# Best Practices for Road Weather Management

## Version 2.01

## Publication Listing

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| 511 DEPLOYMENT IN RURAL STATE: A CASE STUDY OF MONTANA | Montana's 511 system is scheduled for a winter 2002 deployment. This rural system is unique in that its focus is on road and weather information and will incorporate a pavement thermal model and a weather model into the 511 system. Information about mountain passes will be included and both travelers and maintenance crews will utilize the system, which will cover 8,200 miles of interstate and primary roadways in Montana. This paper will focus on the deployment of 511 from the perspective of a rural state including project stakeholders, system content, data collection methods, and the marketing plan. | 2002 Joint Meeting of the CAATS and the RATTS, http://www.caats.org/Press%20Releases/CRCD.htm |
| A BENEFIT/COST ANALYSIS OF INTELLIGENT TRANSPORTATION SYSTEM APPLICATIONS FOR WINTER MAINTENANCE | Washington State DOT assessed the benefits and costs of deploying an automated anti-icing system on a high-accident corridor. | Washington State Department of Transportation, Transportation Research Board 80th Annual Meeting |
| A CASE STUDY IN HIGHWAY MAINTENANCE MANAGEMENT: OHIO'S COUNTY WORK PLANS | Over the past three years, ODOT adopted Strategic Initiatives to revamp the department's maintenance management methods, improve practices and optimize resource utilization. Focused on redefining, prioritizing and tracking all maintenance resources, the department set out to combine planning, implementation, quality review and cost accounting data into one manageable, easily-accessed system. The product of this intensive effort, the ODOT County Annual Work Plans, is revolutionizing the way the department approaches maintenance management. Prior to the implementation of the work plans in July of 2001, roadside conditions and maintenance efforts varied widely across the state. Following the inaugural year of the County Work Plans, conditions are meeting statewide standards, reflecting the state's new focus on more effectively managing Ohio's transportation investment. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| A CORRELATION TECHNIQUE FOR ESTIMATING TRAFFIC SPEED FROM CAMERAS | This paper presents a new algorithm to estimate Speed from roadside cameras in uncongested traffic, congested traffic, favorable weather conditions, and Adverse weather conditions. Individual vehicle lanes are identified and horizontal vehicle features are emphasized using a gradient operator. The features are projected into a one-dimensional subspace and transformed into a linear coordinate system using a simple camera model. A correlation technique is used to summarize the movement of features through a group of images and estimate mean Speed for each lane of vehicles. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

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|---|---|---|
| A DECISION SUPPORT SYSTEM FOR SNOW EMERGENCY VEHICLE ROUTING: ALGORITHMS AND APPLICATION | Summarizes results of research to develop a decision support system to assist the Maryland State Highway Administration Office of Maintenance staff design snow emergency routes for Calvert County, MD and achieve improvements in service and savings in operational costs. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| A GUIDE FOR SELECTING ANTI-ICING CHEMICALS, V1.0 | The purpose of the guide is to specify the key performance measures that are required from an anti-icing chemical, and suggest ways of grading chemicals according to those performance measures. It also provides a method whereby an agency can weight these measures according to the specific needs of that agency. | www.anti-ice-guide.com |
| A LIFE CYCLE COST-BENEFIT MODEL FOR ROAD WEATHER INFORMATION SYSTEMS | Describes a decision tool supporting implementation of RWIS and quantification of costs and benefits. | Transportation Research Board 77th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| A METHOD FOR RELATING TYPE OF CRASH TO TRAFFIC FLOW CHARACTERISTICS ON URBAN FREEWAYS | A method is developed to determine how crash characteristics are related to traffic flow conditions at the time of occurrence. Crashes are described in terms of the type and location of the collision, the number of vehicles involved, movements of these vehicles prior to collision, and severity. A case study using data for more than 1,000 crashes in Southern California identified twenty-one traffic flow regimes for three different ambient conditions: dry roads during daylight, dry roads at night, and wet conditions. Each of these regimes has a unique profile in terms of the type of crashes that are most likely to occur, and a matching of traffic flow parameters and crash characteristics reveals ways in which congestion affects highway safety. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| A PORTABLE METHOD TO DETERMINE CHLORIDE CONCENTRATION ON ROADWAY PAVEMENTS | Studies have shown that the ability to measure the salt concentration on roadway surface would bring dramatic advances in the effective use of deicers. Concentration measurement devices currently in use are only for point measurement and are dangerous for field personnel because they require manual on-site measurement. A new portable concentration system developed in this project is mounted on a truck and enables safer and continuous measurement of salt concentration. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| A TEMPORAL ANALYSIS OF WEATHER-RELATED COLLISION RISK FOR OTTAWA, CANADA: 1990-1998 | This study examines temporal variations in weather-related collision and injury risk using collision and weather data for Ottawa, Canada over the period 1990-1998. A matched-pair approach was used to define precipitation events and corresponding controls in order to estimate and compare the risk of collision and injury druing precipitation relative to normal seasonal conditions for weekdays versus weekends, nighttime versus daytime, peak-period versus other daytime; and early-winter season versus late-winter season. Results indicate that collision risk increased significantly---by more than 100 percent for rain and approximately 50 percent for winter precipitation events. Injury risk was also elevated, but to a lesser extent. Increases in precipitation-related collision risk during the winter were higher on weekends relative to weekdays. Also, collision risks were especially high during the early part of the winter season. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| ADVANCED COLLISION WARNING SYSTEM FOR THE ROADVIEW SNOWPLOW DRIVER ASSISTANCE SYSTEM | Research program conducted in California and Arizona on Advanced Snowplow with a multi-lane, radar-based Advanced Collision Warning system and a magnetic Lateral Sensing System for use in low visibility conditions. A visual display provides two-dimensional driver assistance information. | 7th World Congress on ITS, University of California - Davis. |
| ADVANCED DECISION SUPPORT FOR WINTER ROAD MAINTENANCE | The MDSS is a decision support tool that has the ability to provide weather predictions focused toward the road surface. These predictions are then merged with customized rules of practice that have been captured from maintenance managers and coded into a computer algorithm. An initial demonstration of the MDSS prototype was deployed and evaluated during the second half of the winter of 2002-2003 in central Iowa. It is hoped that after the winter 2003-2004 demonstration that the system will be mature enough to be championed by the private sector and to be embraced by the states. | Pennsylvania Borough News, Volume 03, Issue 10; FHWA & Mitretek Systems |
| ADVANCED TRAVELER INFORMATION SERVICE (ATIS): WHAT DO ATIS CUSTOMERS WANT? | This is the second of two white papers written for the “ATIS Data Gap” workshop with the objective of providing insights from MMDI Customer Satisfaction ATIS evaluations and other USDOT-sponsored ATIS research. The paper synthesizes findings from research and evaluations dating back to 1996, including several field operational tests. | www.itsdocs.fhwa.dot.gov/\JPODOCS\REPTS_TE/9H801!.PDF |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| ADVANCED VEHICLE CONTROL SYSTEMS (AVCS) FOR MAINTENANCE VEHICLE APPLICATIONS | Highway maintenance operations most suitable for the application of AVCS are snow removal and work zone following by a shadow vehicle. This study explores opportunities for AVCS-based snow removal and work zone following vehicles. A description of these operations, and their suitability for the application of AVCS is presented. Previous and on-going work related to vehicle automation for these operations is introduced, along with recommendations for the future, based on an assessment of technical feasibility of AVCS and the attitudes of the highway and airport maintenance communities towards this technology. | http://www.itsdocs.fhwa.dot.gov/%5CJPODOCS%5CREPTS_TE/1VW01!.PDF |
