

Getting on the Right Track: Real-World Approaches to Climate Change Adaptation

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This summary provides highlights from FTA's third climate change adaptation workshop. The workshop convened approximately 100 representatives of public transportation agencies, universities, government agencies, non-profits, and private sector firms. Participants discussed the important issue of ensuring that public transportation systems continue to provide quality service under severe weather and changing climate conditions. The salience of the issue was highlighted by recent events such as Hurricane Irene, Mississippi River flooding, and drought and wildfires in Texas that gave transit agencies experience with the types of events projected to become more common. As this was the third in a series of FTA workshops on the topic, the intent was to build off the earlier workshops by providing grounded tools for adaptation and facilitating peer exchange.

The workshop began with a panel of high level transit decision-makers who offered perspectives on the challenges that transit agencies face in responding to climate impacts. Their identification of information needed for decision making set the stage for the rest of the workshop. Next, researchers from Columbia University with expertise in both climate science and infrastructure shared a framework for adaptation assessment. A case study from New York and perspectives from that city's transit agency provided a grounded example of the framework's use. Subsequently, a Federal Emergency Management Agency (FEMA) representative shared results from a recent study on floodplain expansion due to climate change. Participants then divided into three working sessions where they conducted mock risk assessments, experimented with mapping tools, and shared strategies for communicating climate change and getting buy-in.

On the second day, representatives of FTA-funded pilot projects discussed their approaches to assessing transit vulnerabilities to climate hazards. Participants also heard lessons learned from Federal Highway Administration (FHWA) efforts. Next, participants divided into breakout groups and developed strategies for mainstreaming climate change considerations into a range of transit agency practices, including capital program management, emergency management, planning, operations and maintenance, and environmental review and compliance. During the closing session, participants offered ideas on how FTA can further assist the transit industry in enhancing the resilience of public transportation assets to climate change.

Over the course of the two day workshop, participants grappled with how to develop the information, strategies and tactics necessary to respond to the high level needs broached by the industry leaders at the opening session. While this summary cannot do justice to all of the ideas and themes that were

raised, it attempts to hit the highlights. Readers are also directed to speaker presentations available on the FTA website at www.fta.dot.gov/adaptation, as well as additional resources on the topic at that same link.

Introductory Remarks and Setting the Stage Panel

FTA Deputy Administrator Therese McMillan welcomed the participants to FTA's third workshop on climate change adaptation. Ms. McMillan was pleased by the transit industry's progress in making climate change adaptation a fact-based, solutions oriented, front burner issue for FTA and transit partners. The issue ties directly to key FTA strategic goals of addressing state-of-good repair needs and enhancing transit safety. The earlier workshops were effective in helping to articulate the challenges and issues, learn more about the science behind climate change impacts and begin to gather best practices.

She noted that the objectives of this workshop were to:

1. share analytical methods and tools for climate adaptation;
2. shape ongoing and future transit adaptation assessments by exploring successful approaches;
3. develop strategies for mainstreaming climate considerations as part of a transit agency's standard operating procedures; and
4. gather ideas to inform FTA's work on climate change adaptation planning.

Ms. McMillan noted that while we may not have direct control over climate change and natural disasters, we can control how we respond. We can reduce emissions, and we can adapt to the impacts underway. Adaptation is all about better planning, risk management, and integrating climate change considerations into day-to-day operations and planning.

Nat Bottigheimer, Assistant General Manager of Planning and Joint Development for the Washington Metropolitan Area Transit Authority (WMATA), provided perspectives from the host city of the workshop. Mr. Bottigheimer noted that the DC region is very much organized economically around the metro and that if transit were to become degraded or disrupted by climate hazards, this would have severe impacts on the region. Impacts that WMATA faces include track flooding and rail buckling from high heat. He provided the example of an area on the National Mall where WMATA typically places sandbags around ventilation grates when heavy rains are predicted in order to prevent flooding in the subway tunnels below. He also showed photos of passengers backed up into the street due to flooding delays at Braddock Road station in Virginia and passengers backed up on subway platforms due to delays from rail buckling caused by heat waves. Mr. Bottigheimer concluded by noting the following challenges to mainstreaming climate adaptation into transit practices: 1) measuring the regional economic impact of climate-induced service disruptions; 2) developing robust risk evaluation tools that incorporate climate impacts in order to prioritize asset investment decisions; 3) making the business case for capital project prioritization for adaptation strategies; and 4) coordinating with multiple entities that have related responsibilities.

