Agenda

• Road Weather Management Overview
• What do we mean by Weather-Savvy Roads?
  • Pathfinder
  • Integrating Mobile Observations (IMO)
• Next Steps
Road Weather Management Overview
Average Annual Fatalities Under Adverse Weather

Adverse Weather-Related Fatalities (10-yr. Annual Average 2005-2014)

- Flood: 71
- Lightning: 32
- Tornado: 110
- Hurricane: 112
- Extreme Heat: 124
- Extreme Cold: 29
- Winter Storm: 19
- Wind: 52
- Rain, Fog, Hail, Ice: 6
- Miscellaneous: 81
- Total NWS-Other: 607
- Adverse Road Weather: 5,646

Source: FHWA & NWS
Weather-Related Crashes

Total Annual Crashes
Average = 5,748,564

Other Crashes, 78%
Weather-Related Crashes 22%

Weather Related Crashes By Road Weather Condition*

- Wet Pavement 70%
- Snow/Slushy Pavement 15%
- Icy Pavement 13%
- Fog 2%

*Crashes that occurred under adverse conditions; additional factors such as rain, snow, and fog are not disaggregated from pavement conditions in this graphic. The percentage due to fog is for those crashes that occur under foggy conditions, but not wet, icy, or snowy pavement conditions.

Source: Road Weather Management Program, Table: Weather-Related Crash Statistics (Annual Averages), Available at: http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm
Other Impacts on Transportation

• Mobility
  – About 25% of non-recurring delays are due to weather
  – Congestion costs about $9.5B/yr. for 85 urban areas*

• Productivity
  – Weather-related delays add about $3.4B/yr. to freight costs

• Environment
  – Chemicals used for anti-icing affect watersheds, air quality and infrastructure

*Source: 2015 Urban Mobility Scorecard  http://mobility.tamu.edu/ums/
Impacts Are More Than Just Weather

Source: FHWA
# Weather versus Road Weather

<table>
<thead>
<tr>
<th>Weather</th>
<th>Road Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong> The state of the atmosphere with respect to wind, temperature, moisture, cloudiness, pressure, etc.</td>
<td><strong>Definition:</strong> The state of the driving environment with a focus on precipitation, visibility, wind, and road conditions.</td>
</tr>
<tr>
<td><strong>How will it affect me?</strong> Clothing, utility usage, outdoor activities, etc.</td>
<td><strong>How will it affect me?</strong> Closed roads, reduced speeds, hazardous driving, tire friction loss, etc.</td>
</tr>
<tr>
<td><strong>The message:</strong> Broad and generalized for any audience.</td>
<td><strong>The message:</strong> Specific to impacts and catered to motorists making decisions.</td>
</tr>
</tbody>
</table>
Road Weather Management Program

• **Objective:** Alleviate the impacts of adverse weather on roads
  “Anytime, Anywhere Road Weather Information”

• **Some highlights:**
  • MDSS Prototype
  • Clarus and the Weather Data Environment
  • Weather and Connected/Automated Vehicles
  • Weather-responsive Traffic Management

• **Currently shifting the program focus from applied research to Knowledge and Technology Transfer**
  • EDC-4 and Weather-Savvy Roads
Two Solutions for Weather-Savvy Roads

- Pathfinder
- Integrating Mobile Observations (IMO)

Source: FHWA
What is “Every Day Counts” (EDC)?

State-based model to identify and rapidly deploy proven but underutilized innovations to:

- shorten the project delivery process
- enhance roadway safety
- reduce congestion
- improve environmental sustainability

- EDC Rounds: two year cycles
- Initiating 4th Round (2017-2018) - 11 innovations
- EDC to date: 3 Rounds, 35 innovations
Weather-Savvy Roads

Pathfinder
Pathfinder Goal

Strengthen the working relationships across State DOTs and the Weather and Climate Enterprise for the dissemination of road weather information to travelers that is
• clear,
• concise,
• impact-based, and
• consistent
so that drivers are well informed and able to make safe and efficient travel decisions.

