Analysis of Maintenance Decision Support Systems Benefits and Costs

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MDSS Stakeholders Meeting #11
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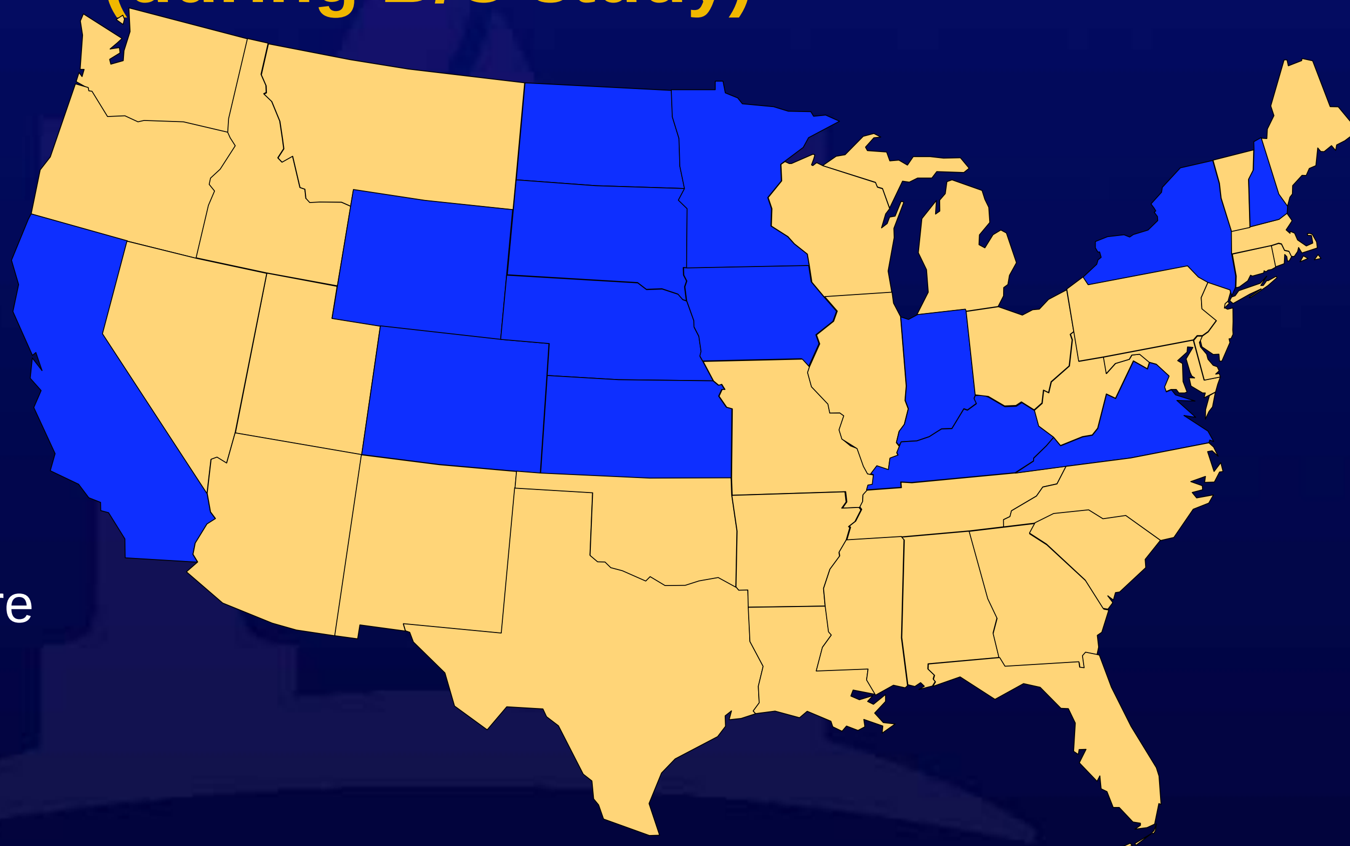
Pooled Fund Study Partners
(during B/C study)

- 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
  - Characterize and estimate the costs and benefits of deploying MDSS in state transportation departments