Jeff Knueppel, the Assistant General Manager and Chief Engineer for the Southeastern Pennsylvania Transportation Authority (SEPTA), noted that his job is completely intertwined with the weather. A

major challenge he faces is maintaining ridership while adapting to the changing weather. SEPTA has been adapting to climate change for quite some time (even if it has not been recognized as such) and is now formulating a formal approach to it. Some of the approaches that SEPTA has taken to address changing weather patterns include: covering vent wells, setting up crews in pump rooms to remove debris, bringing in tree trimmers, moving vehicles in flood prone areas, brush cutting, paying attention to secondary drainage elements, moving third rails out from under platforms, adding salt domes, restructuring snow contracts, replacing vent wells, and raising signal huts. Mr. Kneuppel noted that it is critical to have response plans in place and to pay attention to workforce utilization, costs, and weather forecasts and alerts. In terms of communication, there is a lot of value in working with other agencies and utilizing social media. SEPTA is currently participating in a climate change adaptation pilot project funded by FTA and led by ICF. The pilot focuses on the Norristown line, which runs parallel to the Schuylkill River and suffers from frequent service disruption during flooding events. Mr. Kneuppel is interested to see the recommended adaptation strategies that will result from the pilot and how the pilot will inform future adaptation planning at SEPTA.

Harriet Tregoning, the Director of the Washington, DC Office of Planning, emphasized the need to adapt public transportation to climate change impacts in order to preserve the service transit offers the community. Transportation choices are essential to livability and economic competitiveness. DC has the largest bikeshare in the country, which depends on transit and expands the transit shed. Ms. Tregoning noted that during extreme weather, bike/walk trips decrease and people rely on other transit. She concluded her presentation with an overview of Sustainable DC. Sustainable DC is an effort that was launched in July 2011 by Mayor Gray to help make the District the greenest, healthiest, most livable city in the country. Mayor Gray launched nine working groups to examine best practices, existing conditions, and community input to develop sustainability recommendations. In the climate working group, adaptation was identified as the new top priority. Some ideas for adaptation included white and cool roofs, smart trees, green infrastructure and health protection.

John MacArthur is the Sustainable Transportation Program Manager for the Oregon Transportation Research and Education Consortium (OTREC). OTREC surveyed 150 transit agencies and concluded that transit agencies are currently just beginning to understand adaptation. About 10% of all transit agencies surveyed are currently considering adaptation. Mr. MacArthur noted that most transit agencies that are addressing adaptation serve cities that have active climate adaptation plans and efforts. The departments within transit agencies that are most involved in climate adaptation are emergency response, planning and design. Although the operations and maintenance departments are less often involved, they have a potential to be key players in adaptation planning because maintenance staff are highly knowledgeable about existing weather impacts and maintain records of issues. Transit agencies in the survey noted that the lack of policy, funding, knowledge and leadership are barriers to climate adaptation action. Finally, Mr. MacArthur highlighted a need for transit agencies to focus on return on investment and visualization tools to help leadership and the public realize potential impacts and understand uncertainty related to climate change. It is also important for agencies to connect to regional efforts and strengthen partnerships with other organizations and agencies.

Adaptation Assessment

Dr. David Major of Columbia University presented results from the New York City Panel on Climate Change Report titled *Climate Change Adaptation in New York City: Building a Risk Management Response*. The report is available from the New York Academy of Sciences and can be downloaded for free. In the report, agencies identified future climate hazards and conducted inventories of at-risk infrastructure and assets. The eight steps included in an adaptation assessment are:

1. Identify current and future climate hazards
2. Conduct inventory of infrastructure and assets and begin to identify vulnerabilities
3. Characterize risk
4. Develop initial list of strategies
5. Identify opportunities for coordination
6. Link strategies to rehabilitation and replacement cycles
7. Prepare and implement adaptation plans
8. Monitor and reassess

Dr. Major listed immediate needs for agencies addressing climate change, which included developing cost benefit analyses for different adaptation options, creating inventories of all built infrastructure, and preparing high resolution LIDAR (Light Detection and Ranging) elevation datasets. He concluded with recommendations that agencies develop methods to operationalize adaptation steps for different circumstances and that they consider future impact scenarios now to avoid catastrophic impacts.

Dr. Klaus Jacob of Columbia University discussed a case study of New York City that examined the impact of coastal storm surge on transit systems. He discussed the use of risk management tools, where risk is a function of hazards, assets, and vulnerability. Risk is reduced by adaptation approaches that address hazards, protect assets and reduce vulnerabilities. Analysis of sea level rise should take into consideration the frequency of flooding. Dr. Jacob noted that the 1% annual chance flooding case will soon become the 10% annual chance flooding case and that agencies must start planning for this. Agencies need to develop and implement engineering standards and then conduct quality control of their assets. The New York City subway system is particularly vulnerable to the combined impact of sea level rise and storm surge. Per model estimates, if a 100 year flood occurs, it will take only 40 minutes to flood the New York subway system. It will take time and equipment to pump this water out and return the system to operation, which requires a minimum of 21 days and may take up to a year in some places. The economic loss that results from a New York City subway shutdown is estimated at \$4 billion per day. Some adaptation activities that the study examined include sealing vents, installing flood gates and performing engineering studies. Dr. Jacob recommends that agencies incorporate current climate data into planning and capital decisions and incorporate a buffer into storm surge height estimates. He notes that agencies will save money by considering these impacts now, rather than going back and addressing them after they have incurred huge losses.