Source: Georgia DOT
Pathfinder Core Partners

- **National Weather Service:** Experts at weather forecasts
- **Private Sector Weather Providers:** Experts at road weather forecasts
- **State DOTs:** Experts at operating and maintaining the roadways - knowledgeable about the state of the roadways and the impact to the traveling public
- **State Emergency Managers:** included in core partners to coordinate activities during high impact events

Source: FHWA
“[W]e [forecasters] were very clear snow would begin between 4-6 a.m., which it did. We were very clear accumulating snow would coincide with commuting time – which it did. We were very clear the commute would be a difficult one – which it was.

But in spite of this “clear” forecast, many motorists, school systems, and governments treated Tuesday morning’s rush hour like any other. **Somehow the message that the roads would be horrible did not reach the masses.**

But I think where we all erred was in the messaging. Our forecast wording – across the board – did not convey the necessary sense of urgency. **We did not say in a consistent, unified way it could be really bad Tuesday morning: stay off the roads if possible and wait the storm out.”**

Washington Post 1/7/2015

**Travelers need to know:**

- Timing, location and duration of weather event
- Impact of weather on road conditions
- Impact of agency maintenance and traffic management actions

**Impacts of Road Weather**

- Timing, location and duration of weather event
- Impact of weather on road conditions
- Impact of agency maintenance and traffic management actions
Pathfinder Document

The document... 

- Describes 8 basic steps and associated requirements 
- Provides examples from State DOT implementations 
- Characterizes agency organizational structure 
- Companion workbook walks team through the implementation process 

Source: FHWA
Pathfinder States - Current

Source: FHWA
Utah DOT Experience with Pathfinder

- **Motivations/Expectations for adopting Pathfinder**
  - Ensure road weather messages are a tool for the public to make appropriate advanced travel decisions
  - Sync media and weather outlets on road weather impacts
  - Decrease congestion, increase snow plow effectiveness, promote safety
  - Gain public’s trust with UDOT traveler information systems
  - Promote data/information sharing across agencies

- **Partners Involved:**
  - NWS - Salt Lake City, Grand Junction
  - UDOT/Utah Emergency Manager, UDOT Communications (High Impact Events only)

- **Road Weather Events:** Snow, Freezing Rain, High Winds

- **Types of Messages:**
  - UDOT - VMS, Road Weather Alert, Travelwise Alert (push), 511 weather forecasts, TV interviews
  - NWS - Watches, warnings and advisories products, Weather stories, TV interviews
Utah DOT Experience with Pathfinder (Cont.)

• Results Achieved/Conclusions
  o Well forecasted, unified messages
  o Reduction in VMT during snow events
  o Public is more apt to modify their travel plans
    ✓ Changed schedule
    ✓ Changed route
    ✓ Did not travel
    ✓ Used transit
  o Trust is built among the public if all sources state the same roads impacts
  o DOT Maintenance is more effective, with less congestion on the roads
  o Improved safety and mobility overall

Source: Utah DOT
Weather-Savvy Roads

Integrating Mobile Observations
Integrating Mobile Observations (IMO) Goal

Deploy advanced, vehicle-based technologies to

- collect,
- transmit, and
- use

weather, road condition, and related vehicle data for improved transportation system management.
IMO Project

Goal: Exploring the feasibility of using vehicle-based data to improve transportation safety & mobility

**Minnesota DOT**
- ~590 Vehicles
- Data
  - Air Temperature
  - Relative Humidity
  - Surface Temperature
  - Wiper Status
  - Brake Status
- Camera Images
- AVL, Cellular, & DSRC

**Michigan DOT**
- ~15 IMO Vehicles + 310 Snow Plows
- Data
  - Air Temperature
  - Relative Humidity
  - Surface Temperature
  - Brake Status
  - Accelerometer
- Camera Images
- Cellular, DSRC, & WiFi

