Road Weather Management And Connected Vehicles

Improving Road Safety - A Benefit-Cost Analysis
Agenda

1. INTRODUCTION
2. CURRENT ROAD WEATHER SAFETY IMPACTS
3. ROAD-WEATHER CONNECTED VEHICLE APPLICATIONS
4. BENEFIT-COST ANALYSIS
5. PRELIMINARY RESULTS
6. NEXT STEPS
Introduction

- More than 7,000 fatalities occur under adverse road conditions annually
- Weather forecasts don’t provide enough information
- Connected vehicle technology provides an opportunity

- DOT Road Weather Management Program is evaluating road-weather specific applications
- Benefit-Cost Analysis of applications estimated the safety benefits and the incremental costs of deploying road-weather applications
Current Road Weather Safety Impacts

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
Connected Vehicle Technology can Enable Road-Weather Applications

PAVEMENT TEMPERATURE:
28 degrees

Freezing Pavement - Max Speed 35 MPH

Data from vehicles
Message to vehicles
# Road-Weather Connected Vehicle Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Enhanced Maintenance Decision Support System</strong></td>
<td>Road-weather connected vehicle data from snow plows, other agency fleet vehicles, and other vehicles operated by the general public provide input data to Enhanced-MDSS, resulting in improved maintenance operations and increased safety.</td>
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<tr>
<td><strong>Information for Maintenance and Fleet Management Systems</strong></td>
<td>Road-weather connected vehicle data are key inputs to Maintenance and Fleet Management Systems and can, in turn, be passed to an Enhanced-MDSS to refine the recommended winter weather response plans and treatment strategies.</td>
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<tr>
<td><strong>Variable Speed Limits for Weather-Responsive Traffic Management</strong></td>
<td>Road-weather connected vehicle data can be used to inform Variable Speed Limits systems to provide real-time information on appropriate speeds for current conditions and warn drivers of coming road conditions; this application is envisioned in particular in work zones during adverse driving conditions.</td>
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<tr>
<td><strong>Motorist Advisories and Warnings</strong></td>
<td>Road-weather connected vehicle data will provide advanced warning on deteriorating road and weather conditions on specific roadway segments to travelers pre-trip and en-route.</td>
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<tr>
<td><strong>Information for Freight Carriers</strong></td>
<td>Road-weather connected vehicle data will provide information on deteriorating road and weather conditions on specific roadway segments to both truck drivers and their dispatchers. This information can be used to improve scheduling decisions and parking availability and delivery schedules.</td>
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<tr>
<td><strong>Information and Routing Support for Emergency Responders</strong></td>
<td>Road-weather connected vehicle data will provide emergency responders, including ambulance operators, paramedics, and fire and rescue companies road-weather alerts and warnings. Road-weather conditions, especially road or lane closures due to snow, flooding, and wind-blown debris, for specific roadway segments will be used to determine response routes, calculate response times, and inform decisions to hand-off emergency calls from one responder to another in a different location.</td>
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The Benefit-Cost Analysis is being conducted in multiple phases.

**Concept of Operations**
- Identify Road-Weather Applications

**Phase I:**
- Benefit-Cost Analysis: Safety
- Assumption Vetting

**Phase II:**
- Benefit-Cost Analysis: Mobility, Environmental, Cost Savings

*Revisit & Improve*
Overall Approach

Model/Tool: Extrapolates Net Benefits of Applications to the National Level

Road-Weather Connected Vehicle Applications

Identify Benefit Categories
- Safety (Phase I)
- Mobility (Phase II)
- Others (Phase II)

Develop Baseline & Assumptions
- Road Weather Info Benefits w/o BSM II
- Vehicle Miles Travelled
- Number of Crashes

Identify Cost Categories
- In-vehicle costs
- Infrastructure costs

Benefit Analysis

Estimate Benefits for Applications

Cost Analysis

Estimate Costs for Applications

= Activities with substantial stakeholder input
Key Assumptions of the Analysis

• Only safety benefits and incremental costs considered
• Safety benefits include:
  • Fatalities avoided
  • Injuries avoided
  • Property damage avoided
• Core connected vehicle components assumed to be in-place
• Incremental costs include:
  • Development, integration, and management of the applications
  • Additional equipment and communications required to enable applications
• Benefits realization is dependent on deployment of:
  • Connected vehicles
  • Road-weather applications
## Estimating Safety Benefits

### Approach

<table>
<thead>
<tr>
<th>Incidence (i.e., number of accidents)</th>
<th>Effectiveness (i.e., % of accidents avoided)</th>
<th>Deployment (i.e., % connected vehicles, technology maturity, application adoption)</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>[X]</td>
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### Example

<table>
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<tr>
<th>5,590 fatalities under adverse weather</th>
<th>Motorist Advisory has the potential to reduce by 20%</th>
<th>Deployment leads to a realization of 66% of potential benefits in 2042</th>
<th>737 fatalities avoided</th>
</tr>
</thead>
</table>
Benefit-Cost Analysis - Preliminary Results
Monetized Net Benefits of All Road-Weather Applications

\[ \text{Monetized Net Benefits} = \text{Safety Benefits} - \text{Incremental Costs} \]

Total Safety Benefits (2012 - 2055):
- Crashes Avoided: 4,528,432
- Fatalities Avoided: 21,355
- Injuries Avoided: 1,879,691
- Property Damage Avoided: $10,991,210,850

Cumulative Net Benefits* = $518,582 Million

Net Present Value in 2012 USD using 7% discount rate
Monetized Benefit Components of All Road-Weather Applications

Cumulative Benefits* = $718,325 Million

- Property Damage Avoided
- Injuries Avoided
- Fatalities Avoided

Net Present Value in 2012 USD using 7% discount rate
Cost Elements of All Road-Weather Applications

All Applications Cost Elements

- Cumulative Costs* = $199,743 Million
- Variable Speed Limit Sign
- Incremental OBE
- Education and Outreach
- System integration and backoffice costs
- Application Development
- Incremental non-DSRC Telecom Backhaul
- Incremental DSRC Telecom Backhaul
- Maintenance Vehicles will have ESS
- Vehicle Data Translator

Net Present Value in 2012 USD using 7% discount rate
Application Comparison - Benefits & Costs

Safety Benefits do not outweigh the costs

Safety Benefits (e.g., lives saved) far outweigh costs
Application Comparison - Crashes Avoided

Application could reduce crashes by 4.4 million through 2055
Comparison of Applications - Fatalities Avoided

Application could lead to more than 20,000 fatalities avoided through 2055.
Comparison of Applications - Injuries Avoided

Application could reduce injuries by 1.8 million through 2055
Next Steps

- Phase II will evaluate additional benefits
  - Mobility - passenger and freight time savings
  - Environmental - reduced use of deicing chemicals/salts with same level of service
  - Cost Savings - reduced use of materials and labor
  - Other - additional benefits may be estimated as research continues