| ADVERSE WEATHER TRAFFIC SIGNAL TIMING | Study conducted for Minnesota DOT to determine the impact of bad weather on a coordinated signal system (three-mile section of Trunk Highway 36 with five signals) and to determine if it would be beneficial to develop timing plans to accommodate adverse weather conditions. | www.trafficware.com/documents/1999/00005.pdf |
| AN ANALYSIS OF THE WORST COMMUTING DAYS IN WASHINGTON, DC (JUNE 1, 2000 to MAY 31, 2001) | This report explores how much benefit pre-trip traveler information provides on some of the worst commuting days in Washington, DC. It analyzes the impacts on a commuter who does not utilize traveler information services, and examines what would have happened to his commute if he had made use of a notification-based pre-trip traveler information service on those days. The worst days were determined as those that had high travel times, travel disutility cost, travel-expenditure, late and early schedule delays, and poor on-time reliability and just-in-time reliability. When possible, contributing factors that made the days the worst with respect to a particular measure were identified from data on incidents, weather and high-demand. | http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13782.html |
| AN APPLICATION OF NEURAL NETWORK ON TRAFFIC SPEED PREDICTION UNDER ADVERSE WEATHER CONDITION | A neural network model for predicting traffic speed under adverse weather conditions is proposed. One link located in Chicago was chosen and all the data involved was collected from the Internet. The Back Propagation algorithm was used to train the neural network model for approaching the best prediction results. The MATLAB software was used to solve this model. The result has demonstrated that, neural network is an effective tool theory to predict traffic situation if appropriate model architecture and input data are available. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| AN ASSESSMENT OF SELECT METROPOLITAN WASHINGTON PUBLIC SAFETY AND TRANSPORTATION AGENCIES USER NEEDS | Study of integrated information projects within the transportation community nationwide. | www.capwinproject.com/extras/reports/user_needs_assessment.pdf |

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|---|---|---|
| AN IMPROVED DISPLACEMENT SNOWPLOW | Describes the research on improving the design of snowplows, as well as design, fabrication and testing of plows incorporating improvements. The primary goal was to decrease energy consumption during plowing by twenty percent. | http://gulliver.trb.org/publications/shrp/SHRP-H-673.pdf |
| AN INDEPENDENT EVALUATION OF THE OK-FIRST DECISION-SUPPORT SYSTEM | The Oklahoma Climatological Survey (OCS) implemented a DSS known as OKlahoma's First-response Information Resource System using Telecommunications to provide public safety officials with customized, county-level environmental information within minutes of observation. | http://okfirst.ocs.ou.edu/press/preprints/2envapps/1_11.pdf |
| AN INTRODUCTION TO STANDARDS FOR ROAD WEATHER INFORMATION SYSTEMS (RWIS) | This brochure describes three categories of standards being considered for RWIS applications: siting standards, calibration standards, and communication standards. Note that the term "standard" refers to guidelines, recommended procedures, protocols, and other practices that formalize some of the processes involved in deploying and maintaining RWIS sensors. The standards described here are still being developed and are not mandated by the U.S. Department of Transportation. The U.S. DOT encourages agencies to use this brochure as a starting point to learn about RWIS standards and to consider how they might use these standards to reinforce their own RWIS operations. | http://www.ops.fhwa.dot.gov/weather/Publications/RWIS_brochure.pdf |
| AN INVESTIGATION OF INCIDENT FREQUENCY, DURATION AND LANES BLOCKAGE FOR DETERMINING TRAFFIC DELAY | Traffic delay caused by incidents is closely related to three variables: incident frequency, incident duration, and the number of lanes blocked by an incident. Relatively, incident duration has been more extensively studied than incident frequency and the number of blocked lanes. In this study, we provided an investigation of the influencing factors for all of these three variables based on an incident data set that was collected in New York City. The information about the incidents derived from the identification can be used by incident management agencies in New York City for strategic policy decision making and daily incident management and traffic operation. Rain is the only factor that significantly influenced incident frequency. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| AN OVERVIEW OF FEDERAL HIGHWAY ADMINISTRATION ROAD WEATHER MANAGEMENT PROGRAM ACTIVITIES | The Road Weather Management program of the Federal Highway Administration (FHWA) seeks to understand weather impacts on roads and promote techniques to improve roadway operations in inclement weather. This paper presents an overview of program objectives, various research and outreach projects, as well as tools used by traffic, emergency and maintenance managers. | American Meteorological Society 83rd Annual Meeting (2003), Mitretek Systems, ITS Division |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| AN OVERVIEW OF SURFACE TRANSPORTATION WEATHER RESEARCH CONDUCTED THROUGH THE COOPERATIVE PROGRAM FOR OPERATIONAL METEOROLOGY, EDUCATION AND TRAINING (COMET) | In 2001, the National Weather Service (NWS) and the Federal Highway Administration (FHWA) began a joint research effort to evaluate how ESS data can best be used for both road condition forecasting and broader weather forecasting. This paper will describe the five research projects and their results to date. The five projects selected are located in Iowa, Nevada, New York, Pennsylvania, and Utah. | American Meteorological Society 83rd Annual Meeting (2003), Mitretek Systems, ITS Division |
| ANALYSIS OF WEATHER IMPACTS ON TRAFFIC FLOW IN METROPOLITAN WASHINGTON, D.C. | The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has been sponsoring research into the impacts of weather on surface transportation. One specific research task involved attempting to quantify the amount of travel delay imposed upon drivers due to the effects of inclement weather. This paper describes two different methods used to approximate travel delay impacts of weather along specific roadway segments around metropolitan Washington, D.C. | Institute of Transportation Engineers 2003 Annual Meeting, Mitretek Systems, ITS Division |
| ANALYSIS OF WEATHER-RELATED CRASHES ON U.S. HIGHWAYS | This paper presents results of an analysis of crashes on U.S. highways in poor road weather conditions. The objectives of the analysis were to update a March 2001 report titled "A Preliminary Analysis of U.S. Highway Crashes Against an Exposure Index", and to identify trends in the frequency of weather-related crashes. | Mitretek Systems, ITS Division |
| ANALYSIS OF WEB-BASED WSDOT TRAVELER INFORMATION: TESTING USERS' INFORMATION RETRIEVAL STRATEGIES | This report details the findings of a usability study of the Washington State Department of Transportation (WSDOT) traffic and weather information on the web. The purpose of this test was to examine the user experience associated with retrieving traveler information, such as road conditions, traffic congestion, pass information, construction, and weather from the WSDOT Traffic and Weather web site. | http://www.depts.washington.edu/trac/bulkdisk/pdf/552.1.pdf |
| ANALYZING THE EFFECTS OF WEB-BASED TRAFFIC INFORMATION AND WEATHER EVENTS IN THE SEATTLE PUGET SOUND REGION: DRAFT REPORT | Analysis of web-based ATIS usage logs against observed weather conditions, and generation of a new profile of ATIS market penetration. Simulation results were analyzed and compared to results from Mitretek's earlier MMDI study. Analysis showed that non-uniform ATIS utilization rate related to severe weather has a small positive impact on road system efficiency. | Mitretek Systems, ITS Division |

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| ANOTHER STEP TOWARD A NATIONALLY INTEGRATED TRAVELER INFORMATION SYSTEM | Overview of traveler information including definition, explanation of growth, USDOT role and vision, and next steps. | www.itsdocs.fhwa.dot.gov/jpodocs/periodic/8ph01!.htm |
| ANTI ICING SUCCESS FUELS EXPANSION OF THE PROGRAM IN IDAHO | Idaho Transportation Department anti-icing success story on section of US Highway 12. | www.sicop.net/US-12%20Anti%20Icing%20Success.pdf |
| ANTI-ICING STUDY: CONTROLLED CHEMICAL TREATMENTS | Correlations between meteorological parameters and chemical effectiveness can indicate the optimum conditions for a particular anti-icing chemical application. Anti-icing chemical treatments are more efficient when used for adhesion prevention than for removing snow and ice already in place | http://gulliver.trb.org/publications/shrp/SHRP-H-683.pdf |
