SD2006-10-F

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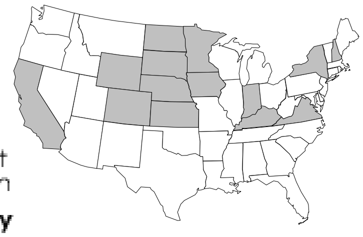
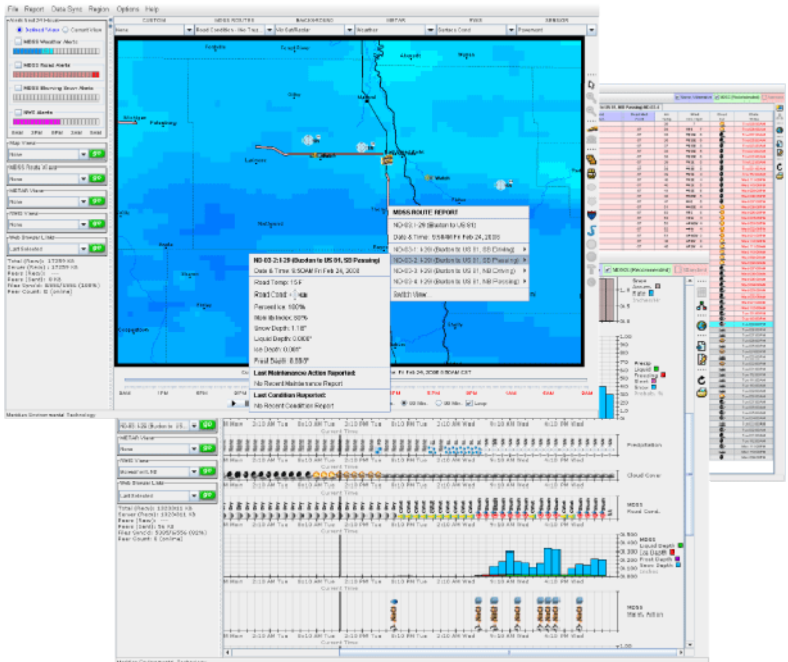


MDSS Pooled Fund Study TPF-5(054)



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

Study SD2006-10
Final Report

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May 2009

1. EXECUTIVE SUMMARY

1.1 Objectives

The purpose of this research project is to assess the benefits and costs associated with implementation of Maintenance Decision Support System (MDSS) by a state transportation agency, and to distill this information in a format that is accessible and actionable to transportation agency decision-makers and elected officials. The objectives of this project include: describing the essential functions of the Pooled fund MDSS, and characterizing and estimating the benefits and costs of implementing MDSS in state transportation agencies. The results of this assessment are intended for use by South Dakota Department of Transportation (SDDOT) and other pooled fund study MDSS partner agencies in making decisions on future investments in MDSS. This study will also provide a transportation agency with the foundation to evaluate deployment requirements, potential benefits of, and methods for measuring improvements relevant to MDSS technology and philosophy.

1.2 Essential Functions of MDSS

The MDSS is a global essential function of itself: it integrates several functions essential to winter maintenance in a single suite, relating them in manners not previously accomplished. These integrated functions are either primary or secondary essential functions. A secondary function is one that is or can be accomplished by existing systems such as road weather information systems (RWIS) or road weather forecasts. Primary functions are those that have been created as part of the MDSS development process such as the road treatment module. The relationship between these functions is shown in Table 1.

Table 1: Essential MDSS Functions

Global	
In-situ integration of several primary and secondary functions essential to winter maintenance	
Primary	Secondary
Function(s) created as part of MDSS (e.g. road treatment module)	Function(s) accomplished by existing systems (e.g. RWIS, road weather forecasts)

The global essential function of the MDSS is fulfilled as two inter-related applications:

- MDSS Application 1: Predict and portray how road conditions will change due to the forecast weather and the application of several candidate road maintenance treatments, based on an assessment of current road and weather conditions and time- and location-specific weather forecasts along transportation routes. (This may be termed a "real-time assessment of current and future conditions".)
- MDSS Application 2: Suggest optimal maintenance treatments that can be achieved within available staffing, equipment, and materials resources. (This may be termed "real-time maintenance recommendations".)

