U.S. Department of Transportation

Road Weather Management

ITS Benefits, Costs, and Lessons Learned: 2017 Update Report

Road Weather Management

Surveillance, Monitoring, and Prediction
Information Dissemination
Traffic Control
Response and Treatment

Highlights

- Colorado Road Weather Management System eliminates winter weather related crashes on dangerous curve.
- Study finds that costs of procuring private sector data to support WRTM can range from $28,000 to $200,000 per year.
- Weather-Responsive Traffic Management systems have the potential to reduce rear-end conflicts by approximately 22% for moderate volume levels and 43% for high volume levels.

Introduction

This factsheet is based on past evaluation data contained in the ITS Knowledge Resources database at: www.itskrs.its.dot.gov. The database is maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments by tracking the effectiveness of deployed ITS. The factsheet presents benefits, costs and lessons learned from past evaluations of ITS projects.

Weather-related crashes are defined as crashes that occur in adverse weather (i.e., rain, sleet, snow, fog, severe crosswinds, or blowing snow/sand/debris) or on slick pavement (i.e., wet pavement, snowy/slushy pavement, or icy pavement). An investigation of vehicle crashes from 2005 to 2014 shows that approximately 22 percent of all crashes occur under adverse weather conditions, resulting in more than 445,000 people injured and nearly 6,000 fatalities each year [1].

Adverse weather not only affects safety but degrades traffic flow and increases travel times by as much as 50 percent during extreme conditions [2]. Motorists endure more than 500 million hours of delay each year as a result of fog, snow, and ice, and weather-related delays cost trucking companies $2.2 billion to $3.5 billion annually [1].

In spite of these statistics, there is a perception that transportation managers can do little about weather. However, three types of mitigation measures may be employed in response to environmental threats: advisory, control, and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity.

Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies.

The ITS Knowledge Resources is a great place to find information about the adoption of effective, state-of-the-art technologies by the Road Weather Management (RWM) industry and its customers. This information includes private, public, and network-based benefits, costs and lessons learned to help those considering implementation of advanced RWM systems. The following information provides a sampling of the road weather management evaluation data available in the ITS Knowledge Resources.

Benefits

Rear-end conflicts are projected to be the most eliminated conflict type by a weather-responsive traffic signal system, with a potential average reduction of approximately 22 percent for moderate volume levels and 43 percent for high volume levels.

High-quality road weather information benefits travelers, commercial vehicle operators, emergency responders, and agencies. Road Weather Information Systems (RWIS) are now a critical component of many agencies' winter maintenance programs. Information dissemination such as automated wind warnings have proven successful. Traffic control technologies that enable agencies to reduce speed limits with variable speed limit (VSL) signs and modify traffic signal timing based on pavement conditions are starting to show results. For example, a Speed Management System for winter maintenance resulted in zero (100 percent reduction) winter weather related accidents on one section of highway in Snowmass Canyon, Colorado (2014-00894). The Maintenance Decision Support System (MDSS) is a decision support tool that automatically combines weather model output with a road model, road maintenance rules of practice, and maintenance resource data. MDSS can be used by winter maintenance managers to obtain more objective road treatment recommendations. Winter maintenance vehicles can be equipped with automatic vehicle location (AVL) systems and mobile sensors to monitor pavement conditions and optimize treatment application rates. A sampling of the benefit cost ratios reported from these strategies is shown in Table 1 below.

Table 1: Benefit-to-Cost Ratios of Road Weather Management Strategies.