Essential Functions of MDSS

- Assess past & present weather conditions
- Assess present state of the roadway
- Report actual maintenance treatments
- Report actual road surface conditions
- Predict storm-event weather
- Predict road surface behavior
- Recognize resource constraints
- Identify feasible maintenance treatments
- Communicate recommendations to supervisors and workers

How PFS MDSS is Used

"A Tool"	"A Revolution"
Use MDSS real-time assessment of current and future road weather	Rely on MDSS real-time assessment of current and future road weather
Maybe use real-time maintenance recommendations	Rely on MDSS real-time maintenance recommendations

PFS states' experiences are generally between these levels

MDSS Benefits and Costs

	Agency	Motorist	Society
Benefits	• **Reduced materials use** • *Reduced labor costs* • *Reduced equipment & fuel use* • *Reduced fleet replacement costs* • *Reduced infrastructure damage* • *…*	• **Reduced motorist delay (through improved LOS)** • **Improved safety (through improved LOS)** • *Reduced response time* • *Reduced clearance time* • *Reduced vehicle corrosion* • *…*	• *Reduced environmental degradation*
Costs	• **Software and support** • **Communications** • **In-vehicle computer hardware** • **Training** • **Administration costs** • *Additional weather forecast provider costs*		

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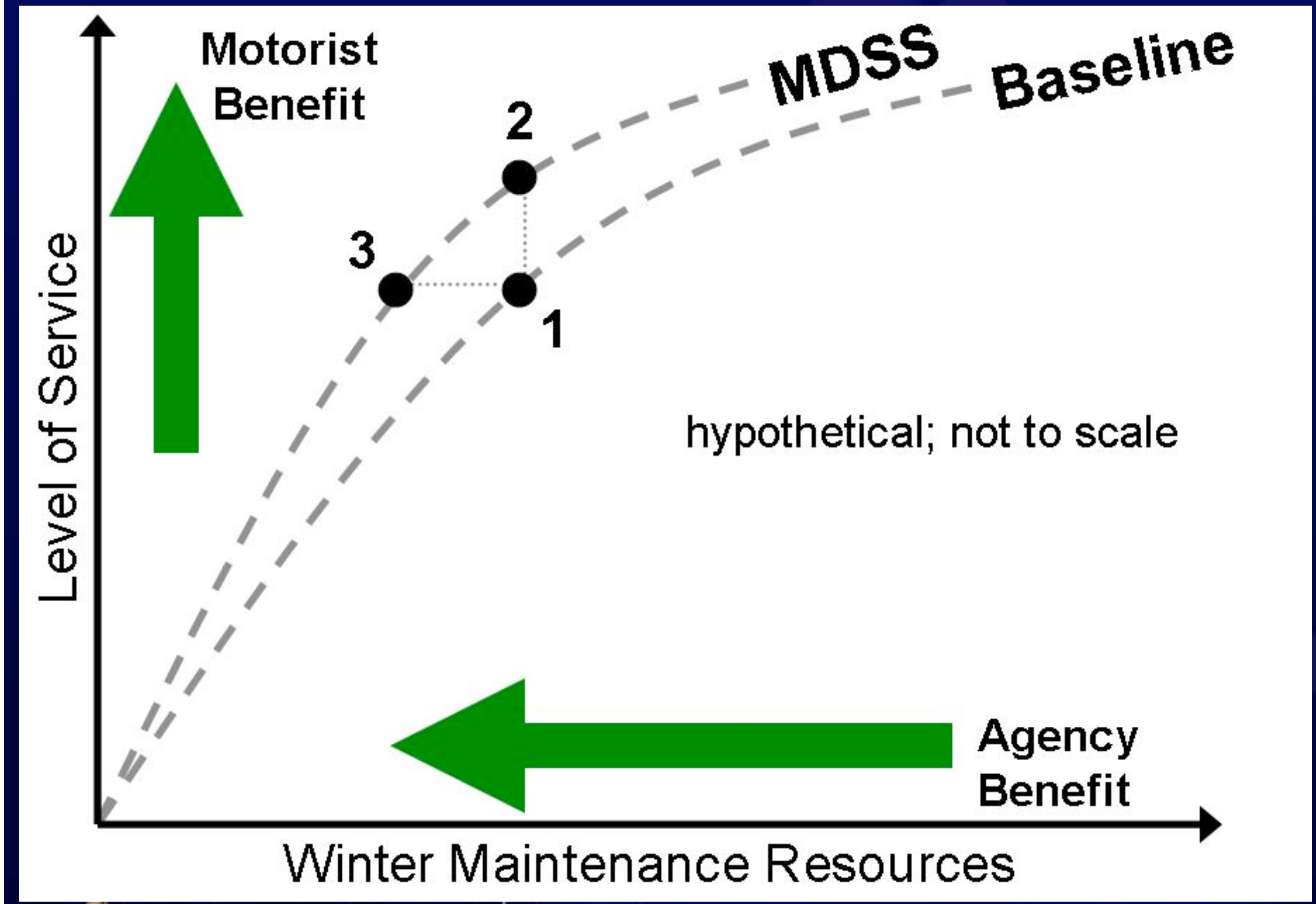
Bold – included in analysis
Italics – not included in analysis

