Connected Vehicles and Road Weather: How the Public Works Community Can Take Advantage of these New Technologies

APWA Public Works Expo, Orlando, FL

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Welcome and Introductions
Today’s Topics

• Connected Vehicle (CV) Overview
• CV and Road Weather Solutions
• Every Day Counts / Weather-Savvy Roads
• Q&A
Connected Vehicle Overview
USDOT’s ITS Strategic Plan (2015 -2019)

Vision – Transform the Way Society Moves

How? By conducting research, development, and education activities to facilitate the adoption of information and communication technology to enable society to move more safely and efficiently.

http://its.dot.gov/strategicplan/index.html
Connected Vehicles “101”

1. A wireless device in a car sends basic safety messages 10 times per second
2. Other nearby cars and roadside equipment receive the messages
3. Drivers get a warning of a potential crash

- Saves lives by **significantly reducing traffic crashes**
- Make **travel easier**, more efficient, and enjoyable
- Helps **curb pollution**
Connected Infrastructure

- **Connected Infrastructure** - Devices installed along the roadway capable of sending and receiving messages...and can interface with traffic control systems

- **Vehicle-to-Infrastructure (V2I)** USDOT is developing V2I applications in many operational areas, including road weather
Connected Vehicle Pilot Deployment Program

- Spur Early CV Tech Deployment
  - Wirelessly Connected Vehicles
  - Mobile Devices
  - Infrastructure
- Measure Deployment Benefits
  - Safety
  - Mobility
  - Environment
- Resolve Deployment Issues
  - Technical
  - Institutional
  - Financial

PILOT SITES
- New York City
- ICF/Wyoming
- Tampa (THEA)
Connected Vehicle Pilot Deployment Sites

WYDOT’s pilot is focused on reducing the impact of adverse road weather.

- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

New York City
- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 10,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.

Tampa (THEA)
- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.
CVs are the Foundation for Automated Vehicles

**Connected Vehicle**
Communicates with nearby vehicles and infrastructure; Not automated

**Connected Automated Vehicle**
Leverages autonomous automated and connected vehicles

**Autonomous Vehicle**
Operates in isolation from other vehicles using internal sensors
ITS Joint Program Office Offers Free Resources

https://www.its.dot.gov/

• Connected Vehicle and Road Weather Data
• Professional Capacity Building
  • ITS Training
  • Webinars
• Research Fact Sheets
• National Transportation Library
• National ITS Architecture
• Connected Vehicle Help Desk
Connected Vehicles and Road Weather
Why care about adverse weather?

The average number of deaths that occur under adverse weather conditions is over 5,000 more than any other type of weather-related fatality.
Weather-Related Crashes

Total Annual Crashes
Average = 5,761,121

By Road Weather Condition*

- Wet Pavement 71%
- Snow/Slushy Pavement 14%
- Icy Pavement 13%
- Fog 2%
- Other Crashes 79%
- Weather-Related Crashes 21%

*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.

Other impacts of adverse road weather...

- **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/](http://mobility.tamu.edu/ums/)
Impacts are more than just weather...

- Current weather? Forecasted weather?
- When will road conditions deteriorate?
- Current conditions? Forecasted conditions?
- Current motorists? Anticipated motorists?

Source: FHWA
Leveraging CV Data for Road Weather

• Potentially low cost data source as technology becomes mandated
• Direct measures of vehicle
• Enables greater data resolution and data density
• Enables the integration of traffic management and maintenance deployment

- Windshield Wiper
- Head Lights
- Outside Air Temperature
- Barometric Pressure
- Speed Location
- Heading Elevation
- ABS/Brakes
- Traction and Stability Control
- Steering Angle
- Throttle Position
- Differential Wheel Speed
- Accelerometer
- Yaw/Pitch/Roll
- Engine Load
Leveraging CVs - Potential for Higher Resolution

**Today**
60% chance of snow, mainly afternoon. Sunny early, then cloudy

**The Future**
CVs provide a continuous picture of what’s happening on the roadways
Sample Deployment Concept

**Improve Snow Removal**
- Enhanced Maintenance Decision Support System

**Improve Management of Work Zones**
- Work Zone Traveler Information

**Improve Situational Awareness**
- Probe-based Pavement Maintenance

*Synergies among applications increase benefits and reduce costs*
Some Discussion....
Discussion

• What vehicle-based capabilities do you have in place?
  • Do you use it for road weather management?

• What management strategies do you use that can benefit from additional road weather data?

• What barriers exist within your agency for deploying CV-based road weather strategies?
Every Day Counts
Weather-Savvy Roads
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
✓ Executing 4th Round (2017-2018) - 11 innovations
✓ EDC to date: 3 Rounds, 35 innovations
How can we better manage adverse events?

FHWA’s Weather Savvy-Roads (WSR) Initiative

- Pathfinder
- Integrating Mobile Observations (IMO)

Today’s Focus

RWM strategies that help agencies manage road systems and inform travelers ahead of, and during, adverse road weather conditions.
Video overview of FHWA’s WSR
What is Pathfinder?

