Project Summary Report: 8229-001

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Assessment of Montana Road Weather Information System (RWIS)

http://www.mdt.mt.gov/research/projects/rwis.shtml

Introduction

Weather presents considerable challenges to highway agencies both in terms of safety and operations. From a safety standpoint, snow, ice and other forms of precipitation may reduce pavement friction, increasing the potential for crashes. From an operations standpoint, heavy snow storms may affect the connectivity of the highway network due to closures that need to be cleared in an efficient and timely fashion. Further, travelers should be informed about unusual pavement conditions and road closures on time to minimize the effect of adverse weather on safety and mobility of the traveling public. For these reasons, road weather information has become increasingly important for highway agencies particularly in regions that experience harsh winter weather conditions.

Road weather information is used by highway agencies in many applications such as winter maintenance, traveler information, and other weather-related intelligent transportation system (ITS) applications. Montana Department of Transportation (MDT) currently has 73 Road Weather Information System (RWIS) stations throughout the state used as major sources of weather data for transportation applications. This project was undertaken to perform a comprehensive review and assessment of MDT's road weather data collection program to ensure the efficient use of weather data in various transportation applications and the optimum use of MDT resources.

What We Did

Six major tasks were completed for this project, namely:

1. Review of the state-of-the-art which covered literature related to the history and use of RWIS, RWIS data adequacy and reliability knowledge in terms of different sensor and hardware technologies, site selection and geographic coverage practices, and preliminary benefit-cost findings from prior analyses.
2. Review of the state-of-the-practice that focused on RWIS use, management, and planning and used a survey tool to solicit input from transportation agencies of all 50 States, Washington D.C., Puerto Rico, and the Canadian Provinces.
3. Needs assessment of RWIS users by questionnaires and interviews with key MDT personnel to understand their weather information needs. Stakeholder groups included the

primary users, winter maintenance personnel, and secondary users from traveler information and aeronautics.

4. Detailed weather data and software analysis to provide an overview of the current MDT RWIS system, identify gaps in the current system compared to the needs of the agency, and identify and analyze potential hardware and software alternatives that may best meet the needs of the agency.
5. Extensive benefit-cost analysis to investigate outcomes related to using different software functionalities and geographic expansion alternatives. Agency specific and total benefits, including societal benefits, were included in the analyses.
6. Development of an environmental sensor station (ESS) site prioritization model to increase the objectivity of a traditionally subjective practice for determining the best ESS placement given multiple potential sites.

What We Found

The state of the art review found that RWIS programs have expanded and evolved since their initial primary focus of winter maintenance support to include other uses like traveler information, operations activities, advanced ITS applications, and third-party weather service providers. RWIS technologies are available from many vendors and manufacturers, and some agencies are beginning to desire and/or require open architecture and flexible systems to allow for the use of technologies from more than a single provider. Traditionally, ESS siting was a subjective process relying solely on personal judgement, and some agencies are starting to define systematic, objective ESS placement methods that attempt to quantify and optimize the knowledge held by agency personnel. Optimization models were found to be using data related to winter crash history, traffic volumes, and historical climate information. Overall the literature suggests RWIS programs produce many benefits that outweigh the costs.

The state of the practice review received twenty-eight responses, representing 24 states and 2 Canadian Provinces. The survey found that RWIS data are being used for purposes including weather-responsive ITS and tracking weather-related performance metrics, but remain primarily focused on winter maintenance support. Operational data like traffic speeds, traffic volumes, and vehicle classifications, are not widely collected at most agencies' RWIS sites. Overall RWIS programs are still expanding with most agencies adding more sites for additional geographic coverage, many agencies enhancing existing locations with additional sensors, and some agencies adding mobile RWIS. In general, most agencies support the idea that more RWIS stations with fewer sensors (i.e. camera and pavement temperature only) would be better than fewer sites with their current configurations if made possible by cost savings using fewer sensors per site.

