ADAPTATION TO CLIMATE CHANGE IN TRANSPORTATION OPERATIONS AND MAINTENANCE
Technical Staff Briefing
• Climate change and extreme weather events
• Impacts of climate change on transportation systems management and operations (TSMO) and maintenance
• Why address climate change?
• Getting started: an adaptation framework
• Resources
A CHANGING CLIMATE

- DOTs are already observing and responding to the impacts of climate change
- Accelerating climate change means more frequent or more intense weather events (e.g., large storms, changes in winter precipitation, heat waves)
- These events will have critically important ramifications on the planning, design and engineering, management, operations, and maintenance of transportation facilities and services

Flooding in Phoenix in 2014.
Extreme weather events are becoming more frequent and severe.
EXTREME EVENTS IN 2014

• Anne Arundel County in Maryland received over ten inches of rain on August 12, 2014, washing out roadways

Source: The Daily Record

Source: breakingnews.com
Phoenix, Arizona, broke 24-hour rainfall records with nearly three inches of rain on September 8, 2014, causing widespread flooding that closed Interstate highways.
EXTREME EVENTS IN 2014

• Buffalo, New York, received over seven feet of snow November 17 - 21, 2014, stranding drivers in their cars

Source: The Telegraph

Source: necn
• California experienced a severe drought and thousands more wildfires than usual

Source: Fox News

Source: Daily News
Weather refers to the atmosphere state in a particular location at a particular time.

Extreme weather events refer to significant anomalies in temperature, precipitation and winds (e.g., heavy precipitation and flooding, heatwaves, drought, wildfires and windstorms (including tornadoes and tropical storms)).

Climate change refers to any significant change in the measures of climate lasting for an extended period of time.

Climate change includes major variations in temperature, precipitation, or wind patterns, among other environmental conditions, that occur over several decades or longer (e.g., a rise in sea level, increase in the frequency and magnitude of extreme weather events now and in the future).
CLIMATE CHANGE IS WIDENING AND SHIFTING WEATHER PROBABILITY DISTRIBUTIONS

RARE WEATHER EVENTS COULD BECOME INCREASINGLY FREQUENT

U.S. Selected Significant Climate Anomalies and Events
May and Spring 2015

AK was record warm for May with a temperature 7.1°F above average. The warmth was widespread with Barrow and Juneau being record warm.

Seven states across the West had a top 10 warm spring. CA had its warmest Jan-May on record, at 5.1°F above average.

The contiguous U.S. drought footprint shrunk to 24.6%, the smallest since Feb 2011. Drought conditions improved across the Great Plains, but remain entrenched in the West.

The Northeast was warm and dry with drought developing. CT, MA, NH, and RI were record warm for May.

There were over 400 preliminary tornado reports during May, the most since Apr 2011. There were 7 tornado-related fatalities.

CO, OK, and TX were record wet for May with widespread flooding. It was also the all-time wettest month for OK and TX. TX was record wet for spring.

On May 10, Tropical Storm Ana made landfall in SC with sustained winds of 45mph. Ana is the 2nd earliest landfalling tropical cyclone on record for the U.S.

HI had a mixed precipitation pattern during May with little change in drought conditions. Over 20% of the state is in drought.

FL had its warmest spring on record with a temperature 4.6°F above average. GA had its 3rd warmest spring.

The average U.S. temperature during May was 60.8°F, 0.6°F above average. The spring U.S. temperature was 53.2°F, 2.2°F above average. May U.S. precipitation was 4.36 inches, 1.45 inches above average and the wettest month of any month on record. The spring precipitation total was 9.33 inches, 1.39 inches above average.

Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc
Historical climate ≠ Future climate

- Because of climate change, historical climate is no longer a predictor of future climate
- Assumptions based on historical climate may need to be revisited
  - Expected timing of freeze/thaw, snow melt, vegetation growth
  - Rates of weather-related degradation
  - Weather conditions over asset lifetime
  - Optimal construction work times
CHANGES WILL BE NEEDED IN:

- System maintenance (e.g., inspection, frequency of repairs, need for “quick maintenance” patrols)
- System operations practices and strategies (e.g., more frequent diversion to more robust alternate routes)
- Travel behavior (e.g., motivation to use alternate modes of transport such as transit, biking, or walking)
- Freight transportation (e.g., dynamic or seasonal restrictions for trucks or rail during times of high heat)

Climate changes could result in:

• Reduced roadway capacity
• Loss of alternative routes
• Decreased situational awareness (due to power/communications outages)
• Inability to evacuate
• Shortened service life (due to faster deterioration)
• Increased safety risk
• Loss of economic productivity
• Reduced mobility

Landslide from heavy rain in August 2013. Source: TN DOT
WHY ADDRESS CLIMATE CHANGE?

