Optimizing RWIS Information
In the
Decision Making Process

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ABSTRACT

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Today's maintenance managers in Canada and the United States must be able to handle multiple tasks during snow and ice control operations or risk falling behind the onslaught of winter weather. Although today's managers have a variety of good information which can lead to effective snow and ice control, all of the regulations concerning chemical applications, environmental impacts and multiple, often contradictory, weather and road weather forecasts can lead to information overload for the field operations decision maker.

The Federal Highway Administration (FHWA) recognized these problems and since 1999 has been developing and field testing a Maintenance Decision Support System (MDSS) for snow and ice control operations. The MDSS project integrates state-of-the-art weather and road weather forecasting, data fusion, and optimization techniques with computerized snow and ice control rules of practice logic. MDSS provides a specific forecast of surface conditions and treatment recommendations customized for individual maintenance garages snow plow routes. Treatment recommendations include the following information:

- Recommended treatment plans such as plow only, chemical use, and abrasives
- Recommended chemical amount (pounds per lane mile)
- Timing of initial and subsequent treatments
- Indication of the need to pre-treat or post-treat the road

After successful field evaluations during the past two winters in Iowa, there was general agreement among maintenance managers that these new technologies were able to assist them with maintaining safety and mobility on roadways and provide for more efficient use of chemicals, equipment and staff. Private sector road weather providers also agreed there is a market for these new technologies.

This paper will provide an overview of the prototype MDSS system, its successes and lessons learned in snow and ice control operations in the Midwestern United States and the 2004-2005 field tests in the more complex weather regions of Colorado. Annual maintenance savings (materials, equipment and labor) will also be discussed.

TEXT

Background

In 2000, the Office of Federal Coordinator for Meteorology and the FHWA Road Weather Management Program in an effort to capture surface transportation weather requirements and unmet user need, cosponsored symposiums on weather information for surface transportation. These symposiums brought together users and providers in an effort to capture surface transportation weather requirements and identify unmet user needs. An unmistakable message emerged that users were not satisfied with the current surface transportation weather capabilities and that much more could be done to address their needs. Although weather forecasts were plentiful and a few private service providers issued road-specific forecasts, there was a lack of linkage between the information available and the decisions being made by winter maintenance managers. Thus, the FHWA Road Weather Management Program decided to address some of the unmet weather needs by launching the Maintenance Decision Support System (MDSS) project.

During the past four years, MDSS has evolved into a functional prototype system. A prototype MDSS was deployed at several maintenance garages in central Iowa in winter 2002-2003. During the winter of 2003-2004 a second, more comprehensive field demonstration was conducted. As one would expect, the performance of the prototype MDSS was much improved during the second winter of use, but still not sufficiently mature to convince the private sector the system was ready to market, or the public sector to require MDSS as part of their forecasting specifications. A third field demonstration was held in Iowa during the winter of 2004-2005 and a first demonstration was held in the difficult climate in Colorado.

Project Resources and Organization

The MDSS research project is funded and administered by the FHWA Road Weather Management Program. The project builds upon the work accomplished in the Strategic Highway Research Program (SHRP) and the Test and Evaluation Project TE-28 that FHWA, American Association of State Highway and Transportation Officials (AASHTO), and Transportation Research Board (TRB) completed in the mid 1990s. A consortium of five national laboratories in coordination with state DOTs, academia, and private sector have been participating in the development and field evaluations of the project. These laboratories are:

- Cold Regions Research and Engineering Laboratory (CRREL)
- National Center for Atmospheric Research (NCAR)
- Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL)
- National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory (FSL)
- NOAA National Severe Storms Laboratory (NSSL)

Both CRREL and MIT/LL had participated in the SHRP and TE-28 projects so brought some familiarity and background to the project. CRREL brought experience in creating models for predicting road surface temperature while MIT/LL concentrated on translating the road maintenance rules of practice into computer algorithms. FSL provided high resolution weather models while NSSL contributed algorithms for determining precipitation type in weather models. NCAR was the lead laboratory providing the core data processing capability, the graphical user display, and the engineering to integrate all the parts into a working MDSS prototype.