Points of Comparison (Scenarios)



Point 1: Calibration Point (Base Case)

Point 2: Keep resources same (Same Resource)

Point 3: Keep LOS same (Same Conditions)

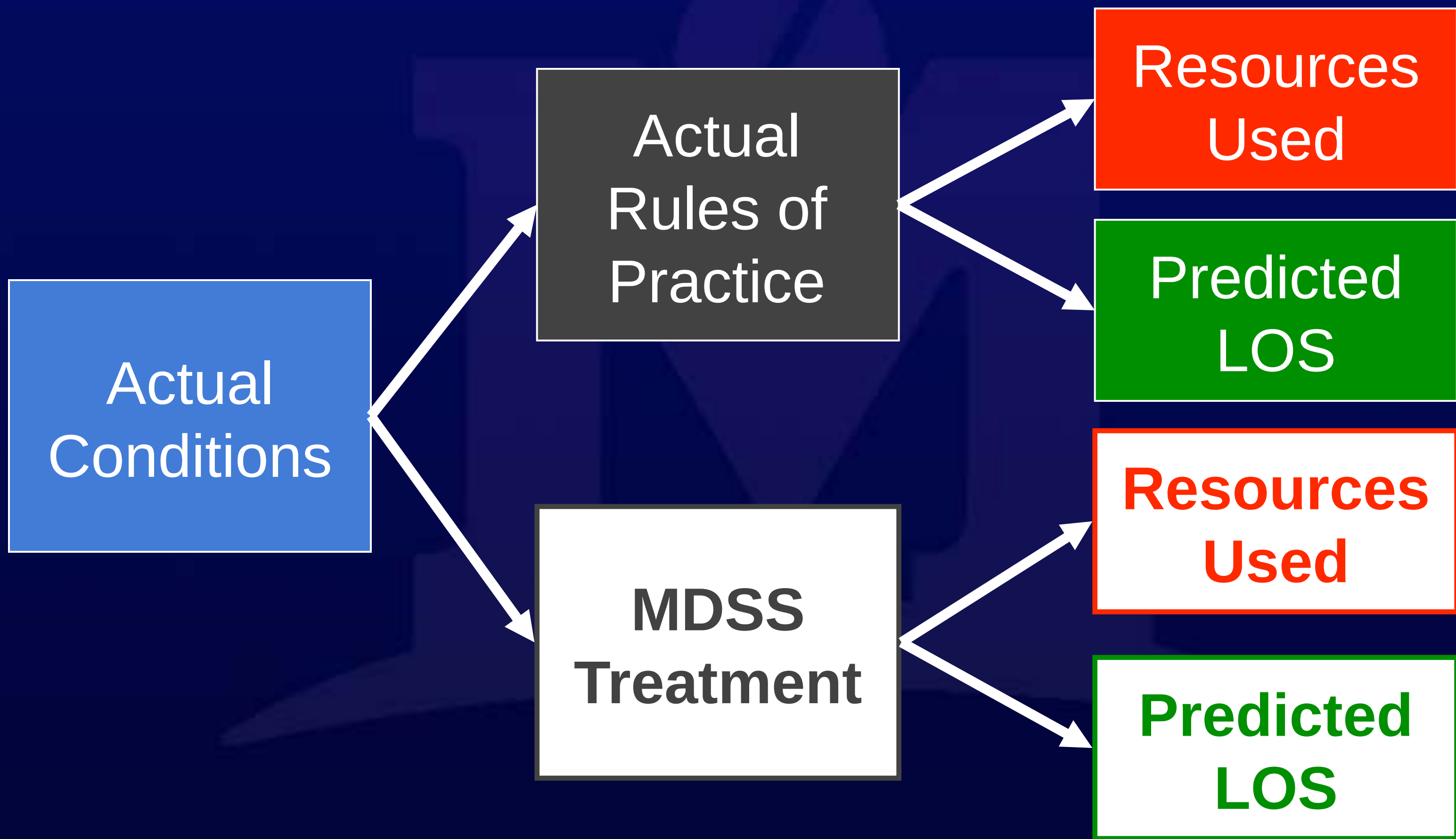
Case Studies

- Three states (NH, MN, CO)
  - 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
- Simulate three scenarios: base case (Point 1), same resource (Point 2), and same conditions (Point 3)
- Extrapolate to other routes in each state

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

How to Simulate?



Calibration

$$Resources = f\,(\,Rules\ of\ Practice,\ Weather\,)$$

Result: Actual Rules of Practice

Storm Classification

- Large number of storms were identified
- Classification method: K-Means Cluster Analysis
  - A simple procedure to classify a given dataset through a certain number of clusters (assume *k* clusters)
  - Aims at minimizing an objective function

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^j - c_j \right\|^2$$

J = Squared Euclidean distance
i: data point; *j*: cluster center

Motorist Benefits: 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)
- Factors for around 15 types of pavement conditions
- Use storm types to connect the two modules

All three case studies confirm the benefits of MDSS

State	Scenario Same:	Benefits ($M)	User Savings (%)	Agency Savings (%)	Costs ($M)	B-C Ratio
NH	Condition	$2.37	50	50	$0.33	7.11
	Resources	$2.88	99	1		8.67
MN	Condition	$3.20	51	49	$0.50	6.40
	Resources	$1.37	187	-87		2.75
CO	Condition	$3.37	49	51	$1.50	2.25
	Resources	$1.99	90	10		1.33