**Nevada DOT**
- ~60 Vehicles
- Data
  - Air Temperature
  - Relative Humidity
  - Surface Temperature
  - Wiper Status
  - Diagnostics Status
- Camera Images
- Radio, Cellular, & DSRC

Source: FHWA
Nevada IMO System Framework

Applications & Management Strategies
- Winter Maintenance
- Treatment Recommendations
- Material Usage Tracking
- Traffic Management
- Traveler Information
- Data Management Systems
- Weather Data Environment
- Vehicle Data Translator

In-Vehicle Equipment
- Weather sensors
- Vehicle sensors (OBU, CANBus)
- Equipment sensors (spreader)
- Location sensor (GPS)
- Radio(s)

Source: Nevada DOT
Used with permission
Minnesota DOT’s System Framework

- **Maintenance Decision Support System (MDSS)**
  Unique forecasts for all 810 MnDOT plow routes
- **Automated Vehicle Location (AVL)**
  590+ units now installed and reporting in Snow plows
- **Cameras**
  Installed in 240 plows
- **Images**
  Will be used internally and sent to 511 for public info
- **Additional AVLs**
  Installed and collecting data in Mower tractors and Light Duty Vehicles
Minnesota IMO System Framework

Applications for Operations

Motorist Advisory and Warning

Android/iOS App
Forecasts/Recommendations
Management Reports

Pavement Model
Road Weather Forecasts

Predictive Modeling System

MnDOT MDSS/AVL Servers

AVL equipped Snow Plows

Cellular Connection
Developing DSRC

Data Inputs

511 Dash Cams
App for Voice Alerts
AVL activated DMS

Users of Data

NCAR
WxDE
MADIS

Airport Wx Stations
RWIS
AVL DATA
Radar
Forecasts

Source: Minnesota DOT
MnDOT 511 Interface

Source: Minnesota DOT
Michigan IMO System Framework

15 - IMO MDOT Vehicles & 310 Snow Plow Trucks

DSRC, cell, WIFI

Communication Line

Michigan DOT DUAP Server

DOT TMC/TMC

Communication Line

USDOT Data Warehouse

NCAR/VDT Server

LOW VISIBILITY
NEXT 5 MI
REDUCE SPEED

changeable message board

Source: Michigan DOT
IMO Captured Images

Source: Michigan DOT
Examples of Motorist Advisory and Warnings

- Variable Speed Limit Sign
- Severe Weather Warning Sign
- Dynamic Message Sign

- WHITE OUT CONDITIONS ON I-94 REDUCE SPEED
- SLIPPERY ROADS WB I-94 REDUCE SPEED

Source: Michigan DOT
Benefits of IMO
IMO data has the potential to:

• **Fill gaps** in road weather observations

• **Spur development** of new applications

• **Dramatically enhance existing systems:**
  - Aid in **overall salt reduction** strategies
  - Optimize the use of **maintenance resources**
  - Generate **actionable, automated alerts and messages** to TOC/TMCs, maintenance personnel, work zone teams
  - Provide traveling public with **more timely and valuable information**

• **Ultimately, it can improve efficiency (costs), effectiveness (results) and accountability (measurement)**
Weather-Savvy Roads

Next Steps
## Innovation Deployment Team Members

<table>
<thead>
<tr>
<th>Team Role</th>
<th>Team Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiative Lead</td>
<td>• <strong>Paul Pisano</strong> (FHWA HQ - RWM Management Team)</td>
</tr>
</tbody>
</table>
| FHWA Team                     | • **Roemer Alfelor** (FHWA HQ - RWM Management Team)  
|                               | • **Gabriel Guevara** (FHWA HQ - RWM Management Team)  
|                               | • **Ray Murphy** (FHWA Resource Center)            |
| NWS Team                      | • **Andrew Stern** (NWS HQ)                       |
| State DOT                     | • **Jeff Williams** Utah DOT                      |
| Subject Matter Experts        | • **Joe Huneke** Minnesota DOT                    |
|                               | • **Sue Lodahl** Minnesota DOT                    |
|                               | • **Rodney Shilling** Nevada DOT                   |
|                               | • **Steve Cook** Michigan DOT                     |
EDC Innovation Deployment Stages