The needs assessment determined maintenance personnel need camera images, pavement conditions, air temperature, pavement temperature, wind speed and direction, precipitation type and occurrence, and visibility as

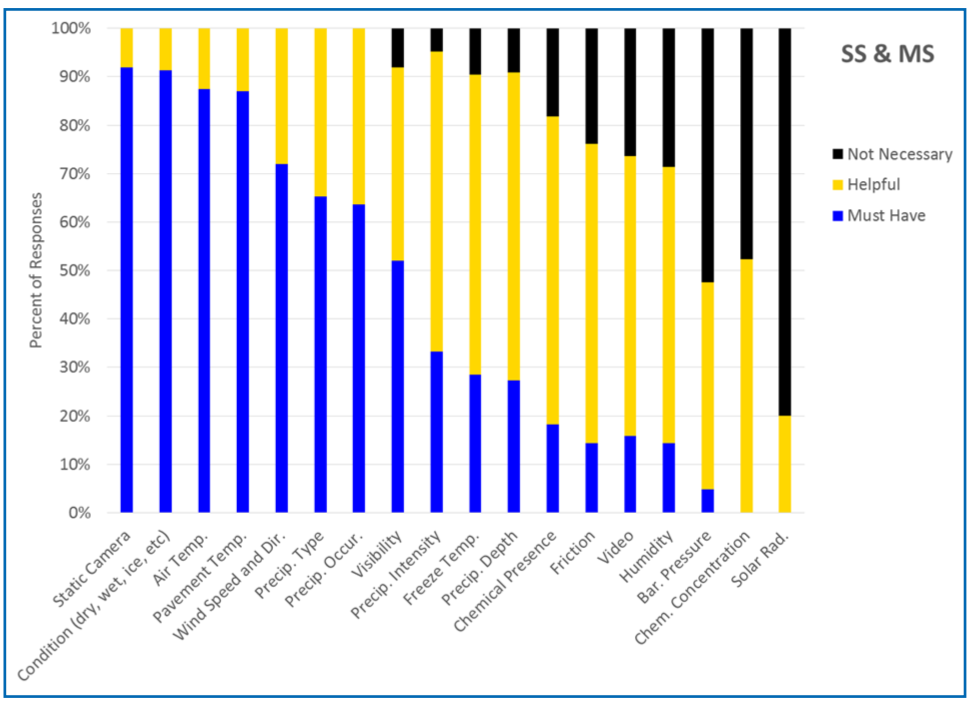

Figure 1: Weather Attribute Importance by Section Supervisors (SS) and Maintntenance Superinendents (MS)

shown in Figure 1. All stakeholder groups generally favor the idea of having more sites with only a camera and pavement temperature sensor compared to fewer sites with more sensors per site. Maintenance personnel may also need wind sensors or visibility sensors at certain locations. The most problematic pieces of equipment from a maintenance perspective, the pan-tilt-zoom (PTZ) cameras, are also the most valuable. Cellular communications are the main source of RWIS data outages and those outages are out of MDT's control. There are certain sensor and camera technologies that may be desired including non-invasive sensors, more robust precipitation sensors, visibility sensors, live video, and cameras with the ability to produce images in the dark. The ability to display RWIS data for maintenance personnel on mobile devices is desired. More RWIS sites are desired overall and especially near maintenance section boundaries. Mobile RWIS are not generally desired. Required RWIS software and server upgrades have recently resulted in some specific functionality losses, namely those related to condition and status alerts. RWIS data is widely used by the public via the traveler information systems from MDT. Cameras are the most popular type of information for the public. RWIS is a secondary data source for the Aeronautics Division and general aviation uses in Montana, with camera images with horizon views being the most valuable RWIS information for aviation.