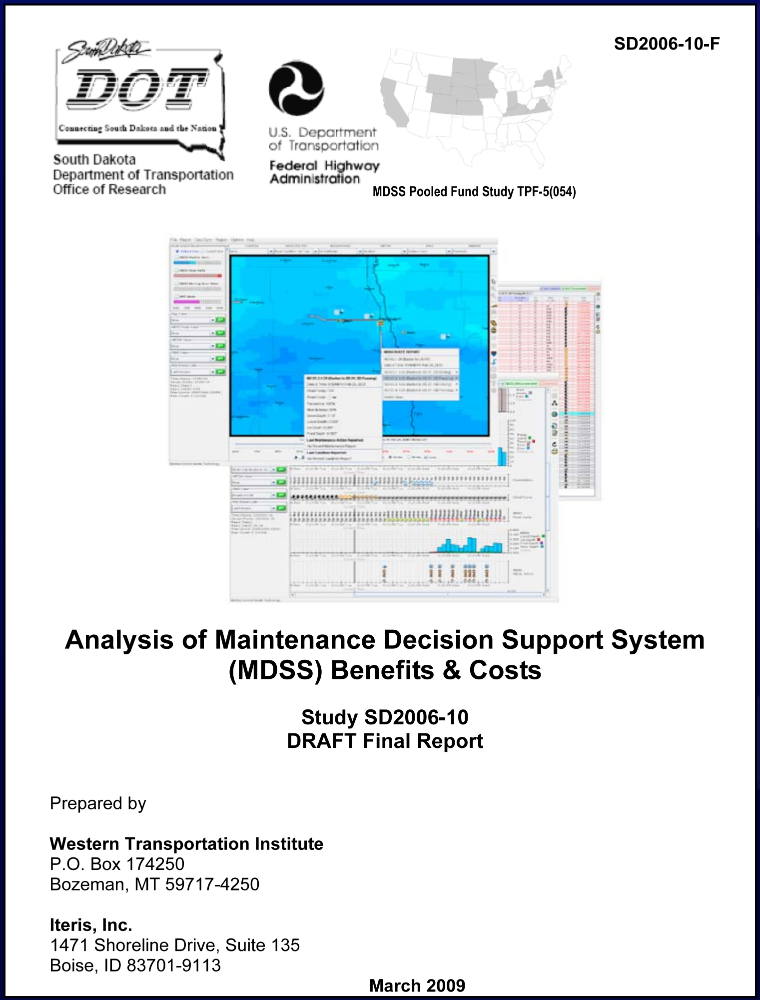
Intangible Benefits

- Ability to portray information
- Improved documentation of actual maintenance activities for analysis
- Rich data to support performance monitoring and optimization
- A training tool
- Reduced response time
- Reduced clearance time
- A tactical operations tool to enable mid-course corrections to improve storm response
- Improve winter maintenance practices and encourage continuous improvement

Intangible Benefits

- Reduced labor costs
- Reduced equipment & fuel use
- Reduced fleet replacement costs
- Reduced infrastructure damage
- Reduced vehicle corrosion
- Reduced environmental degradation
- Allow consistency between areas
- Platform for future technology implementation
- Foster an agency climate of innovation and acceptance of new ideas

Project Deliverables



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South Dakota DOT
Connecting South Dakota and the Nation
South Dakota
Department of Transportation
Office of Research

U.S. Department of Transportation
Federal Highway Administration

MDSS Pooled Fund Study TPF-5(054)

Analysis of Maintenance Decision Support System (MDSS) Benefits & Costs

Study SD2006-10
DRAFT Final Report

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Objectives

Background

- Background
- Objectives
- Methodology
- Tangible and Intangible Analysis
- Findings/Results
- Summary of Benefit & Cost Analysis

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Analysis of
Maintenance Decision Support System (MDSS)
Benefit & Costs

Prepared for the South Dakota Department of Transportation Office of Research Pierre, SD
and
The Member States of the Development of the Maintenance Decision Support System Pooled Fund Study

State of South Dakota Department of Transportation

Summary of Benefit - Cost Analysis

Methodology

Tangible and Intangible Analysis

Findings/Results

Conclusions

1. Report includes a synthesis of prior studies on quantitative effects of adverse weather
2. Stakeholder interviews revealed a generally positive view of the PF-MDSS, with potential for improved maintenance, cost savings, and training benefits
3. Study evaluated two of three identified types of benefits and costs associated with MDSS
    1. agency
    2. user (motorists)
    3. society

Conclusions

4. A simulation-based methodology was developed to analyze tangible benefits and costs, and validated through comparison with historical material use
