agency increased the size of another location in order to accommodate 50-75 of these vehicles. The remainder are stored on a nearby military base with which they have an agreement. Mr. Burke showed another adaptation example of expanding a narrow beach by replenishing a sand bar.