The weather data and software analysis established MDT's current RWIS program attributes includes 73 ESS providing data for winter maintenance personnel and traveler information systems within MDT as well as sharing the data outside MDT to 511-provider Iteris, NOAA, and MSU/WTI for multistate traveler info/operations systems. Figure 2 shows the overall RWIS system architecture. The core sensor setup that exists at virtually all 73 ESS includes an air temperature and humidity sensor, wind speed and direction sensor, in-pavement sensor, subsurface temperature sensor, precipitation occurrence sensor, and a camera; selected sites (6 or fewer) also have advanced precipitation sensors, visibility sensors, or infrared illuminators for nighttime camera images. MDT's internal RWIS software for data polling, processing and display is a legacy Vaisala system (SCAN Web 6.0) that no longer has the ability to provide weather condition or sensor/site status alarms, limited usability on mobile devices, and no forecasting functionality. Alternative sensors including various atmospheric combination sensors, infrared lights for cameras, visibility sensors, advanced precipitation sensors, and non-invasive sensors are available and may provide additional functionality or configuration options compared to the current core sensor setup. Many alternative RWIS software systems exist categorized by their functionality from basic observational only software to options for alerting, forecasting, mobile sensor integration and automated performance metric functionalities.

The benefit-cost analysis found that agency specific benefits exceed costs

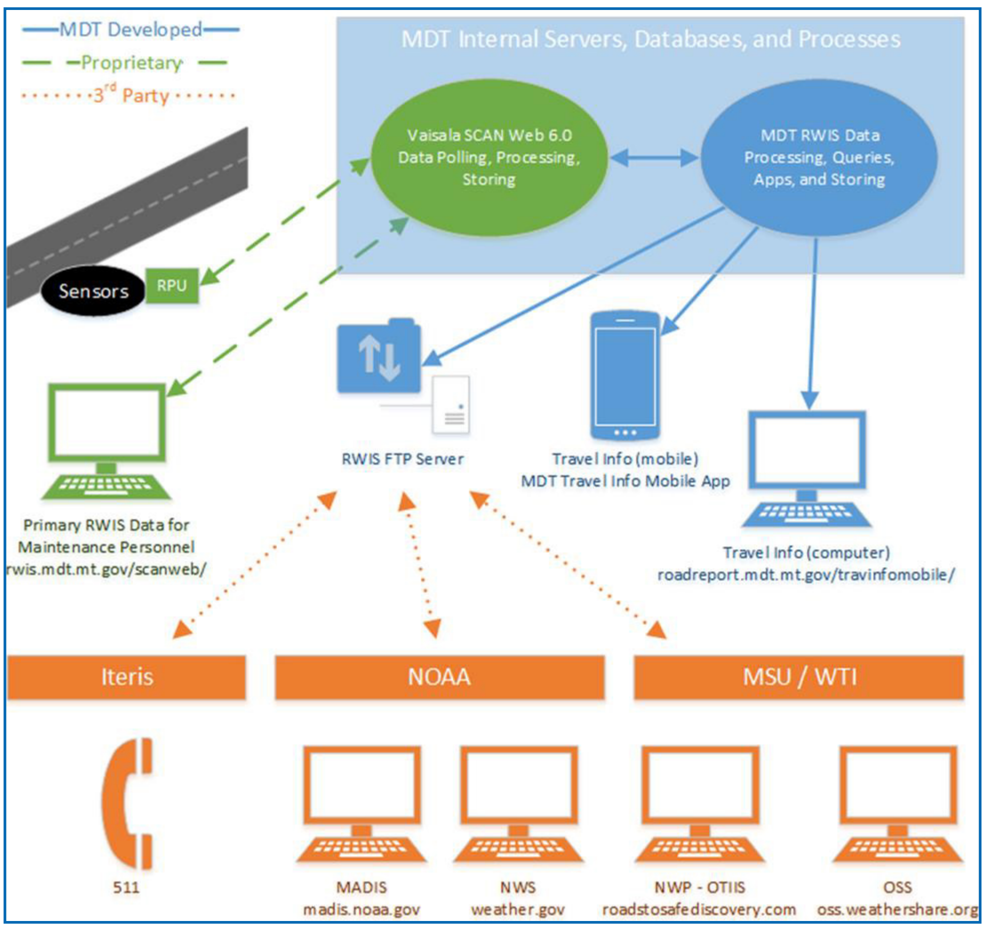

Figure 2: System Architechture

for all three alternative software systems (alerting, forecasting and automated performance metrics) when considering the current ESS sites. The highest agency specific benefit-cost ratios were found to be possible with advanced forecasting and automated performance metric functionalities. Total benefits, including societal benefits, exceed costs for all ESS expansion options (base, simple, non-invasive, and mobile) and all alternative software systems (alerting, forecasting and automated performance metrics), as shown in Table 1. The highest total benefit-cost ratios were found to be possible with forecasting and automated performance metrics functionalities. One scenario, obtaining alerting functionality without expanding sites, is potentially both relatively low cost and highly beneficial, depending on the specific software product used.

The ESS site prioritization model adds the possibility of increased objectivity to the traditionally subjective practice for determining the best ESS placement given multiple potential sites. The model quantifies the overall merit of potential ESS sites based on Montana's specific historical weather conditions, traffic levels, crash history, existing geographic coverage and opportunistic factors related to the availability of power and communications. The model is customizable and allows MDT to place selected weights on certain aspects according to their agency priorities. Use of the model is highlighted through an application of the model to five hypothetical sites around the state.