Projjal Dutta of New York Metropolitan Transportation Authority (MTA) discussed some of MTA's current adaptation efforts. To prevent flooding, MTA has recently raised 19 station entry pads, paved

over 770 ventilation gratings, raised 813 ventilation gratings, and installed 14 mechanical closing devices, at a total cost of \$33.6 million. Mr. Dutta pointed out the irony that adapting transit to climate change impacts takes funding away from expanding transit service, which is a strong strategy for reducing regional greenhouse gas emissions and thus lowering overall climate impacts.

Impact of Climate Change and Population Growth on the National Flood Insurance Program

Mark Crowell of the Federal Emergency Management Agency (FEMA) shared the methodologies and key findings from a recently completed FEMA-sponsored report that examines the impacts of climate change on the National Flood Insurance Program. The study examined coastal flooding from sea level rise and storm surge as well as inland riverine flooding from increased heavy precipitation. Key findings from the report include:

- Riverine: The 1% annual chance (100-yr) floodplain depth and width is project to increase, on average, by 45% across the nation by 2100. (About 30% of the increases is attributable to population growth, while 70% represents the influence of climate change.)
- Coastal: Coastal 1% annual chance floodplains may increase anywhere from 0% to 55% by 2100, depending on type and scale of shore protection measures.
- Combined Riverine and Coastal: The weighted national average size of the floodplains may increase by about 40% to 45% by 2100.
- Population within riverine and coastal floodplains will increase by approximately 130-155% by 2100.
- The total number of policyholders participating in the National Flood Insurance Program is estimated to increase approximately 80-100% cumulatively through the year 2100.
- The average premium per policy will increase by about 10-70% in today's dollars, because of the increase in flooding caused by climate change.

Mr. Crowell noted that the conclusions of the study indicated that there is a need for FEMA to directly incorporate the effects of climate change into various aspects of the National Flood Insurance Program. The study did not address options for how climate change might be incorporated into the program.

Working Session Breakouts

Breakout 1: Interactive Risk Assessment

Participants were divided into groups and each group was given a scenario comprised of two parts: a region of the country and a mock transit agency description. Groups were instructed to brainstorm potential climate change impacts for their scenario. Things to consider included: the climate variable, impact and consequence, adaptation strategy, timing of implementation, and operational linkages. Next, the team prioritized risks according to likelihood and consequence using the risk matrix provided.

Key risks that the groups identified included: precipitation, sea level rise, temperature, coastal storm surge, wind, drought, and wildfires. Temperature, coastal storm surge, and precipitation were ranked as

having a high likelihood of risk and a high impact on transit in most of the regions discussed. Sea level rise was ranked as having a low likelihood of risk near-term, but high impact long-term. Wind, drought, and wildfires were ranked as having a low likelihood of risk and low impacts.

Participants highlighted the need for an increased focus on impacts to customers and workers. Climate impacts can affect passenger comfort, the reliability of an area's workforce and employee health. Several approaches to address this were discussed including: allowing flexibility in uniforms, providing water, conducting work at night, and providing better customer information (intelligent transportation systems, such as NextBus). Air conditioning loads and power reliability were also a major concern; there is a need for alternative power sources. There is a need for the implementation of planning strategies and action plans that include route detours and system redundancy. Over the long-term, land-use planning is a key adaptation strategy. In the short-term, it is critical for agencies to develop adaptation plans and to implement these by training their employees.

Breakout 2: Demonstration of Mapping Tools

Josh Murphy of the National Oceanic and Atmospheric Administration (NOAA), discussed NOAA's Sea Level Rise and Coastal Flooding Impacts Viewer. This tool is available on the web at <http://www.csc.noaa.gov/digitalcoast/tools/>. So far, most of the Gulf Coast information is available on the web. The remainder of the Gulf Coast region as well as the Pacific Northwest is expected to be loaded in Spring 2012, the San Francisco Bay Area in Summer 2012, the rest of California and the Mid-Atlantic region in Fall 2012, and the Northeast in Spring 2013. The tool is intended as a screening level assessment of sea level rise impacts. It provides consistent, standardized elevation data to avoid duplication of effort and assist state and local governments. It is a simple-to-understand visualization tool that shows potential impacts of sea level rise scenarios and shows how everyday tidal flooding will become worse and more frequent. The tool shows sea level rise overlaid on aerial imagery, street maps, and terrain maps. It also includes photos of sea level rise on individual structures to illustrate site-specific impacts. It shows zones of higher and lower certainty, coastal flood frequencies, impacts on marshes, population vulnerabilities, and economic vulnerabilities.