1.3 Research Methodology

The research team conducted extensive interviews with pooled fund stakeholders in order to develop the methodology used to analyze MDSS benefits and costs. The research team interviewed two different groups of stakeholders: maintenance personnel at pooled fund member state transportation agencies and selected staff at Meridian Environmental Technologies, the contractor responsible for development of the pooled fund MDSS.

Through stakeholder interviews and literature review, the research team identified the benefits and costs associated with MDSS. The tangible benefits of implementing MDSS can be achieved by reducing material use (resources), improving motorist safety, and decreasing motorist travel time. The latter two items are realized through the improvement of pavement conditions or Level of Service (LOS).

Under a given operational philosophy, the level of service improves only with an increase in personnel, material and financial resources. The relationship between level of service and winter maintenance costs is represented in the following figure. An agency operating under a baseline condition, following its standard rules of practice, might operate at point 1. Additional or fewer resources would move the agency along the curve labeled "Baseline". If an agency implements MDSS, it is anticipated that this would move the agency to a curve labeled "MDSS", on which it is assumed that the same level of resource investment would yield a better level of service. It is not clear where on the curve the agency might fall. An agency could continue to devote the same resources to winter maintenance operations, which would put the agency at point 2 on the MDSS curve. In this case, there are no savings in resources due to MDSS, but instead a level of service improvement results. Another agency may elect to maintain the same level of service and choose to economize on winter maintenance costs. This would be represented as point 3. It is likely that an agency implementing MDSS would fall somewhere between points 2 and 3, seeking to achieve both a level of service improvement and a reduction in winter maintenance costs.

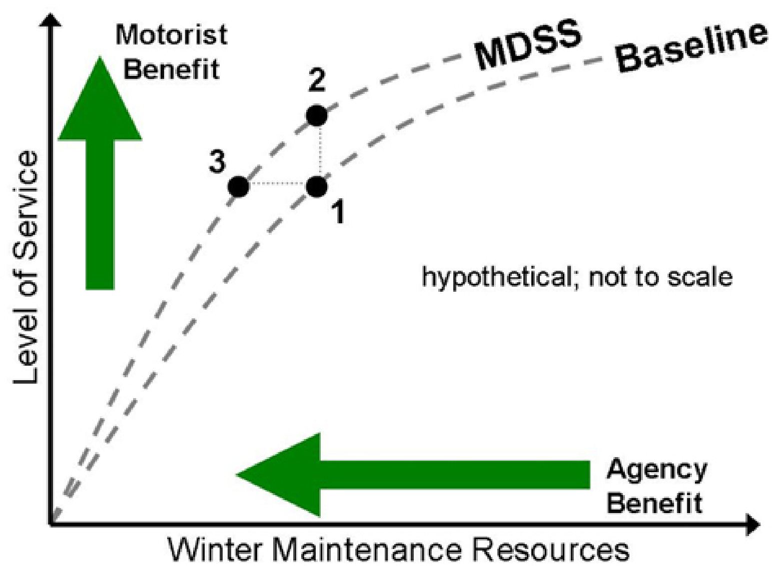

Figure 1: Benefit-Cost Methodology and Relationship between Level of Service and Costs

The methodology for benefit-cost analysis consists of two modules: a baseline data module and a simulation module. MDSS was used as a simulation tool to support the benefit-cost analysis. In the baseline data module, various data, including highway route information, winter maintenance resource use data, traffic volume, crash data, and weather information, are incorporated to establish detailed baseline information for each route segment. The simulation module was used to generate simulation output from MDSS for the each of the three scenarios (baseline, Same Resources, and Same Condition), based on the inputs of selected route segment(s) for simulation, weather data, daily resource use data, and rules of practice. The simulation outputs from selected route segment(s) are extrapolated to other route segments within the state to achieve a statewide benefit-cost analysis.