- Climate change presents a business risk for transportation agencies
  - *Not addressing climate change could put transportation agencies at greater risk than changing practices now*
- TSMO is the public face of extreme weather response
- Even though many agencies are successful operators and maintainers of facilities, they still need to revisit their approach and practices given these changes
STAFF MAY BE ASKING...

• Over the last 20 years, we have gotten really good at managing winter storms. We will deal with whatever nature throws at us. **Do I need to plan for climate change?**

• My last few summers have resulted in a lot of delays in construction due to the heat. **Should I change how I bid out my projects?**

• Over the last 20 years, we’ve never had an ice storm, and I don’t typically budget for ice removal equipment. We got one last year. **Should I invest?**

• My maintenance budgets are typically insufficient, and I end up going over each year. **How can I plan ahead and better use my limited resources?**

• We worked well together during Hurricane Sandy, but there were still a lot of challenges. **What will help us be better prepared?**
GETTING STARTED: AN ADAPTATION FRAMEWORK

Define Scope
- Articulate program goals and operations objectives
- Identify key climate variables
- Develop information on decisions sensitive to climate change

Assess Vulnerability
- Document existing capabilities (both technical and institutional)
- Collect and integrate data on past performance
- Develop climate inputs
- Characterize impacts and risks

Integrate into Decision Making
Identify Performance Measures
(tolerance for disruption)

Identify Potential Adaptation Measures

Evaluate and Select Adaptation Measures
- Technical and political feasibility
- Costs and benefits
- Efficacy
- Flexibility
- Environmental and societal impacts

Determine Improvements in Capabilities Necessary for Successful Implementation
- Business processes
- Systems and technology
- Performance management
- Culture
- Organization and workforce
- Collaboration

Monitor and Revisit
Develop New Objectives
Articulate Program Goals and Operations Objectives

- Define what must be achieved to ensure resilient operations
  - Include expected level of performance during adverse weather
- Determine outcome-based operations objectives

Identify Key Climate Stressors

- Which climate change stressors or extreme weather events are projected to occur locally?
- Which climate change stressors or extreme weather events could affect TSMO and maintenance programs?
DEFINE SCOPE: IDENTIFY KEY CLIMATE VARIABLES

Projected Temperature Changes
Source: 3rd National Climate Assessment

Projected Change in Heavy Precipitation Events
Source: 3rd National Climate Assessment
Develop Information on Decisions Sensitive to Climate Change

*Decisions are climate-sensitive if their continued effectiveness could be compromised by projected changes in climatic conditions (e.g., changes in temperature, precipitation, weather patterns, and the frequency and intensity of extreme weather events)*

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<thead>
<tr>
<th>Climate-Sensitive Decision Areas</th>
<th>Specific Decisions</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Plan for future workforce needs.</td>
<td>Determine the right level of workforce requirements and capabilities.</td>
<td>Operating agencies make a variety of workforce related decisions, including the number of staff required, their locations, and capabilities necessary to monitor, control, report and maintain the roadway system.</td>
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<tr>
<td>2. Plan for Operations and Maintenance investments.</td>
<td>Determine criteria to prioritize operational resource investments (including capital improvements).</td>
<td>Resource investments may include new capital improvements for operations and maintenance. They may also include investments for annual maintenance.</td>
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Document Existing Capabilities (both technical and institutional)

- Document current capabilities across the six areas of the Capability Maturity Framework (CMF):
  - Business processes
  - Systems and technology
  - Performance management
  - Culture
  - Organization and workforce
  - Collaboration
Collect and Integrate Data on Past Performance

Examples of vulnerabilities:
- Loss of roadway capacity
- Loss of alternative routes
- Loss of situational awareness (due to power/communication)
- Inability to evacuate/shelter-in-place
- Loss of service life (e.g., due to faster deterioration)
- Increased safety risk
- Loss of economic productivity
- Reduced mobility
ASSESS VULNERABILITY