Sam Merrill, the Director of the New England Environmental Finance Center, demonstrated the Coastal Adaptation to Sea-level-rise Tool (COAST). COAST assesses costs and benefits of adaptation to sea level rise scenarios by incorporating a variety of existing tools and datasets. These datasets include data from NOAA's Sea, Lake, Overland Surges from Hurricanes (SLOSH) model, U.S. Army Corps of Engineers depth-damage functions from flooding, projected sea level rise data, property values, and infrastructure costs. This data is added to a GIS model to display location specific avoided costs associated with various adaptation actions. COAST can help planners determine what adaptation approaches will be the most cost-effective. The COAST model allows users to use observed local data, scenarios and visualization when talking to local communities. This tool can aid in decision-making by helping transit planners evaluate the costs and benefits of various adaptation options. More information on the tool can be found here: http://efc.muskie.usm.maine.edu/pages/projects_cre.html.

The files and webpages for the tools were pre-loaded onto computers in the breakout room. Participants experimented with the tools and viewed different scenarios.

Breakout 3: Strategies for Getting Buy-in and Communicating Climate Change

Justin Rolfe-Redding, a doctoral student at George Mason University's Center for Climate Change Communication, launched the discussion with some information and advice on communicating climate change to a variety of audiences. Some of the challenges of communicating climate change can be attributed to the characteristics of the issue: the impacts are distant and intangible, the science is complex, the issue is politicized, and the solutions seem difficult. However, Mr. Rolfe-Redding pointed out that people are receptive, and if offered credible messengers (those with trust and expertise) the likelihood that they will listen increases. Researchers at George Mason University conducted a large survey and found that Americans tend to fall into six general categories in terms of attitudes towards climate change: alarmed (13% of the population), concerned (28%), cautious (24%), disengaged (10%), doubtful (12%), and dismissive (12%). To maximize impact, agencies should target their most important audiences and tailor the messages accordingly. Communication approaches should activate the alarmed and concerned, convince the cautious and disengaged, and reach out to the doubtful and dismissive. Mr. Rolfe-Redding concluded that the formula for high impact communication is simple clear messages, repeated often, by a variety of trusted sources. The key narrative is: "Climate change is happening. It is real and we are measuring it. People are causing it this time. Virtually all scientists agree on this. It will be harmful to people. We can limit the damage if we choose to. We can lower the damage by reducing emissions and we can adapt with better planning."

Participants in the breakout session then divided into groups and selected a situation in which they needed to communicate to members of the public about actions that their transit agency was taking related to climate change adaptation. Participants discussed how messages could be tailored to different groups based on differing perspectives.

Next, Rachel Healy, Chief Sustainability Advisor at WMATA, discussed strategies for getting buy-in within the particular context of a public transportation agency. She noted that all of the participants work in a particular job in a particular organizational culture, which greatly influences which buy-in strategies will be most effective. Some transit agencies for instance have a military-type culture, very hierarchical where lower organizational units are expected to carry out orders from the top. Others have an engineering culture, where the emphasis is on analysis and optimization. In many transit agencies, the capital and operating parts of the agency are separated, which means that optimal life cycle decisions are often not chosen. Asking questions such as "how can we do this more efficiently?" can stimulate discussion and encourage problem-solving across organizational units. Professional identity is a large part of personal identity. As such, it is not surprising that planners are more likely than others to embrace the concept of climate change, as they are accustomed to big picture thinking and large ranges of possibilities. Engineers, with strong capacities in analytical methods and tools, may become frustrated when told they need to provide an answer but are not given the relevant information to be able to do so. Meanwhile, most professionals become frustrated when told they need to address yet another area while at the same time still being responsible for all of the other items under their

purview. As such, it is helpful to incorporate adaptation considerations into existing processes and to take a risk management approach to deal with incomplete information.

Participants then divided back into groups and conducted an exercise in which they developed a tailored strategy for approaching an individual within their agency on a climate change issue.

Participants then shared with the larger group what they had learned from the discussion. Framing climate adaptation as an issue of service reliability was one recommended strategy. Another was to frame adaptation not as a capital cost but as an operations savings. Participants also raised the issue of getting buy-in from other public agencies outside of the transit agency, such as departments of public works.

Adaptation Pilot Projects

Tina Hodges of FTA gave an overview of FTA's goals for the climate change adaptation assessment pilot projects the agency is funding. FTA selected seven pilot projects funded at just over \$1 million and scheduled to be completed in May 2013. These pilots will provide case studies to increase knowledge on how transit agencies can adapt to climate change. FTA's objectives are to gain insights on thresholds for impacts, adaptation options, costs and savings from adaptation strategies, and strategies for mainstreaming adaptation into transit agency practice. FTA also intends for the pilots to be able to tell a strong narrative to other transit agencies by having concrete examples. Ms. Hodges noted that adaptation is just better planning and risk management. Pilots should think about how to plan for future conditions in addition to analyzing past impacts. Unlike FHWA, FTA is not piloting a new model and thus pilots should use existing tools. Rather than focus on detailed, original climate science, FTA is encouraging the pilots to use climate science that is already well established (such as the direction of change and increases in extremes) and focus on transit impacts and strategies. FTA looks forward to the pilots serving as examples of transit agencies that are taking steps to limit damages and having success.

