Cost Benefits of Weather Information for Winter Road Maintenance

Executive Summary
April 2009

Sponsored by:
Aurora Program

Administered by:
Iowa Department of Transportation

COST BENEFITS OF WEATHER INFORMATION FOR WINTER ROAD MAINTENANCE

Executive Summary
April 2009

Principal Investigators
Xianming Shi, Ph.D., P.E.
Christopher Strong, P.E.

Authors
Zhirui Ye, Ph.D.
Christopher Strong, P.E.
Laura Fay, M.Sc.
Xianming Shi, Ph.D., P.E.

Sponsored by
Aurora Program
Administered by
Iowa Department of Transportation

Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its research management agreement with the
Western Transportation Institute

A report from
Western Transportation Institute
Montana State University
P O Box 174250
Bozeman, MT 59717-4250
Phone: 406-994-6112
Fax: 406-994-1697
www.westerntransportationinstitute.org

EXECUTIVE SUMMARY

This purpose of this research project is to provide a current benefit-cost assessment for weather information in winter maintenance. To achieve this goal, the research team first summarized the weather information resources used by transportation agency personnel in making winter maintenance decisions and investigated how weather information was used to support winter maintenance operations, through extensive literature reviews and surveys to winter maintenance professionals and the meteorological community. Following this, the research team developed a model for winter maintenance costs. A methodology consisting of artificial neural network and sensitivity analysis was proposed and applied to three case studies to analyze the benefits and costs associated with the use of weather information. Finally, this study identified secondary benefits of deploying and using road weather information systems. These research results should help transportation agencies to guide and direct future investment in weather information services and technologies.

The findings and conclusions of this research project are summarized as follows:

1) The survey of winter maintenance personnel found that free weather information sources, private-sector weather providers, and Road Weather Information System (RWIS) were the most widely used weather information sources. The other two sources, the road weather observation mesonets and Decision Support Systems (DSS), had fewer users; they usually collect road and weather data from two or more other sources such as the National Weather Service (NWS) and RWIS, and fuse them to generate information of interest for winter maintenance. Private-sector weather providers, who act similarly to mesonets and DSS, collect weather data from NWS or other sources to provide specialized information of current weather conditions and/or forecasts. Thus, free weather information sources and RWIS are the two primary direct sources for collecting road weather information.

2) Cost considerations and easy access contribute to the wide use of free weather information sources. However, these sources may have problems with timeliness and a lack of detail, which may result in the use of inaccurate weather information. Based on the survey of winter maintenance professionals, the accuracy of weather sources is the biggest barrier preventing the use of weather information.

3) One barrier to using private services and RWIS is the cost. For RWIS, the design and installation as well as communications are the highest cost components. Design and installation are one-time costs, however, and ongoing costs are perceived to be much smaller. The majority of the post-installation costs are related to maintenance. Survey responses indicated that the percentage of winter maintenance budgets spent on obtaining weather information is relatively low (less than 1 percent or between 1 and 5 percent).

4) Air temperature, wind, and the type and amount of precipitation are primary parameters of current and forecast weather conditions. Road weather elements such as pavement temperature, bridge temperature, and pavement conditions are also widely used in

winter maintenance. In addition to these, winter maintenance personnel are highly concerned with forecasts of the onset, conclusion, intensity, and duration of storm events. The importance of weather forecasts decreases with the scale of time from nowcasts to short-term, medium-term, and long-term forecasts.

5) The most noticeable benefit of using weather information for winter maintenance is reducing maintenance cost. The perception that using weather information could save on staffing, materials/chemicals and equipment costs was more likely to be reported by maintenance managers than by field crews/supervisors.

6) Survey results revealed that plowing, deicing, and anti-icing were widely used by survey respondents, and that the employment of anti-icing in winter maintenance is anticipated to increase. Weather information is important in supporting a variety of winter maintenance operations; however, respondents reported needing more weather information to support anti-icing and plowing/de-icing than to support sanding/grit operations. Together, these findings suggest that the demand for weather information among winter maintenance personnel will increase in the future.

7) Survey results showed that maintenance personnel relied less on forecast weather parameters than information on current conditions. Current road and weather parameters of interest included pavement temperature, air temperature, pavement surface condition, precipitation rate, precipitation occurrence, wind speed and direction, and humidity/dew point. Forecast road and weather parameters of interest included the onset/end time of precipitation, precipitation type and amount, pavement temperature trends, and pavement surface condition.

8) The use of weather information varied among the three case study states. The average frequency values of using RWIS and private weather forecasts were 2.75 (Iowa), 3.49 (Nevada), and 1.77 (Michigan). The differences among the states might have been due to their levels of trust in weather information services (e.g., accuracy) and associated service costs.