Project Overview

The MDSS project integrates surface weather forecasting, data fusion, and optimization techniques with the computerized anti-icing techniques of the TE-28 project rules of practice logic. The result is a specific forecast of surface conditions and treatment recommendations customized for individual sections of highway.

The MDSS project goals are:

- to show the state DOTs that new technologies can be integrated to provide maintenance managers decision making support in improving safety and mobility on roadways while making more efficient use of chemicals, equipment and staff.
- to convince the private sector surface weather providers that there is a market for these new technologies

FHWA defined success for this MDSS project would be reached when private sector companies integrated MDSS components into their product line and state DOTs were writing MDSS requirements into their purchase specifications.

Field Evaluations

Six state DOTs competed to win the opportunity to evaluate the prototype MDSS. Factors used in selecting the winning candidate were the availability of high-speed communications and computers at the maintenance garages, progressive winter maintenance programs, and a willingness of the DOT personnel to participate in training and field verification activities. Iowa DOT met those criteria and did not have complex terrain.

The first demonstration period began February 3, 2003 and concluded April 7, 2003. A total of 15 plow routes in 3 maintenance garages around Des Moines and Ames, Iowa were selected. During that time, five light snow events (3 inches or less accumulation), three heavy snow events (more than 3 inches), and one mixed rain/snow/ice event occurred. The demonstration was a success because the prototype was deployed and utilized and the following list of lessons learned was compiled:

- unable to capture light precipitation events which caught crews off guard

- rules of practice module needed additional development to handle a wider variety of weather and road condition scenarios and treatment responses
- availability and quality of observed real-time precipitation rate and accumulation data were very poor for snow and ice
- need algorithms in the road condition treatment model (RCTM) to account for the impact of vehicle speed and volume on chemicals and the complex problem of blowing and drifting snow on the roadway

A second demonstration was held in central Iowa from December 29, 2003 to March 24, 2004. Although the MDSS Graphical User Interface (GUI) was highly rated by the Iowa DOT for its ease of use and logical layout further enhancements were made for the second demonstration. These enhancements included adding digital values to state and route view graphics, a real-time display of RWIS data, historical window to review guidance from previous forecast cycles and an event summary of weather and road variables for each forecast period and for each plow route. The GUI is illustrated on the MDSS web site http://www.rap.ucar.edu/projects/rdwx_mdss.

The RCTM and rules of practice module were significantly enhanced to recognize the overall storm situation and handle changing weather situations and also provide a blowing snow alert. Other enhancements included were modifying the road temperature model to accept actual road temperature and subsurface temperatures as input, rather than relying on model-derived values.

The road weather forecast system (RWFS) was configured to utilize and integrate ten different forecast modules and probabilistic forecast information was added. Since winter maintenance supervisors are in the business of risk management, the probabilistic prediction products are helpful. Results were the forecasts had significantly better skill in the first six hours because of their forward error correcting capability but still had poor quality of precipitation measurements. Also the ability of models to predict insolation varied greatly between models, particularly in partly cloudy conditions. Since insolation measurements are critical for road temperature prediction, it was recommended that insolation measurements be added to surface observing stations and be provided in real time to weather service providers. Further enhancements to the prototype are explained in (Reference 1).

The third year of demonstration for the winter of 2004-2005 was held in both Iowa and Colorado. The Iowa implementation went well since most of the problems had been worked out in the previous two years. Several of the recommended treatments were utilized without modifications and proved to be optimal solutions. Others needed only minor tuning. Any that were in serious error were so because of errors in the forecasts. The demonstration in Colorado had difficulties. The major effort for MDSS was concentrated on the 470 toll road. As in previous demonstrations the RWFS was configured to utilize and integrate ten different forecast modules. Unfortunately in the complex terrain, there were large spreads between the models and it was difficult to tune a best model. Work is needed to provide a better coupling between the land surface models to the atmospheric models.

Detailed reports on the third year demonstration will be developed during the summer of 2005. Results will probably be available for reporting at the Transportation Association of Canada meeting in September 2005.