| APPLICATION OF ADVANCED ITS INTERFACING THAT IMPROVES MAINTENANCE OPERATIONAL EFFECTIVENESS AND WINTER SAFETY IN RURAL AREAS | In 1995, the state DOT's of Iowa, Michigan, and Minnesota formed a consortium to define and develop the next-generation highway maintenance vehicle that would utilize the latest maintenance operational technologies and interface with Intelligent Transportation Systems. This advanced technology highway maintenance vehicle functions as both an operational truck and a mobile data-gathering platform. Sensors mounted on the vehicle record air and roadway surface temperature, roadway surface condition, and roadway surface friction characteristics. | http://www.ctre.iastate.edu/pubs/midcon/Smithson.pdf |
| APPLICATION OF JETTING TECHNOLOGY TO PAVEMENT DEICING | Over 20 years ago, the Connecticut DOT investigated the use of pressurized salt brine jets to enhance the deicing performance. Despite promising results from several field trails, technical difficulties led to abandonment of this technology in the early 80's. Recent advances in high pressure jetting technology suggest that the use of high pressure jets in conjunction with improved chemical agents for pavement deicing may now be practical. In this study, the application of modern high pressure jetting technology as a means of pavement deicing is explored. The proposed system removes ice and snow through the combined action of mechanical jetting forces and controlled use of deicing chemicals. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| APPLICATION OF ROAD WEATHER INFORMATION SYSTEMS IN THE WESTERN UNITED STATES | MesoWest software links weather observations from roughly 350 stations in the NWS surface aviation network and 2,100 additional stations, including RWIS stations. MesoWest collects and processes data from over 40 organizations. MesoWest data is available in Montana, Nevada, Utah and Wyoming through cooperative agreements between local NWS offices and state DOT agencies. | www.met.utah.edu/jhorel/html/mesonet/rwis.pdf |

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| APPLICATION OF THE ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS) MESSAGE STANDARD | Mitretek demonstrated an information system that provides route-specific travel forecasts that contain weather, traffic, and road closure information using eXtensible Markup Language (XML). The demonstration used XML data sets from a DOT's web site containing manual weather observations and RWIS data, as well as data from a web-based Pavement Condition Reporting System (PCRS). | 8th World Congress on ITS, Mitretek Systems ITS Division |
| APPLICATIONS OF A ROADWAY FROST PREDICTION SYSTEM IN IOWA | Various predictive systems have been explored to determine the best method to predict frost formation. Several different road frost, weather, and road temperature forecasts were examined and verified against human observations of frost on a bridge in Ames, Iowa during the winter of 2001-02. A frost deposition model was used to determine accumulated frost depth. | http://ams.confex.com/ams/annual2003/techprogram/paper_56029.htm |
| APPLICATIONS OF INTELLIGENT TRANSPORTATION SYSTEMS FOR WINTER MAINTENANCE | This paper describes potential applications of ITS for winter maintenance and provides examples of case studies. Moreover, the paper identifies and discusses the institutional, technical and operational barriers to the implementation of advanced technologies for ice and snow removal. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| APPLICATIONS OF INTELLIGENT TRANSPORTATION SYSTEMS FOR WINTER MAINTENANCE | This paper describes potential applications of ITS systems for winter maintenance and provides examples of case studies. Moreover, the paper identifies and discusses the institutional, technical and operational barriers to the implementation of advanced technologies for ice and snow removal. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| ARE SIMPLISTIC WEATHER-RELATED MOTORIST WARNING SYSTEMS "ALL WET"? | On a two-lane exit ramp in Ft. Lauderdale, Florida; an automated motorist warning system (including a wet pavement sensor and vehicle detector) that activates flashing beacons atop static speed limit signs. Speed reductions and reduced crash frequency resulted. | 7th World Congress on ITS, University of South Florida. |
| AURORA PROGRAM RWIS SPECIFICATIONS | The goal of the "Compilation of RWIS Specifications" project is to develop a database of Aurora member RWIS construction, maintenance, and forecast specifications. This resource includes specifications from agencies in Arizona, Illinois, Iowa, Minnesota, Pennsylvania, Tennessee, Virginia, and Wisconsin | http://www.aurora-program.org/matrix.cfm |