- Not Implementing
- Development
- Demonstration
- Assessment
- Institutionalized

Source: FHWA
Pathfinder Goal

Strengthen the working relationships across State DOTs and the Weather and Climate Enterprise for the dissemination of road weather information to travelers that is

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- consistent

so that drivers are well informed and able to make safe and efficient travel decisions
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<tr>
<th>Pathfinder: Innovation Implementation Stage Definitions</th>
<th>Consider the following questions - NOT MANDATORY.</th>
</tr>
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<tbody>
<tr>
<td><strong>Not Implementing</strong>: The State is not pursuing Pathfinder.</td>
<td>Is the State not implementing due to:</td>
</tr>
<tr>
<td></td>
<td>• Resources</td>
</tr>
<tr>
<td></td>
<td>• Not Interested</td>
</tr>
<tr>
<td><strong>Development Stage</strong>: The State:</td>
<td>• Under what circumstances do you communicate with the NWS?</td>
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<tr>
<td></td>
<td>• establishes a cross-cutting Pathfinder team; and</td>
</tr>
<tr>
<td></td>
<td>• documents the roles and responsibilities, communication methods, and messages that each team disseminates surrounding weather events.</td>
</tr>
<tr>
<td></td>
<td>• How does your private weather service provider, if applicable, assist in crafting traveling information messages?</td>
</tr>
<tr>
<td><strong>Demonstration Stage</strong>: The State, in partnership with the Pathfinder team:</td>
<td>• What dissemination methods did the Pathfinder team use?</td>
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<td></td>
<td>• pilots the project for at least a 3 month time period over an inclement weather season (e.g., winter weather, monsoon season, etc.);</td>
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<tr>
<td></td>
<td>• documents each collaboration event, with a focus on capturing the impacts of disseminating consistent messages; and</td>
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<tr>
<td></td>
<td>• holds a recommended minimum of 3 meetings during the pilot.</td>
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<tr>
<td></td>
<td>• How successful were you in coordinating a clear, concise, and consistent impact message?</td>
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<tr>
<td></td>
<td>• Did the media pick up on the message?</td>
</tr>
<tr>
<td></td>
<td>• How much did it cost the State to implement Pathfinder?</td>
</tr>
<tr>
<td><strong>Assessment Stage</strong>: The State, with input from the Pathfinder team:</td>
<td>• Was the project successful?</td>
</tr>
<tr>
<td></td>
<td>• assesses the overall results from the demonstration stage (e.g., cost, benefits, lessons learned, challenges, and future team members such as the local media);</td>
</tr>
<tr>
<td></td>
<td>• and documents the assessment.</td>
</tr>
<tr>
<td></td>
<td>• How easy will it be to deploy a statewide implementation?</td>
</tr>
<tr>
<td></td>
<td>• Is the State willing to share their results with other states?</td>
</tr>
<tr>
<td><strong>Institutionalized</strong>: The State, in coordination with the Pathfinder team:</td>
<td>• What are the main benefits and successes the State has encountered from deploying Pathfinder?</td>
</tr>
<tr>
<td></td>
<td>• documents processes in the form of Standard Operating Procedures (SOP);</td>
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<td></td>
<td>• routinely collaborates on Pathfinder events as defined in the SOP and documents results; and</td>
</tr>
<tr>
<td></td>
<td>• trains new team members and helps share success stories with others.</td>
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Source: FHWA
Integrating Mobile Observations (IMO) Goal