Overall, MDT's RWIS program was found to be effectively providing valuable weather information for many user groups, with a limited number of specific recommendations that may improve weather information related practices and future directions.

What the Researchers Recommend

Given the overall findings, the researchers' recommendations include:

- Consider requiring or encouraging new RWIS sensor, hardware, and software options be as flexible as possible through the use of non-proprietary communications and compatibilities.
- Reduce the RWIS data and camera image update interval to 15 minutes or less for all sites.
- Include a horizon view for aviation users at all ESS with PTZ cameras.
- In areas that currently have little or no RWIS coverage, make maintenance personnel aware of resources like http://mesowest.utah.edu/ that may have additional weather information from non-RWIS sites.
- Utilize the proposed site prioritization model with agency selected weights to plan future RWIS installations.
- The future direction of MDT's RWIS program should consider funding available for implementing RWIS program changes and the potential acceptance of somewhat different winter maintenance procedures. If funding levels are relatively low for the foreseeable future, then substantial benefits may still be realized through modest investment in alerting capable software. Realizing the benefits of the change to alerting software requires little or no change to overall winter maintenance practices. If a more substantial investment in RWIS improvements can be made, then two possible directions may provide greater benefits, namely, obtaining a software service with advanced forecasting and treatment recommendations or obtaining a software service with automated performance metrics. These two more costly directions may be the most beneficial overall, but would require changes to winter maintenance practices.

TOTAL Current Sites	Current Software		1 (+Alerting)		2 (+F.cast)		3 (+P.M.) no F.cast		3 (+P.M.) with F.cast	
	min	max	min	max	min	max	min	max	min	max
	Baseline		1.0	20.6	20.5	36.0	~ 21.8		~ 33.3	
A (+Base)	1.2	1.8	1.1	2.2	7.9	11.6	8.4	10.3	13.1	15.9
B (+Simple)	2.1	3.6	1.6	4.3	9.5	16.8	11.2	13.8	17.3	20.1
C (+N-I)	1.0	1.4	1.0	1.7	6.6	10.0	15.1	18.1	17.0	20.2
D (+Mob.)	1.4	2.9	1.8	3.7	~ 14.5		~ 12.7		~ 19.7	

Table 1: Total (Agency + Societal) Benefit-Cost Ratios

For More Details . . .

The research is documented in Report FHWA/FHWA/MT-17-001/8229-001, http://www.mdt.mt.gov/research/projects/rwis.shtml

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To obtain copies of this report, contact MDT Research Programs, 2701 Prospect Avenue, PO Box 201001, Helena MT 59620-1001, mdtresearch@mt.gov, 406.444.6338.

MDT Implementation Status: January 2017

Information from this research will be used by MDT's Maintenance Division when making RWIS program decisions.

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