Rebecca Lupes of FHWA discussed lessons learned from the FHWA climate change adaptation pilot projects. FHWA developed a climate change vulnerability and risk assessment conceptual model to assist state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) in addressing climate change. The purpose of the pilots was to test drive this model as well as to accelerate existing efforts. The pilots focused on risk and vulnerability and did not take the next step of considering adaptation options. FHWA learned much from these pilots. These studies can take a lot of time and it is important to define the study objectives and scope up front. This includes looking at the potential audience, the desired output products and the level of detail that the study will entail. It is also important to identify impacts of concern and thresholds for these impacts. Pilots should keep in mind that these studies are iterative in nature (findings in one area influence data in another area). Also, collecting data on assets can be challenging because much of the data is not digital, is in different formats, and isn't consistently available. FHWA concluded that probabilities of impacts are hard to quantify and that low, medium, and high were as precise as the pilots could get. In conclusion, Ms. Lupes recommended that pilots focus on solutions and asset management.

Jeff Perlman of North Jersey Transportation Planning Authority (NJTPA) presented NJTPA's pilot project completed with FHWA funding. NJTPA established a partnership with six agencies with a goal to build capacity and an understanding of the issues and challenges of climate change. Mr. Perlman recommended that future pilots ensure that the project scope is not too broad initially. NJTPA's project scope included airports, coastal wetlands, tunnels, bridges, freight rail, passenger rail, and roadways in two study areas – a coastal area and a central area. The project first assessed the criticality of assets, as measured by connectivity, magnitude and degree of impacts and redundancy in capacity. LIDAR elevation data was used to derive a score for each road length to indicate criticality. Next, the project looked at sea level rise, flooding from heavy rainfall, and temperature projections using thresholds, not averages. Historic weather data was collected from local weather stations to assist with downscaling global climate change models to the local level. Downscaling introduces additional uncertainty since the models are not very robust at the local level. The project concluded that the Northeast Corridor, the River LINE, and possibly the Port Authority Transit Corporation (PATCO) line are all very vulnerable to flooding. There is a need for more targeted studies looking at the likelihood of flooding along these lines. There is also a need for better operations data to determine how travel patterns change as a result of storms to help agencies identify criticality and redundancy.

Karl Peet of Chicago Transit Authority (CTA) discussed CTA's pilot project funded by FTA. Chicago has a climate adaptation plan and has developed citywide adaptation strategies that include increasing tree canopy to reduce urban heat islands and developing sustainable streetscapes. Chicago is currently faced with extreme heat and precipitation. The approach for the pilot is to survey system vulnerabilities, identify shovel ready projects where adaptation principles can be applied, and examine how to integrate adaptation into standard business practices. There are urban heat island maps for Chicago and these can be combined with FEMA flood maps, the regional grid and CTA specific data. Operations staff needs to know how to better deal with climate extremes and how to work these into operations plans. The pilot will address system safety and security and how to integrate adaptation into capital asset management strategies and budgets.

David Springstead of the Metropolitan Atlanta Rapid Transit Authority (MARTA) gave an overview of MARTA's pilot project, which is being conducted in partnership with Georgia Tech. MARTA will take data from maintenance records and examine climate changes, monitor changes, and identify response strategies. They will then create a guidebook that can be used for other transit agencies to help improve planning and investment decisions. The guidebook will allow for the identification of current and future climate hazards, characterize the risk on agency infrastructure and operations and identify key elements of MARTA's asset management program that are conducive to climate change related information. MARTA will develop adaptation strategies and link these to agency organization structures and activities. The idea is to then embed these adaptation strategies as a business practice. The MARTA pilot has a specific focus on integrating climate impacts into asset management, capitalizing on MARTA's state of the art asset management system as well as Georgia Tech's expertise in this area. Finally, MARTA will roll out an agency-wide dissemination strategy for the adaptation strategy.

Cris Liban of Los Angeles County Metropolitan Transportation Authority (LACMTA) described climate change issues currently facing the Los Angeles region. In rainy seasons, bus stops are being moved due

to flooding and there is an increase in service disruptions. Mr. Liban hopes that the climate data will help inform mode selection, siting, and materials for the significant number of transit expansion projects funded under a voter-approved measure known as “Measure R.” There is a need to understand the nature and magnitude of risk, the planning and operational options for reducing this risk, and the relative costs and benefits of these options. The pilot will identify assets and services, analyze climate projections, identify vulnerability to impacts, and evaluate potential adaptation options to determine what services are critical. The pilot will also consider what system impacts will occur if a service or asset is removed from the system. LACMTA intends to develop a criticality index based on location, ridership, and connectivity and use this to analyze different vulnerabilities based on impacts to services and assets. A key component will be estimating costs of integrating adaptation into management and planning in an iterative way that can be monitored and updated. Upon completion of the pilot, LACMTA intends to adopt policies, change procurement requirements, revise design criteria and specifications, and identify mitigation measures. They also will integrate results from the pilot into their existing Environmental Management System (EMS) and Environmental Information Management System and develop outreach strategies.

