Benefits and Costs Associated with Maintenance Decision Support Systems (MDSS)

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Pooled Fund Study Partners

- California
- Colorado
- Indiana
- Iowa
- Kansas
- Kentucky
- Minnesota
- Nebraska
- New Hampshire
- New York
- North Dakota
- South Dakota
- Virginia
- Wyoming

- Meridian Environmental Technology
Project Background

- Field tests have not examined economic benefits and costs of MDSS
- Project Objectives
  - Describe the essential functions of a winter MDSS
  - Describe the resources needed to supply the essential functions of an MDSS
  - Characterize and estimate the costs and benefits of deploying MDSS in state transportation departments
Essential Functions of MDSS

• **Applications:**
  1. Real-time assessment of current and future road weather conditions (Road)
  2. Real-time maintenance recommendations (Resources)

• **Pooled Fund Study** states’ experiences lie generally between these levels

“**A Tool**”
- Use MDSS Application 1
- May Use MDSS Application 2

“**A Revolution**”
- Rely on MDSS Application 1
- Rely on MDSS Application 2
# Tangible Benefits and Costs

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Agency</th>
<th>Motorist</th>
<th>Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduced materials use</td>
<td></td>
<td>• Reduced motorist delay</td>
<td>• Reduced environmental degradation</td>
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<tr>
<td>• Reduced labor costs</td>
<td></td>
<td>(through improved LOS)</td>
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<tr>
<td>• Reduced equipment &amp; fuel use</td>
<td></td>
<td>• Improved safety (through</td>
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<td>• Reduced fleet replacement costs</td>
<td></td>
<td>improved LOS)</td>
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<td>• Reduced infrastructure damage</td>
<td></td>
<td>• Reduced response time</td>
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<td></td>
<td>• Reduced clearance time</td>
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<td>• Reduced vehicle corrosion</td>
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<td></td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Software and support</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Communications</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• In-vehicle computer hardware</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Weather forecast provider</td>
<td></td>
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</tbody>
</table>

**Bold** – included in analysis

**Italics** – not included in analysis
Benefit Tradeoff

Winter Maintenance Resources

Level of Service

Motorist Benefit

Agency Benefit

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Simulation Approach

- Use MDSS as analytic tool to predict future pavement conditions resulting from various maintenance actions.
- Use MDSS outputs to compare the outcomes associated with different maintenance philosophies.
- Incorporate risk factors to “dampen” potential benefits.
Why Simulate?

• Benefit-cost analysis must be quantifiable
• No PFS member state has adequate LOS data to measure tradeoff
• Simulator can generate objective and complete LOS data
• Simulation can allow for control of outside factors
Calibration

\[ \text{Resources} = f(\text{Rules of Practice, Weather}) \]

Result: Actual Rules of Practice
Application of Calibrated Simulation

- Actual Weather
- Actual Rules of Practice
- MDSS Treatment
  - Resources Used
  - Predicted LOS
  - Resources Used
  - Predicted LOS
Points of Comparison

- **Point 1**: Calibration Point
- **Point 2**: Keep resources same
- **Point 3**: Keep triggers same
Case Studies

• Three states (CO, MN, NH)
  – Representative of different climates
  – Good historical data on maintenance practices
  – Capture variety of traffic and terrain conditions

• Simulate using several years of historic weather and maintenance data
  – Helps to “tune” MDSS and provide some validation

• Extrapolate to other routes in each state
Storm Classification

• Historical weather data from case study states
  – NH: 13 weather stations, including 150 winter seasons
  – CO: 29 weather stations (414 winter seasons)
  – MN: 60 weather stations (857 winter seasons)
• Over 30,000 storm events identified according to duration, precipitation amount and rate, air temperature range & trend, wind speed (before & after storm), condensation
• Storm events were classified using the K-means clustering method
Safety and Speed Adjustment Factors

• Crash rate and speed are affected by and vary with different pavement conditions.
• Adjustment factors for crash rate and speed reduction were identified through literature review (> 30 past studies).
• Around 15 types of pavement conditions were used (e.g., day, wet, chemically wet, damp, lightly slushy,...).
MDSS Alternatives

- No implementation
  - Follow rules of practice
- Various levels of following recommendations
  - User acceptance
  - Technology (i.e. in-vehicle GUI)

If MDSS does not change the way that an agency performs winter maintenance (e.g. application material, rate, and timing), there would be no LOS benefit and no resource use benefit, so no tangible benefit would show up in this analysis.
Costs

• Operational Infrastructure
  – Computers
  – Training
  – MDSS service
  – Agency IT support

• Supporting Infrastructure
  – Weather forecasts
  – RWIS
  – Bandwidth
  – Mobile Data Collection
Intangible Benefits

• Ability to portray information
• Training tool
• Improved documentation of actual maintenance activities
• Platform for future technology implementation
## Findings: New Hampshire

<table>
<thead>
<tr>
<th>SAVINGS</th>
<th>Resources (ton)</th>
<th>Delay ($M)</th>
<th>Safety ($M)</th>
<th>Total ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenarios</strong></td>
<td></td>
<td></td>
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<tr>
<td>Same Condition</td>
<td>23,644</td>
<td>$1.182</td>
<td>$0.017</td>
<td>$1.168</td>
</tr>
<tr>
<td>Same Resources</td>
<td>442</td>
<td>$0.022</td>
<td>$0.242</td>
<td>$2.622</td>
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<tr>
<td><strong>MDSS COSTS/YEAR</strong></td>
<td></td>
<td></td>
<td></td>
<td>$0.333</td>
</tr>
<tr>
<td><strong>BENEFIT/COST</strong></td>
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</table>
Findings: Minnesota & Colorado

**Minnesota**
- “Supercommuter” results similar to NH
- Rural commuter results variable, less distinct benefit
- Analysis is completing

**Colorado**
- Obtaining adequate weather data delayed analysis
- MDSS simulations have been performed
- Analysis is completing
Next Steps

- Complete Minnesota analysis
- Complete Colorado analysis
- Analyze intangible benefits
- Prepare final report (December 2008)
- Transportation Research Board Annual Meeting (paper submitted for January 2009 presentation)
Questions?

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