Estimated Operational Savings

There was consensus in the second demonstration year among maintenance supervisors that participated in the MDSS that they had confidence in the system and it had proven itself to be a valuable tool both for operations and training. This confidence was further strengthened in the third year. As reported in (Reference 1), the Iowa DOT estimated they had a potential operational savings of between 10% to 15% in their materials and labor costs, which equates to about $3.5 million per year.

Estimating MDSS Success

As stated earlier in this paper, success as defined by FHWA will be reached when private sector companies integrate MDSS components into their product lines and the state DOTs purchase these new services. Guidance to state DOTs in preparing and evaluating specifications for weather forecasting services that include capabilities similar to those found in the FHWA prototype MDSS can be found in (Reference 2). This guidance includes:

- Candidate functional requirements for MDSS products and services
- Information that DOT personnel can use to evaluate prospective DMSS service
- Questions that could be asked when interviewing prospective vendors

Request for Proposals for Weather Forecasting Services are currently being developed by the Iowa DOT for a summer 2005 letting. MDSS guidance is currently listed in the Mandatory Requirements section. MDSS capability requirements are divided into three-year steps to allow time for the development of the system over the three year contract period. The Virginia DOT has contracted with Vaisala to provide MDSS assistance in their 2005-2006 Winter Weather Forecasting Services. DOTs in the states of Oregon, Nevada, Wisconsin, New York, Pennsylvania, and West Virginia and the Cities of Indianapolis and Denver are considering adding MDSS to their winter weather forecasting services contracts.

Iowa DOT presented its success with evaluating and implementing MDSS during the past three winters at the 2005 Midwest Snow and Ice Workshop, held in Kansas City, Kansas, on April 19 and 20, 2005. Eleven Midwestern states attended this Workshop. All eleven states expressed interest in learning more about MDSS and how it could be evaluated in their states. This same MDSS presentation is scheduled for September 8, 2005 at the 10^{th} Eastern Winter Road Maintenance Symposium & Equipment Expo being held in Hartford, Connecticut. The opinion of the author is that some of these Midwestern states and other states beyond the Midwest will soon follow the Iowa DOTs lead in implementing MDSS and eventually requiring MDSS guidance on their future Weather Forecasting Services.

Application in Canada?

Since the MDSS builds on SHRP RWIS and Anti-icing research (References 3, 4 & 5) and the FHWA "Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance Personnel" (Reference 6), which are the same foundational winter maintenance research being applied in Canada, converting MDSS for use in Canadian snow and ice control practices should be relatively straight forward. Several Canadian Provinces and cities have purchased the AASHTO Road Weather Information System (RWIS) Anti-icing (AI) Computer Based Training (CBT) program to train their managers, supervisors, operators, and their contractors. MDSS builds on the RWIS/AI CBT program to help improve efficiency and effectiveness of snow and ice control operations.

REFERENCES

1. Mahoney, W.P. et al, "The Federal Highway Administration's Maintenance Decision Support System Project: Summary Results and Recommendations", Preprints, *Transportation Research Board, 84th Annual Meeting, January 2005.*
2. "The Maintenance Decision Support System (MDSS), Functional Specification Template and Procurement Guidance, Version 1.1", National Center for Atmospheric Research, Boulder, CO, November 27, 2004. (See MDSS web site at http://www.rap.ucar.edu/projects/rdwx_mdss.
3. Boselly, S.E., J.E.Thornes, C. Ulberg, and D. Ernst. *Road Weather Information Systems, Volume 1: Research Report.* Report SHRP-H-350, SHRP, National Research Council, Washington, DC, 1993.
4. Boselly, S.E., and D. Ernst. *Road Weather Information Systems, Volume 2: Implementation Guide.* Report SHRP-H-351, SHRP, National Research Council, Washington, DC, 1993.
5. Blackburn, R.R., E.J. McGrane, C.C. Chappelow, D.W. Harwood, and E.J. Fleege. *Development of Anti-icing Technology.* Report SHRP-H-385, National Research Council, Washington, DC, 1994.
6. Ketcham, Stephen A., L.D. Minsk, R.R. Blackburn, and E. J. Fleege. *Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance Personnel.* Federal Highway Administration, Washington, DC, June 1996.