Erik Johanson of SEPTA explained that the funding from FTA is enabling SEPTA to conduct adaptation research that they would not otherwise have been able to undertake. SEPTA has a legacy system that is especially vulnerable to climate change. SEPTA is partnering with their MPO for stakeholder outreach and long-range planning and with consulting firm ICF to actually execute the pilot project. The pilot will look at assets, service disruptions and operational impacts. The pilot will start with existing data on the Manayunk / Norristown commuter rail line, including service disruptions, and then build this data into the risk assessment model. Next, SEPTA will prioritize impacts and develop adaptation strategies. The output of the pilot will be a playbook of adaptation strategies based on information gathered in the planning process for use by a wide variety of stakeholders. The City of Philadelphia is considering using this pilot as a model for city adaptation plans.

Linda Cherrington of Texas Transportation Institute (TTI) discussed the partnership that TTI established for their pilot project. The partnership includes Texas A&M University (TTI), the Texas A&M Galveston Center for Texas Beaches and Shores and three public transit agencies in the Gulf Region -- Houston Metro, Tampa Hartline, and Galveston Island Transit. The partnership is a combination of transit professionals and university researchers. The pilot will not look at a single system or mode, but will look at the Gulf region as a whole. TTI hopes to coordinate with the FHWA study in Mobile, AL. The project will focus on the destruction of assets, the breakdown of transit operations (frequent and extreme events), the reduction in levels of service and the impact on passenger customer and safety. The pilot will begin with a literature review of case studies and outreach to other transit agencies. Because of the large scope of the project, TTI will focus only on the greatest impacts and risks.

Tian Feng of the Bay Area Rapid Transit District (BART) presented an overview of BART’s pilot project. The pilot will focus on the development of risk analysis strategies for sea level rise and heavy downpours. BART will look at risk assessments to develop adaptation strategies and then determine how to implement these strategies into daily operations. Mr. Feng noted that BART’s Water Intrusion Mitigation Program had a similar approach and that the findings of that program can inform this study.

The goal of the project is to implement a strategy and to define a program where it can be implemented. The pilot will look at inspection reports, maintenance reports, and meetings/interviews with maintenance and operations staff and incorporate these findings into design guidelines for future construction and operations response procedures.

Breakout Sessions – Putting Adaptation into Practice

The purpose of these breakout sessions was to convene participants by disciplines and facilitate a discussion on climate change adaptation in the context of their respective disciplines. Participants divided into the following groups: capital program management, emergency management, planning, operations and maintenance, and environmental review and compliance. Facilitators posed three questions to each group:

1. Challenges: What is your biggest challenge to working on climate adaptation in your agency?
2. Lessons: What are the most potent lessons/most valuable take aways from what you have heard so far during the workshop?
3. Mainstreaming: How do we mainstream climate adaptation into transit practices?

Below are summaries of the responses of each group to each of the three questions.

Operations and Maintenance

1. Challenges: Unscheduled maintenance is very disruptive and costly. Climate impacts and events need to be integrated into maintenance schedules and transit agencies need to establish response plans. Funding is a challenge in the new paradigm of severely restricted budgets. There is a need for a champion within the organization. How do agencies obtain executive level buy-in, organizational acceptance, and cut across silos? How can operations and maintenance staff better interface with planners on issues such as this? There is a problem of stovepiping in that ideas don't travel between disciplines. How do agencies capture current impacts?
2. Lessons: There is a clear message of need because the effects and vulnerabilities are apparent. The interrelated nature of climate effects results in profound system impacts that agencies don't understand. Adaptation work needs to be done within the context of shrinking budgets. There is a need to frame the societal costs that transit investments can help to mitigate. The changing weather is already having a huge effect on systems- how can agencies use this awareness to plan for climate change? There is a need for more and better data on life-cycle asset costs and current weather related maintenance costs.
3. Mainstreaming: Adaptation should be framed as a business case using risk assessments. One approach to mainstreaming adaptation is to implement an Environmental Management System (EMS) throughout the entire organization. Another approach is to integrate adaptation into continual education and training. An agency could hold quarterly forums of different disciplines discussing the issues. It is important to focus on the potential costs of conducting "business as usual" and highlight the missed opportunity of not investing now. Also, an agency can set up

iterative procedures to work with as they implement their recapitalization and replacement programs.