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• collect,
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for improved transportation system management.
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<td><strong>Innovation Implementation Stage Definitions</strong></td>
<td><strong>- NOT MANDATORY.</strong></td>
</tr>
<tr>
<td><strong>Not Implementing:</strong> The State is not pursuing IMO.</td>
<td>Is the State not implementing IMO due to: lack of resources, not interested, or other reason?</td>
</tr>
<tr>
<td><strong>Development Stage:</strong></td>
<td>• Is the State documenting its use of data internally, along with exploring ways it’s being done in other DOTs?</td>
</tr>
<tr>
<td>• The State establishes a project team and gets acquainted with applications (e.g., Enhanced MDSS, End-of-Shift Reporting, Performance Measures) that leverage connected vehicle / mobile data; and</td>
<td>• Has the State documented the applications the data would support?</td>
</tr>
<tr>
<td>• the project team develops an implementation plan and uses it to secure support and funding from middle and upper management;</td>
<td></td>
</tr>
<tr>
<td><strong>Demonstration Stage:</strong> The State conducts a demonstration project for at least a season, including the installation of sensors on vehicles, the testing of data flows, and the use of the data to support weather-related applications. The project team documents the costs to deploy, benefits, and lessons learned.</td>
<td>• What have been the main deployment challenges?</td>
</tr>
<tr>
<td></td>
<td>• What applications are being used and/or considered?</td>
</tr>
<tr>
<td><strong>Assessment Stage:</strong> Following a successful demonstration, the project team:</td>
<td>• Was the demo successful?</td>
</tr>
<tr>
<td>• develops a statewide deployment plan that includes a financial outlay plan, a data management plan, a communications plan, and training needs; and</td>
<td>• What will it take to deploy statewide?</td>
</tr>
<tr>
<td>• documents other applications and management strategies that the data can support.</td>
<td>• What are the anticipated challenges and paths to overcome them?</td>
</tr>
<tr>
<td>The team executes the deployment plan and conducts independent evaluations of the outputs and outcomes.</td>
<td></td>
</tr>
<tr>
<td><strong>Institutionalized:</strong> As part of its standard operating procedures, the state routinely captures road weather and related data from its fleet vehicles and incorporates that data into a range of transportation system management strategies that enable them to better manage their system. In addition, appropriate policy documents are developed, and knowledge and technology transfer materials are developed and readily available.</td>
<td>• What are the main benefits and successes the State has encountered from deploying mobile data collection technologies?</td>
</tr>
</tbody>
</table>

Source: FHWA
Implementing Weather-Savvy Roads

The Innovation Deployment Team (FHWA, NWS, State DOT subject matter experts) will develop and promote the following materials:

Pathfinder
  • Implementation Plan
  • Workbook

Integrating Mobile Observations
  • Implementation Tool Kit
    • Materials to assist in deployment, such as sample specifications, case studies, etc.
    • IMO Final Reports (Benefits, Costs, Lessons Learned)

A variety of Knowledge & Technology Transfer efforts, such as:
  • Webinars
  • Stakeholder Meetings
  • Peer Exchange Workshops
  • Site Visits
  • Training
EDC-4 Funding Opportunities:

- **Accelerated Innovation Deployment (AID) Demonstration**
  - *New* Notice of Funding Opportunity (NOFO) under FAST Act
  - GOAL: $10 million per year, authorized by 23 USC 503(c)(2)(B) or FAST Act Sec. 6003
  - [https://www.fhwa.dot.gov/innovation/grants/](https://www.fhwa.dot.gov/innovation/grants/)

- **State Transportation Innovation Council (STIC)**
  - Up to $100,000 per STIC per year
  - [https://www.fhwa.dot.gov/innovation/stic/guidance.cfm](https://www.fhwa.dot.gov/innovation/stic/guidance.cfm)

- **Increased Federal-share for Project-level Innovation**
  - Increase federal share up to 5 percent of the total project cost
Contacts