9) Compared with frequency, the average accuracies of weather information among the states had smaller variations, ranging from 3.4 to 3.6. (Accuracy takes the values of 1 to 5. A value of 3 means that the accuracy of fee-based weather information services is the same as a free weather service; the higher the value, the better.) The survey results indicated that fee-based weather information was more accurate than free weather services, especially for the Iowa and Nevada cases.

10) The case studies found that weather information use had positive effects on winter maintenance costs. Case studies collectively showed that winter maintenance costs decreased as the use of weather information increased or its accuracy improved.

11) It was found that accuracy had a greater effect on maintenance costs than frequency. In other words, winter maintenance costs were more sensitive to weather information

accuracy than to the frequency of its use. Hence, the improvement of weather information accuracy is critical to achieving more savings in winter maintenance.

12) The benefit–cost analyses showed that the use of weather information could bring more benefits than costs. The benefits and costs associated with weather information are summarized in the following table. The Michigan case had the highest benefit–cost ratio due to low costs in weather service. However, the percentages of benefits over total winter maintenance costs were 5.6 percent (Iowa), 6.5 percent (Nevada), and 0.9 percent (Michigan). Although the Michigan case had the highest benefit–cost ratio, the percentage of benefits over total winter maintenance costs is the lowest. For this reason, benefit–cost numbers in this research study cannot tell the whole story. Actually, the benefit–cost ratios of the Iowa and Nevada cases are more representative numbers because the costs associated with weather information in these two states were based on statewide numbers, while the Michigan case was not. Please note that the amortized RWIS capital costs were excluded when calculating the cost of weather information for winter maintenance, considering that such costs are often covered by construction projects and the benefits of RWIS are well beyond the winter maintenance community. The in-house equipment and personnel costs related to RWIS maintenance were also excluded since they are often considered to be part of other ITS (intelligent transportation systems) and/or operations costs and hard to track down. The cost of maintaining RWIS sensors, however, were included as part of the maintenance contract. For some agencies, it may be deemed necessary to include some of the abovementioned costs in the total cost of weather information for winter maintenance.

Summary of Benefit–Cost Analysis

Case Study State	Winter Season	Winter maintenance Cost ($ 000s)	Benefits ($ 000s)	Weather Information Costs ($ 000s)	Benefit-Cost Ratio	Benefits/ Maintenance Costs (%)
Iowa	2006–07	14,634	814	448	1.8	5.6
Nevada	2006–07	8,924	576	181	3.2	6.5
Michigan	2007–08	31,530	272	7.4	36.7	0.9

13) The benefit–cost analysis only considered agency benefits and did not include benefits to motorists and society. The case studies show that the use of weather information is able to reduce resource usage, which in turn can reduce degradation of the surrounding environment, corrosion effects on motor vehicles, and infrastructure damage. In addition, it will benefit motorists with reduced delay and improved safety as the road surface returns to a normal condition more quickly.

14) Weather information from RWIS is mainly used by maintenance personnel, but it can be also useful to other users. The study identified potential RWIS extensions as well as associated benefits and costs. RWIS has been widely used in many applications such as weather-responsive operations, dynamic warning systems, anti-icing spraying systems,

and traveler information systems. Information provided by RWIS can improve accessibility of information, reduce vehicle crashes and crash severity, help travelers develop better trip planning, provide more comfortable driving and so on.

The research team also provided recommendations for the use of weather information in winter maintenance. The recommendations of this study are as follows:

1) A variety of weather sources can provide useful weather information for winter maintenance. It is recommended that a state DOT identify the resources that can be used within the state. A comparison of the sources (e.g., accuracy, ease of access, cost) may be conducted to rank the sources and provide recommendations.

2) Use of accurate weather information in winter maintenance is critical to reducing costs. The accuracy of weather information, however, is usually limited by the availability of weather sources, budget, and weather detection and forecasting technologies. Thus, it is recommended that state DOTs use the most accurate weather sources for winter maintenance within budget limits and other constraints.

3) The level of trust in weather information and the frequency of using weather information are interrelated. Increased level of trust will improve the use of weather information and, as a result, save more in winter maintenance. For this reason, it is important to know about the level of trust among winter maintenance personnel towards various weather resources. If accuracy problems exist with fee-based services, provide feedback to service providers to solve problems or find better alternatives.

4) It is also recommended that the use of weather information be more focused towards the road environment. The use of road weather information (e.g., pavement temperature and trend, bridge temperature) is important information for developing better maintenance strategies.

5) The case studies collectively showed that winter maintenance costs decreased with the increase use of weather information or accuracy. As such, the maintenance agencies should continue to invest in road weather information with high accuracy (such as RWIS and customized weather service) and to ensure high usage of the existing road weather information services. One way to boost the user acceptance and to increase the usage of weather information would be through training along with close communication of weather service providers and winter maintenance practitioners. It is also recommended that agencies leverage existing infrastructure (e.g. existing ITS sites with available power and communications) when choosing RWIS installation sites to help reduce costs.