5. The analysis method enabled comparison of different MDSS implementation scenarios
6. Three case studies collectively showed that the benefits of using MDSS outweigh associated costs. An agency implementing MDSS would likely seek to achieve both a level of service improvement and a reduction in winter maintenance costs.

Questions?

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Objectives

The goal of this research project was to conduct a benefit-cost analysis of the PF-MDSS that will provide applicable results. This study was tasked to:

- Describe the essential functions of a winter MDSS.
- Characterize and estimate the costs and benefits of deploying MDSS in state transportation departments.
- Offer a range of recommendations relating to future MDSS implementation or pre-MDSS activities that could improve the likelihood of successful MDSS implementation.

The driving force behind this study is that justification is an important issue in sound management practice when considering the incorporation of such a technological advancement and departure from existing methods of practice. A benefit / cost analysis is appropriate since field tests have not examined economic benefits and costs of MDSS.

Background

This project follows the earlier State-led Pooled Fund Study to develop and demonstrate a reliable decision support system capable of integrating multiple sources of data (weather observations, weather forecasts, fixed and mobile environmental sensor stations data, camera imagery, and maintenance resource information) and providing direct maintenance response recommendations.

The objective of the PF-MDSS is to provide support (through software systems) for proactive maintenance decision making before and during adverse weather events, with its use resulting in a higher level of service (LOS), reduced operational costs, and/or safer highway conditions.

The objective of winter maintenance operations is not zero delay or zero crashes. Rather, the to improve the LOS, restoring the pavement to normal operations more quickly. MDSS meets this objective by providing information that can allow maintenance personnel to "stay on top of" a winter event and not be overwhelmed by it. It also allows maintenance personnel to see when a forecasted weather event will overwhelm available resources. This should have the positive benefits of reducing delay and improving safety.

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