EDC-4 Coordinators & STIC Network

http://www.fhwa.dot.gov/innovation/stic/stic-contacts.cfm

Paul Pisano  Paul.Pisano@dot.gov
Roemer Alfelor  Roemer.Alfelor@dot.gov
Gabe Guevara  Gabriel.Guevara@dot.gov
Ray Murphy  Ray.Murphy@dot.gov
Integrated Modeling for Road Condition Prediction (IMRCP)

Project Update
IMRCP Update Agenda

Overview project goals and background
Provide an update on the project progress

- Review of existing models
- Concept of operations
- System requirements
- System architecture
- System Design
- Stakeholder engagement

Describe the development plan and next steps
What it really is...

Incorporates real-time and/or archived data and results from an ensemble of forecast and probabilistic models

- atmospheric and road weather
- traffic
- work zones
- incidents
- special events
- demand

- Travelers
- Transportation operators
- Maintenance providers
IMRC P Project Objectives

Provide the foundational systems engineering documentation to create a tool that...

- incorporates real-time and/or archived data and results from an ensemble of forecast and probabilistic models
  - atmospheric and road weather
  - traffic
  - work zones
  - incidents
  - special events
  - demand
- fuses them in order to predict the current and future overall road/travel conditions
- for travelers, transportation operators, and maintenance providers
User Needs

Transportation Operators

• Accurate data representing network traffic conditions
• Status of network traffic controls
• Locations and status of incidents
• Locations and status of work zones
• Road weather forecasts
• Forecasts of network traffic conditions
• Locations/times with highest likelihood of incidents
• Consequences of implementing response strategies

Winter Maintenance

• Accurate data representing network road weather conditions
• Status of road treatment assets
• Road weather forecasts
• Forecasts of network traffic conditions
• Locations/times with highest likelihood of incidents
User Needs

Traveling Public
- Accurate data representing route traffic conditions/travel times
- Accurate data representing route weather conditions
- Status of route traffic controls
- Locations and status of incidents
- Road weather forecasts
- Forecasts of route traffic conditions
- Locations/times with highest likelihood of incidents
- Personalized fastest route

Emergency Management and Responders
- Accurate data representing network traffic conditions
- Status of network traffic controls
- Locations and status of incidents
- Locations/times with highest likelihood of incidents
Opportunities for Change

- Improve accuracy of road weather condition effects in traffic models
- Enable link-specific traffic impacts on road weather condition forecasting
- Forecast network traffic conditions for operations
- Estimate incident likelihood based on current and forecast conditions
- Estimate forecast route travel times/reliabilities
- Identify strategies for pre-positioning of emergency response assets based on forecasts and incident likelihoods
- Identify strategies for winter maintenance route prioritization based on weather and traffic forecasts
- Identify strategies for forecast-aware traffic management
- Enable forecast-aware routing for travelers

Data acquisition

- Using social media data to get data
- Using trajectory/probe data
- Deploy new sources of data acquisition

Ability of TMC/maintenance operators to reduce analysis/response time to changing conditions
Operational Scenarios

Transportation System Management and Operations
- Variable Speed Limits
- Enhanced Motorist Advisories and Warnings
- Enhanced Intelligent Signal Controls

Maintenance
- Winter Road Maintenance
- Non-winter Maintenance

Freight
- Long Haul
- Drayage and Local Delivery

Work Zones

Travelers
- The Daily Commute
- The Road Trip

Emergency Response
Systems Engineering

We are here
Project Steps

2. Concept of Operations (December 2015)
3. System Requirements (January 2016)
4. Summarize ConOps and Requirements (Feb 2016)
5. Create Stakeholder Engagement Plan (Mar 2016)
6. Create System Architecture (Jun 2016)
8. Build and Test the System (Apr 2017)
9. Deploy and Evaluate the System (Jan-Jun 2017)
Questions/Discussion