Environmental Review and Compliance

1. Challenges: Climate change adaptation is not incorporated into a planning horizon. There is a need for requirements to look at lifecycle costs and a need for reliable and quality data. Adaptation is a new issue area and therefore there is a lack of examples, requirements and federal guidance.
2. Lessons: Adaptation is not a part of the decision-making process.
3. Mainstreaming: There is a need for mandates and/or regulations with teeth.

Capital Program Management

1. Challenges: There is a lack of laws, regulations, and guidance regarding adaptation. Agencies need to build in an awareness of climate risk. The timeframe for more serious impacts is 2030/2050 and this is not conducive to motivating action now. Adaptation should be incorporated into 20-year plans.
2. Lessons: Agencies should consider how climate change is going to impact insurance rates. It is helpful to identify thresholds where certain impacts occur so that these can be avoided. Also, agencies should consider customer experience impacts on passengers. Federal evaluation criteria for state of good repair consideration of climate change adaptation would be helpful.
3. Mainstreaming: The federal government needs to take the lead. For example, FTA should send out a Dear Colleague Letter on adaptation. Adaptation should be integrated into risk assessments; it is often left out.

Emergency Management

1. Challenges: Impacts to an intermodal network and of a regional dimension are especially challenging. The severity, frequency and intensity of disasters are increasing. A key element is communication, including public response. There is currently a lack of intergovernmental coordination.
2. Lessons: Agencies will benefit from a shift from competing to complimentary research. There is a need for a greater focus on proactive planning.
3. Mainstreaming: Implement an “all hazards” integrated approach.

Planning

1. Challenges: Where will the funding come from? How can planners best incorporate climate change with other programs? What are the tradeoffs? Where can agencies get quality data? Organizations need to communicate the urgency of this issue. Perhaps transit planners can use

FTA's "Transit at the Table" initiative, which is an effort to better incorporate transit agencies into the metropolitan planning processes. It is difficult to learn to be comfortable with uncertainty.

2. **Lessons:** Planners need to broaden partnerships with different organizations, such as FEMA, NOAA and the military. There should be more of an intermodal focus on adaptation. Planners should frame issues within the context of current activities. The threat of flooding (coastal or rainfall) seems to be a consistent issue across the board.
3. **Mainstreaming:** Planners need to ensure that transit has a voice. Communication to users through public involvement methods is key. Planners can tie adaptation to the economy and jobs to build awareness of the issues with elected officials. Agencies should monitor and communicate progress on adaptation (perhaps via a dashboard) to the public. It is important to celebrate successes.

Pilots Breakout

The purpose of the pilots breakout was to discuss approaches and challenges related to the transit climate change adaptation assessment pilots. Pilot representatives brainstormed about how best to share resources where pilots have similar project elements or approaches. During this session, pilot project participants expressed a desire for opportunities to share ideas with the other pilots via peer exchanges. Participants agreed that those who were able would attend the APTA Sustainability Workshop from August 5-8, 2012 in Philadelphia, PA. In addition, FTA staff agreed to facilitate webinars for information sharing. Pilots also expressed a desire to establish an avenue for sharing resources via SharePoint or some other venue. The pilot representatives discussed overlaps and potential points of collaboration between pilots, noting that SEPTA, CTA, MARTA, and BART had all received asset management grants from FTA that could potentially be capitalized upon during the climate adaptation pilots. Similarly, Sound Transit, BART, LACMTA, MARTA, and SEPTA all have received FTA-funded environmental management systems training that could be an asset to the climate pilots. Participants discussed the different types of costs that might be addressed as part of the pilots, including costs of climate impacts, project life cycle costs, and impacts to operating and capital budgets. Participants discussed focusing on costs to transit agencies rather than to the broader metropolitan regions they serve in order to maintain a more manageable scope. Representatives also shared information on data sources.

Listening Session: Addressing Adaptation at FTA

The goal of the listening session was to generate ideas regarding FTA actions that could assist the public transportation industry in adapting to climate change impacts. Kate Mattice, FTA's Deputy Associate Administrator for Budget and Policy, kicked off the listening session by providing background on the motivation behind FTA's current efforts and asking questions to solicit ideas about future actions the agency could take. Ms. Mattice explained that FTA embarked upon this climate change adaptation work because of the nexus with FTA key strategic goals of state of good repair and safety. As an additional motivator, there is a requirement from the White House originating from Executive Order 13514, which

set sustainability goals for Federal agency operations and directed agencies to improve their environmental, energy and economic performance. As one part of this Executive Order, each Federal agency is to evaluate agency climate change vulnerabilities and to develop strategies to manage both the short- and long-term effects of climate change on the agency's mission, programs, and operations. Ms. Mattice requested feedback from participants on adaptation as FTA continues work in this area. She posed the following questions:

1. What changes to FTA programs and policies would assist the transit industry in adapting to climate change?
2. What technical assistance can FTA provide?
3. What federal actions have been helpful and what federal actions have been not helpful in regards to climate adaptation?
4. What actions would you recommend other federal agencies take?