• **Collaboration** between the National Weather Service (NWS), State DOTs, and support contractors to share and translate forecasts into consistent public transportation impact statements

• Disseminates road weather information that is:
  
  • clear,
  • concise,
  • impact-based, and
  • consistent

**Intended Outcome** - Drivers are well informed and able to make safe and efficient travel decisions
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
Pathfinder Guidance (8-Step Process)

1. Identify Partners
2. Determine Qualifying Collaboration Events
3. Select Communication Mediums and Set Procedures
4. Establish Point Person at Each Participating Entity
5. Synchronize Forecast Schedules
6. Establish Definitions and Create Shared Resources
7. Create Shared Impact Message for the Public
8. Conduct Post Event Review and Data Archiving
What is Integrating Mobile Observations (IMO)?

- **Weather and road condition data collection** from fleet vehicles for a more comprehensive view of network conditions.
- Advanced, vehicle-based technologies are deployed to **collect, transmit, and use** weather, road condition, and related vehicle data.

**Intended Outcome** – Utilizing enhanced data for more informed system management (i.e., maintenance, traffic, asset, performance).

Source: Minnesota DOT
Why implement IMO?

- 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

Improve efficiency, enhance effectiveness, increase accountability
IMO System Components

• On-board Systems & Graphical User Interface (Front-end)
• Communication platform
• Data processing Servers (Back-end)
IMO Pilots

Three states explored the feasibility of using vehicle-based data to improve transportation safety & mobility

<table>
<thead>
<tr>
<th>Minnesota DOT</th>
<th>Michigan DOT</th>
<th>Nevada DOT</th>
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<tbody>
<tr>
<td>~590 Vehicles</td>
<td>~15 IMO Vehicles + 310 Snow Plows</td>
<td>~60 Vehicles</td>
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<td>Radio, Cellular, &amp; DSRC</td>
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<td>AVL, Cellular, &amp; DSRC</td>
<td>Cellular, DSRC, &amp; WiFi</td>
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Source: FHWA
Michigan IMO System Framework
Michigan IMO Data Collection Architecture
IMO Captured Images

Source: Michigan DOT
Examples of Motorist Advisory and Warnings

- **White Out Conditions**
- **On I-94**
- **Reduce Speed**

- **Slippery Roads**
- **WB I-94**
- **Reduce Speed**

Source: Michigan DOT
Minnesota IMO System Framework

Applications for Operations
Android/iOS App
Forecasts/Recommendations
Management Reports

Predictive Modeling System
Pavement Model
Road Weather Forecasts

MnDOT MDSS/AVL Servers

AVL equipped
Snow Plows

Cellular Connection
Developing DSRC

Motorist Advisory and Warning

Data Inputs

Users of Data

511 Dash Cams
App for Voice Alerts
AVL activated DMS

NCAR
WxE
MADIS

Airport Wx Stations
RWIS
AVL DATA
Radar
Forecasts

Source: Minnesota DOT
Nevada IMO System Framework

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

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

Source: Nevada DOT
Nevada IMO 3 On-Board Units

Arada Locomate

Comet T7511 Ethernet
- Weather Sensor Head
  - Barometric Pressure
  - Air Temperature
  - Humidity

Technologic Systems
- CPU (Main Computer)

Roadwatch
- (not included in costs)
  - Air Temperature
  - Surface Temperature

Cradlepoint IBR1100
- Cellular Modem, GPS

Custom Sensors
- Windshield Wiper Sensor
- Spreader Rate Sensor
- Spreader Material Sensor

Adam 6051
- Ethernet DIO/counter

Source: Nevada DOT
Connected Vehicle-Enabled Weather Responsive Traffic Management (CV-WRTM) Guidelines

Three Pathways for Implementation

CV-WRTM Guidelines is a valuable resource for IMO implementers
Pathway #1 – Intelligent Agency Fleets

Starts with equipping agency-owned fleets to collect weather and road condition data (Cellular, UHF, and/or DSRC communications)

Supports:
- Adjust speed limits
- Determine closures
- Provide traveler information (e.g., DMS and HAR)
- Determine vehicle restrictions
- Enhance incident response
WSR Technical Assistance

FHWA is developing a suite of educational materials and events for agencies interested in:

- Building their understanding
- Exchanging information
- Deploying WSR

[Case Studies and Fact Sheets](https://collaboration.fhwa.dot.gov/dot/fhwa/RW/MX/SiteAssets/Weather%20Savvy%20Roads.aspx)
Join us on September 6th!

Learn how locals from across the nation are deploying WSR solutions to improve the safety and mobility of their roadways during adverse weather events!

- September 6, 2017
- 12:30 – 2:00 PM (EST)
- Register by September 4th at: https://collaboration.fhwa.dot.gov/dot/fhwa/WC/Lists/Seminars/DispForm.aspx?ID=1476
Q&A Session
Visit the U.S. DOT Exhibit

Want to learn more about connected vehicles, automated vehicles and vehicle-to-infrastructure deployments?

Visit the USDOT in booth #460 in the PWX 2017 Expo Hall.
For more information...

Contact your state’s representative:

- Paul Pisano (paul.pisano@dot.gov)
- Roemer Alfelor (Roemer.Alfelor@dot.gov)
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