The research team used a Function Analysis System Technique (FAST) method to analyze the intangible benefits and costs associated with MDSS. A FAST diagram was constructed to assist in understanding the relationship of the functions of the PF-MDSS and identifying intangible benefits of the functions.

1.4 Research Findings and Conclusions

This findings and conclusions of this research study include:

1. The exhaustive literature review on weather effects on the roadway system found that, despite numerous studies in this area, there has been wide variance in the quantitative effects of adverse weather. Thus, a synthesis of these effects was presented in this study to help quantify the safety and mobility benefits of deploying MDSS.
2. The stakeholder interviews revealed that the interviewees generally had a positive view of the PF-MDSS. They generally perceived it as a valuable tool for winter maintenance. They believed that MDSS has the potential to help them improve winter maintenance operations, reduce material use, improve scheduling/assignment of personnel, and improve decision making. Respondents from several states also mentioned its potential as an effective training tool. Finally, the level of trust and use of MDSS were anticipated to increase as technical difficulties (communications/computers) were resolved, and as a result, lead to more technological advances in winter maintenance.
3. Through literature review and stakeholder interviews, the research team developed a taxonomy of MDSS benefits and costs. It was perceived that there were three types of benefits and costs associated with the use of MDSS: agency, user (motorists), and society. By using MDSS as a simulator, three benefits including reduced material use (agency benefit) and improved safety and mobility (motorist benefits) were able to be quantified. The methodology for benefit-cost analysis was developed to analyze these tangible benefits and costs.
4. By comparing the actual material use and the simulated use, it was found that they had similar results. This indirectly validates the simulation-based methodology. The analysis method provided the capability of comparing different implementation scenarios and looking at different maintenance results by using rules of practice and MDSS recommendations.
5. Three case studies collectively showed that the benefits of using MDSS outweighed associated costs. The benefit-cost analysis results are presented in the following table. The benefit-cost ratios did not indicate which MDSS scenario was (always) better. However, it is most likely that an agency implementing MDSS would fall somewhere between the Same Resources scenario and the Same Condition scenario, seeking to achieve both a level of service improvement and a reduction in winter maintenance costs. The case studies also showed that there is a trade-off between agency benefits and user benefits. Increased use of material will achieve more motorist benefits while increasing agency costs, and vise versa.

4. Estimate tangible benefits and costs associated with the deployment and use of the Pooled fund MDSS. Technical Memo 2 will document three case studies of MDSS benefit-cost analysis. The analysis results are also described in Chapter 6 of this report.
5. Characterize Intangible Benefits and Costs. Both Technical Memo 2 and Chapter 7 of this report present the intangible benefits and costs.
6. Document the findings and conclusions from the previous two tasks. The findings and conclusions are presented in Chapter 8 of this report.
7. Distill project findings and recommendations into formats (e.g., Web page, brochure) that are easily accessible to appropriate audience. Chapter 9 of this report briefly describes the formats of outreach materials.
8. Submit a final report that summarizes relevant literature, stakeholder interview results, analysis methodology, case study results, findings and conclusions. This is referred to as this report.
9. Make an executive presentation to the SDDOT Research Review Board summarizing the findings and conclusions. The presentation will be presented to the technical panel members after the submission of the final report.

There were four primary components to the study: stakeholder interviews, methodology development, analysis, and outreach. This report, one of three primary documents resultant from this benefit-cost study, summarizes the project. The other documents comprise two technical reports. The first described the methodology for analyzing the tangible benefits and costs associated with winter use of the MDSS. Technical Memo 2 analyzed the tangible and intangible, benefits and costs associated with the use of MDSS.

This study relies on a handful of assumptions. The feasibility of using the selected methodology for analysis depends on MDSS having been validated in its ability to accurately simulate the future pavement condition that will result from weather and maintenance. Through some detailed case studies (5), Meridian has established some confidence that MDSS does reliably predict these pavement conditions. An assumption fundamental to the results presented is that mobile data collection (MDC) is deployed to record the maintenance activities at a spatial and temporal resolution appropriate to integration with the MDSS recommendations and updates.