Develop Climate Inputs
- Determine local projected changes
- Utilize readily-available sources of information

Characterize Vulnerabilities and Risks
- Conduct a qualitative or quantitative assessment, depending on output needs

WSDOT 2010-2011 FHWA Climate Resilience Pilot Vulnerability Assessment Results.
Source: WSDOT
Identify Performance Measures

- Integrate climate change adaptation and resiliency into existing performance measures
- Adopt as stand-alone measures
- Consider whether existing measures will be achievable with a changing climate

Source: MnDOT
Identify Potential Adaptation Measures

- Consider a range of strategies
- Consider phased strategies (near-term, medium-term, long-term)
- Look for best practices in regions with experience, e.g.:
  - Southern states may look north for ice storm preparedness strategies
### INTEGRATE INTO DECISION MAKING

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<tr>
<th>Vulnerability</th>
<th>Response</th>
<th>Implementing Department</th>
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| Increased frequency of extreme events may require additional personnel to monitor, control, report, and respond to events | **Short-term**: Train staff on climate change and how this may affect their roles and responsibilities  
**Medium-term**: Increase availability of contract staff to assist during extreme events  
**Long-term**: Hire additional staff to keep pace with increasing TSMO, maintenance, and emergency management needs | TSMO, Maintenance, Emergency Managers                                   |
| Changes in long-term climate trends may also change seasonal work requirements |                                                                          |                                  |
Evaluate and Select Adaptation Measures

- Use relevant evaluation criteria from other agency projects and/or consider these:
  - Technical and political feasibility
  - Costs and benefits
  - Efficacy
  - Flexibility
  - Sustainability
- Circulate results and accept revisions of priorities from staff and decision makers
CASE STUDY: ALDOT

- Alabama experiences hurricanes, tornados, wet and dry cycles, and snow and ice events
- Pace and severity of weather events have increased in recent years, along with public expectations about levels of service
- Post-event recovery affects ability to perform regular operations
- Infrastructure damage disrupts regular operations

CASE STUDY: ALDOT

• Renewed emphasis on emergency management (EM)
  • Created full-time EM position
  • Improved relationship with state EM agency
  • Increased recurring emergency training
• Focused on “smaller” solutions
  • Portable Highway Advisory Radios (HARs)
  • Coordination across and between divisions
  • Procuring less specialized equipment
• Improved dissemination of road condition information in everyday and extreme events

Improvements in Capabilities Necessary for Implementation

- Successful implementation of adaptation measures may require more overarching enhancements to the agency’s capabilities

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<tr>
<th>Adaptation Strategies</th>
<th>CMF Category</th>
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<td></td>
<td>Business</td>
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<tr>
<td>Develop climate resilient design guidelines</td>
<td>X</td>
</tr>
<tr>
<td>Track weather-related trends and costs over time</td>
<td>X</td>
</tr>
<tr>
<td>Establish stand-by contracts for extreme event response</td>
<td>X</td>
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<tr>
<td>Consider the life-cycle costs of resiliency investments and savings in budgeting and design</td>
<td>X</td>
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Monitoring and evaluation helps keep adaptation efforts on track as:

- New information on climate risks emerges
- Evidence of the effectiveness of adaptation strategies becomes available
- Other programmatic changes occur

Key steps include:

- Establish a monitoring and evaluation plan
- Engage stakeholders
- Monitor and collect data on relevant indicators
- Evaluate the project and its outcomes
- Revisit
• Guide developed to lead State/local DOTs and MPOs in adopting climate change adaptation strategies at the institutional, technical, and financial levels for their TSMO and maintenance programs.

• Available at: http://www.ops.fhwa.dot.gov/publications/fhwahop15026/index.htm
WHAT’S IN THE GUIDE?

- How to obtain buy-in
- Risk assessment checklists and guidance
- Climate change focused performance measures
- How to track progress over time
- Existing benefit-cost assessment tools
- Matrix of climate sensitive decisions
- Sample handout for workshop on climate risk
- Gap assessment for climate ready TSMO and maintenance
- Glossary of terms
OTHER RESOURCES

FHWA VIRTUAL ADAPTATION FRAMEWORK

• Organized around FHWA Vulnerability Assessment Framework key steps

• For each key step, includes guidance, training videos, case studies, related resources, and tools

• Available at: www.fhwa.dot.gov/environment/adaptationframework/
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