Participant responses to each of the questions are summarized below.

1. What changes to FTA programs and policies would assist the transit industry in adapting to climate change?
 - Provide more clear/refined definition for “state of good repair” in Federal Registers and Circulars
 - Add guidance to existing planning processes for states, MPOs, and transit operators
 - Incentivize adaptation into New Starts and include climate change concerns (mitigation and adaptation) in New Starts and State of Good Repair funding
 - Encourage thinking about climate change issues early in the planning process, such as during NEPA. One downside to this is a lack of resources, especially in rural areas.
 - Use case studies to inform national FTA guidelines
 - Require matching funds to mobilize internal money
 - Encourage scaling up beyond pilots
 - Provide states guidance on climate change action plans
 - Provide education and outreach to other non-transit agencies, perhaps via MPOs
2. What technical assistance can FTA provide?
 - Share information from pilot projects in a centralized format
 - Host regional workshops tied to existing trade association conferences
 - Hold webinars, “GoToMeeting” events, and peer exchanges for networking and idea sharing
 - Share methodologies so data can be standardized (consistent) in the analysis
 - Make information/data available in a simple, available, usable, consistent format
 - Create an FTA portal to technical assistance from other agencies (NOAA, military, EPA, USGS, local and state agencies). Coordinate with USGS/NOAA for climate data.
 - Make tools available, especially to small agencies because this helps lower costs
 - Create ATPA standards process for adaptation similar to those for greenhouse gases. This would include tiers for various levels of detail and expertise.

- Increase interaction with climate scientists
- Coordinate within the modes at DOT (FTA, FHWA)
- Provide a means for data consistency, perhaps apply quality standards

3. What federal actions have been helpful and what federal actions have been not helpful in regards to climate adaptation?

Not helpful

- Lack of federal transportation bill
- Not translating science into lay terms
- Poor knowledge dissemination from the natural resource agencies
- Strict mandates

Helpful

- Federal support for the early development of climate change adaptation pilots
- Share transit point of view from the local level
- More transparent sharing of information
- Share different types of visualization techniques (models, maps, etc.)
- Share information in more than one language based upon the affected groups
- Reports and policy statements
- Executive Order 13514 Section 16-Senate Bill Adaptation Provision
- FHWA/FTA coordination on pilots
- Data dissemination
- Established federal livability partnership will make climate change work easier going forward
- Competitive funds that benefit all communities
- Performance standards. Conduct performance monitoring for climate change adaptation, compare, encourage competition, and assign rankings. Assign relative rankings within size class and use a combination of sticks and carrots.

4. What actions would you recommend other federal agencies take?

- Use DOT-HUD-EPA partnership as a model for other partnerships
- Reach out to disaster/emergency workers
- Add climate change to EPA standards
- Partner with local governments and railroads
- More focus on emergency preparedness
- Encourage CEQ to incorporate adaptation into the NEPA process

Conclusion

During the course of the two day workshop, participants heard from senior leaders in the transit industry about their goals and needs for climate analysis, learned how to use an adaptation assessment

framework, and heard from FEMA about the projected expansion of floodplains due to climate change. Participants conducted mock risk assessments, experimented with mapping tools, and shared strategies for communicating climate change and getting buy-in. Representatives from the FTA- and FHWA-funded climate adaptation pilots shared approaches and challenges, professionals from a variety of disciplines developed ideas for mainstreaming climate considerations into a range of transit agency practices, and participants offered ideas for how FTA can support the transit industry in building the resilience of U.S. public transportation to climate change impacts.

Several key themes arose during the workshop, such as the challenge posed by the upfront capital costs of adapting and a lack of funding sources. Participants also highlighted a need to integrate adaptation into agency practices and provided suggestions on how to do this. Case studies of successful adaptation approaches that can be applied to transit agencies nationwide are helpful and FTA will continue to work to share these within the transit community. Many of the speakers emphasized a need to start considering climate change adaptation impacts now, before worse impacts are realized. Adaptation efforts can be more efficient and effective if partnerships between agencies are implemented, efforts are coordinated and communication is prioritized.

Based on the suggestions of stakeholders at the workshop, FTA intends to prioritize the following actions over the next 12 to 18 months:

- Spur systematic approaches for transit asset management systems to institutionalize the consideration of the impacts of climate change into program decision-making for transit capital investments.
- Encourage the inclusion of climate change considerations into hazard management plans at all levels.
- Issue a report that synthesizes the key findings from the climate adaptation pilots.
- Explore methods to incorporate adaptation into the environmental review process.
- Analyze the costs of climate-related impacts to transit infrastructure and operations and develop risk management tools for transit agencies.

FTA would like to thank all of the presenters and participants in the workshop.