B/C Ratio	Description	Application
4.13 to 22.80	In Oregon, the benefit-cost ratios for two automated wind warning systems were 4.13 and 22.80. (2008-00529)	Automated Wind Warning System (AWWS)
2.6 to 24.0	A survey of state and local transportation agencies found that AVL applications for highway maintenance can have benefit-cost ratios ranging from 2.6 to 24.0 or higher. (2008-00536)	Automatic Vehicle Locator
1.33 to 8.87	Maintenance Decision Support System (MDSS) use shows benefit-cost ratios ranging from 1.33 to 8.67. (2011-00668)	Maintenance Decision Support System (MDSS)
1.34	A Maintenance Decision Support System (MDSS) in Denver Colorado helped reduce maintenance operations labor hours, and had a benefit-cost ratio of 1.34. (2010-00654)	MDSS
2.8 to 7.0	Rural Road Weather Information System deployments show estimated benefit-cost ratios of 2.8 to 7.0. (2011-00685)	Road Weather Information System (RWIS)
1.8 to 36.7	Use of weather information shows benefit-cost ratios of 1.8 to 36.7, with winter maintenance costs reduced by $272,000 to $814,000. (2011-00693)	RWIS
11.0	Utah DOT's Weather Operations/RWIS program provides a benefit-cost ratio of 11:1 from reduction in winter maintenance costs. (2011-00691)	RWIS
1.1 to 1.9	In Finland, a benefit-cost analysis supported the deployment of weather information controlled variable speed limits on highly trafficked road segments. (2008-00528)	Weather controlled Variable Speed Limit (VSL)

Integrating Clarus Data in Traffic Signal System Operation

An example of using weather data to improve traffic operations is the survivable weather-responsive traffic signal system developed as part of a project to integrate Clarus data into traffic signal system operations. The potential crash reduction benefits, expressed as the percent reduction in total, rear-end, and crossing conflicts, were shown to be highest during snowy and icy weather conditions. The potential crash reduction benefits were shown to continue to increase as the traffic volume level increases. Rear-end conflicts are the conflict type projected to be most eliminated by a weather-responsive traffic signal system, with a potential average reduction of approximately 22 percent for moderate volume levels and 43 percent for high volume levels. The weather-responsive signal timing plans also show considerable potential in reducing traffic delays and stops. Again, the percent reduction increases as the traffic volume level increases. The potential reduction in delays and stops seems consistent with what has been reported in the literature.

Several studies have investigated the effect of inclement weather on various signal timing traffic parameters. Studies have shown that weather-responsive signal timing plans can improve both the safety and efficiency of the traffic signal system operations. Simulation studies revealed benefits of approximately 7 percent to 23 percent reduction in average delay, 4 percent to 9 percent reduction in vehicle stops, and 3 percent to 12 percent increase in average speeds (2013-00889).

Costs

An October 2012 report published by U.S. DOT's Office of Operations provided results of research conducted to better understand the use of mobile data for Weather-Responsive Traffic Management (WRTM) Models and information needed to support those models. The study found that vehicle trajectory data serves best for the purpose of improving WRTM models.

Weather events have a significant role in traffic operations, road safety and travel time reliability. This research demonstrates how mobile data can enhance the flexibility and performance of traffic models that are used to evaluate WRTM strategies. A lot of research has already been completed in this area, so the goal of this project was not to add to that research, but rather to evaluate the available mobile data and its applicability to existing WRTM models.

As part of this research a compilation of costs and associated parameters of mobile data used for WRTM by various public agencies was presented, see Table 2. These costs provide public agencies with some perspective on procuring the types of private sector data they need for WRTM systems (2013-00294).

Table 2: Public Agency Consumers of Private Sector Data.

	Wisconsin DOT	Houston-Galveston Area Council	Michigan DOT	Texas DOT	Phoenix MPO (MAG)
Status	Request for Information	Purchased	Purchased	Purchased	Purchased
Service Purchased (a)	H	H	H	H	H
Aggregation Level	Hourly day-of-week averages	15 min	5 min	Hourly day-of-week averages	Weekday
Data Purchased (b)	S/TT, PM	S/TT	S/TT	S/TT, PM	PM
Applications (c)	PM, TM	PM, TM, OD	PM	PM	PM
Coverage	All arterials	Houston region	MI Freeways	Statewide TMC network	Region
Timeframe	1-2 years	1 year	5 years	2009	1 year
Validation Criteria	Not yet established	Not yet established	Avail>99.5% Accuracy less than +/- 10mph	None	Not yet established
Validation Techniques	N/A	N/A	Probe, fixed point, re-id	None	Probe, fixed point
Pricing (in thousands)	$80,000(Est.)	$77,000	$200,000 per year	$28,000	negotiating
Licensing	Multiple Use	Multiple Use	Single Use	Single Use	Multiple Use
Multi-Agency	Yes				Yes

