Weather and the Connected Vehicle

Presentation at the Connected Vehicle Program Public Meeting
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Agenda

• What’s the need?
• What are we doing about it?
Crash Situation Under Adverse Weather

Total Annual Crashes
*Average = 6,301,000*

Weather Related Crashes
*By Road Weather Condition*

- Wet Pavement: 75%
- Icy Pavement: 13%
- Snow/Slushy Pavement: 11%
- Fog: 1%
- Other Crashes: 76%
- Weather Related Crashes: 24%

*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
Weather-related Costs

- State DOTs spend:
  - $2 billion/yr on snow and ice control
  - $5 billion/yr on infrastructure repairs

- Delays from snow, ice, and fog cost $11.6 billion per year

- Annual cost to trucking industry due to weather-related delay is ~$7.9 billion/yr

- Lost commerce due to storm-closed roads is $3.82 billion in just 15 states
We can make a difference if...

• Road managers and users get route-specific/segment-specific/spot-specific weather and road condition information to:
  - Reduce weather-related crashes by changing driver behavior
  - Actively manage traffic demand and capacity
  - Carry out winter maintenance activities more effectively and efficiently
  - Make better travel choices

• There are 2 sources for the most critical data:
  - Road Weather Information Systems
  - Connected Vehicles
Road Weather Information Systems

Source: The Clarus System, U.S. DOT
The Potential of Higher Resolution

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

Future
Connected vehicles provide continuous picture of what’s happening on the roadways

Source: The National Center for Atmospheric Research
Agenda

- What’s the need?
- What are we doing about it?
Research Goals

All efforts support two goals:

1. Identify weather-related data elements
   - Especially for the NHTSA decision

2. Demonstrate value of connected vehicle data via the development, test and evaluation of a few key applications
   - Especially for traffic managers (as Weather-Responsive Traffic Management strategies)
Road Weather CV Applications

- Enhanced Maintenance Decision Support
- Information for Maintenance and Fleet Management Systems
- Weather-Responsive Traffic Management
  - Variable Speed Limits
  - Signal Timing Optimization
- Motorist Advisories and Warnings
- Information for Freight Carriers
- Information and Routing Support for Emergency Responders
Connected Vehicles & Road Weather: Illustrative Concept

Source: National Center for Atmospheric Research
Vehicle Data Translator (VDT) 3.0

Stage I
- Mobile data ingesters
- QC Module
- Output data handler

Stage II
- Ancillary data ingesters
- Segment module
- QC Module
- Output data handler

Stage III
- Inference Module
- QC Module
- Output data handler

Parsed mobile data
Basic road segment data
Advanced road segment data

Apps and Other Data Environments

Ancillary: Radar, Satellite, RWIS, Etc.

Source: The Vision for Use of Connected Vehicle Data in Practical Road Weather Applications, U.S. DOT
VDT Precipitation Algorithm

Observed: Moderate Snow
Stage III Output: Frozen

Algorithm Inputs:
- CAN-based:
  - Air Temperature: -4 C
  - Wiper Status: Intermittent
  - Speed Ratio: 0.75
  - Headlight Status: Low

Ancillary:
- Radar: 14 dBZ
- Cloud Mask: Cloudy
- Near Station Visibility: 0.5 mi

Source: National Center for Atmospheric Research
Minnesota observations in *Clarus*

Source: The *Clarus* System, U.S. DOT
Integrating Mobile Observations 2.0

Participating states are serving as both providers of mobile data (CAN-Bus and external sensors) as well as users of the information / RdWx CV applications

- **Michigan DOT**
  - Instrument and deploy 20 snow plows and 50 light trucks with CV technologies
  - Implement weather information communications application

- **Minnesota DOT**
  - 305 heavy duty trucks and 30 light duty trucks
  - Implement and operate applications (Enhanced MDSS, Information for Maintenance or Fleet Management Systems, Records Automation, and Motorist Advisory Warning)

- **Nevada DOT**
  - 25 vehicles (mix of plows, light duty vehicles, and passenger cars)
  - Enhance Maintenance Management System (MMS)
Weather Data Environment (WxDE)

• Develop a WxDE that:
  - Manages and archives real-time weather data from both static and mobile sources
  - Incorporates VDT functionality
  - Supports the development of connected vehicle applications
  - Integrates with other Real-Time Data Capture and Management Program environments

• Prototype WxDE is operational, collecting and archiving data (including IMO from MN)
Road Weather CV Applications – Preliminary BCA Results

- To deploy, operate, and maintain the road weather management connected vehicle applications (including the core connected vehicle infrastructure) for 2012 through 2055 is estimated to cost $45 billion*

- The applications are expected to yield safety and non-safety benefits from 2012 through 2055, equivalent to $1.3 trillion

- The overall benefit to cost ratio of the applications is 28:1

Safety Impacts of Adverse Weather (2012-2055)

<table>
<thead>
<tr>
<th>Crashes</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Property Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>66,000,000</td>
<td>325,600</td>
<td>30,360,000</td>
<td>$258 Billion</td>
</tr>
</tbody>
</table>

Safety Benefits of Road Weather Connected Vehicle Applications (2012-2055)

<table>
<thead>
<tr>
<th>Crashes Avoided</th>
<th>Fatalities Avoided</th>
<th>Injuries Avoided</th>
<th>Property Damage Avoided</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,417,482</td>
<td>28,099</td>
<td>2,601,571</td>
<td>$16 Billion</td>
</tr>
</tbody>
</table>

*Costs in net present value using a 7% discount rate for the period 2012 through 2055
Conclusion

• We are on the cusp of a major game-changer with respect to Connected Vehicles and Road Weather

• This is an interdisciplinary program that needs interdisciplinary collaboration

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