NOTES:
(a) Service Purchased: "H"=Historical, "RT"=Real-time
(b) Data Purchased: "S/TT"=Speed or Travel Time", "PM"=Performance Measures
(c) Applications: "PM"-Performance or Congestion Monitoring, "TM"=Traffic Model Validation or Calibration, "OD"=Origin-Destination Studies

Lessons Learned

The U.S. DOT FHWA partnered with the Wyoming DOT (WYDOT) to develop a Weather Responsive Traffic Management (WRTM) application to improve the way WYDOT maintenance personnel report road weather data, recommend variable speed limit (VSL) changes, and report traffic incidents. The new application designed to work with tablet computers enabled maintenance staff to connect to Wyoming's statewide communication system backbone called WyoLink.

The initial implementation was evaluated from January through May 2015 to assess the effectiveness of the application installed on 20 tablets used by plow truck drivers and other staff operating on I-80 and I-25. The evaluation included quantitative and qualitative analysis including a "with-without" methodology. The methodology compared activities using the new application versus the traditional/standard method of using the radio for reporting. Quantitative analysis focused on time spent receiving, logging, and processing reports and actions between the two methods. Qualitative analysis focused on two surveys – one completed by TMC operators and the other by maintenance employees. The survey focused on perceptions, ease of use, overall impressions, and the benefits and shortcoming of the technology.

Key lessons learned are highlighted below.

- **Fully define requirements for positional information**. Positional information is very important for maintenance employees (particularly in a blinding snowstorm). A local SQL Lite database with positional data may be required if a GIS application program interface is too slow to support near real-time road condition reporting applications.
- **Test communication systems early**. Using the data channel of the WyoLink radio network proved to be more difficult than anticipated. Bugs in communications software not realized prior to the release of the application delayed the project by months.
- **Plan for extensive outreach and training**. Significant effort should be invested to inform the TMC operators and maintenance staff about the new system.

Although the deployment was technically complex and required intense management attention, the application improved the effectiveness and efficiency of WYDOT road condition reporting activities and TMC operations (2017-00759).

Case Study – An evaluation of Weather Responsive Traffic Management (WRTM) strategies in Ogden, Utah

The Utah DOT (UDOT) developed and tested an advanced weather-responsive traffic signal management system on a busy corridor between I-84 and US-89 in Ogden, Utah. The system, known as Wx-SIG, used road weather information, meteorological forecasts, and traffic data from UDOT's traffic signal monitoring system to allow traffic signal operators to anticipate developing roadway and visibility issues, and decide when different weather-responsive traffic signal timing plans should be implemented to respond to severe winter weather events. Once aware of the impending deterioration, the system enabled operators to deploy traffic signal timing plans that best matched prevailing travel conditions.

Controller-based high-resolution detector data were used to automatically generate performance metrics that TMC operators could use to assess the effectiveness of different traffic signal timing strategies and the need to change signal timing plans for future events. Data were collected from road weather monitoring stations and additional traffic sensors were installed upstream of intersection stop bars. Intersection approach volume data and link speed data were used by TMC operators to determine when to activate and deactivate signal timing plans and fine-tune timing parameters. A Traffic Estimation and Prediction System (TrEPS) tool was used to forecast future traffic conditions and serve as a decision support tool for UDOT operators.

In order to evaluate system impacts, traffic volume and speed data were collected with and without the Wx-SIG system. The TrEPS model was used to calculate impacts on travel time and delay, and interviews were conducted with USDOT and UDOT traffic operators and managers to assess overall effectiveness and perceived benefits from improved traffic operations.

Based on data collected during 13 severe winter weather events, WRTM strategies were found to improve corridor travel times by three percent and decrease vehicle stop times by 14.5 percent (2014-00927).

References

[1] "How do Weather Events Impact Roads?" U.S. DOT FHWA Office of Operations Road Weather Management Program Website. http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm. Accessed January 10, 2017.

[2] Goodwin, L., *Weather Impacts on Arterial Traffic Flow*, Mitretek Systems, Falls Church, VA. December 2002.

All other data referenced is available through the ITS Knowledge Resources Database, which can be found at http://www.itsknowledgeresources.its.dot.gov/.