| AVALANCHE HAZARD REDUCTION FOR TRANSPORTATION CORRIDORS USING REAL-TIME DETECTION AND ALARMS | Presents configurations of systems that detect and provide warning to motorists and highway maintainers of the onset of avalanching onto the roadway. Warnings include on-site traffic control signing and in-vehicle audio alarms for winter maintenance vehicles. | www.sicop.net/annals-paper%20total.pdf |

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| BENEFIT/COST STUDY OF RWIS AND ANTI-ICING TECHNOLOGIES | Report describes anti-icing and RWIS research and implementation efforts, and summarizes anti-icing technologies. Benefits and costs as reported in the literature and supplemented with interviews of highway professionals. | www.sicop.net/NCHRP20-7(117).pdf |
| BEST PRACTICES OF OUTSOURCING WINTER MAINTENANCE SERVICES | Contract language and provisions being used by various owner-agencies in the public sector. Best practices include clear contractual language placing responsibility on private sector to develop, train and equip personnel; confine language to measurable outcome-based performance measures; connect producer-contractor to user-customer; producers proactively responding to RWIS-based predictions and encouraged to utilized anti-icing; seek the sharing of knowledge; and maximize opportunities for the private sector to be responsive, efficient and effective. Appendix D contains sample contract provisions. | www.vmsom.com/images/pdf/Best%20Practices%20Outsourcing%20Winter%20Maintenance%20Services.pdf |
| CLOSING THE DATA GAP: GUIDELINES FOR QUALITY ADVANCED TRAVELER INFORMATION SYSTEM (ATIS) DATA | ITS America's ATIS Committee developed guidelines to assist public agencies and private firms in generating and using data to support the expansion of ATIS products and services. The focus of these guidelines is limited to real-time or dynamic traffic-related information necessary to offer traveler information services envisioned in the near-term. | www.itsdocs.fhwa.dot.gov//jpodocs/rept_mis/13580.html |
| COLLECTION OF VEHICLE SPEED DATA USING TIME-LAPSE VIDEO RECORDING EQUIPMENT | This paper describes an innovative application of time-lapse video recording to assist in a highway safety improvement evaluation. The highway safety improvement is an icy curve warning system near Fredonyer Summit in northern California that activates real-time motorist warnings via extinguishable message signs, based on weather readings collected from road weather information systems. One measure of effectiveness of the project is whether motorist speed is reduced as a result of real-time warnings to drivers. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| CONSIDERATION OF ENVIRONMENTAL FACTORS IN TRANSPORTATION PLANNING: REVIEW AND ANALYSIS OF CURRENT POLICIES, PRACTICES AND TRENDS | This paper reviews current trends and practices for considering environmental factors in transportation planning at a systems level, in state DOTs and MPOs. The study is based on a review of the literature, and a survey and case studies of state DOTs and MPOs. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

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| CURRENT PRACTICES IN TRANSPORTATION MANAGEMENT DURING INCLEMENT WEATHER | Best practices include road weather and traffic surveillance to assess threats to transportation system performance, arterial and freeway management to regulate roadway capacity, as well as dissemination of advisory information to influence traveler decisions and driver behavior. These management practices are employed in response to various weather threats including low visibility, high winds, precipitation, hurricanes, flooding, and avalanches. Weather-related transportation management practices (1) improve mobility by increasing roadway capacity and promoting uniform traffic flow, (2) increase public safety by minimizing crash risk and exposure to hazards, as well as (3) enhance the safety and productivity of road maintenance personnel. | Institute of Transportation Engineers 2002 Annual Meeting, Mitretek Systems, ITS Division |
| DATA INTEGRATION AND PLANNING FOR THE INSTALLATION OF AUTOMATIC BRIDGE ANTI-ICING SYSTEMS | This is the first of two papers focused on the issue of bridge prioritization for installation of automatic anti-icing systems. The objective of this paper is to illustrate the integration of data from various sources in a geographic information system (GIS) for the planning of automatic bridge anti-icing system installations. Database integration involved merging information on various criteria that were deemed important in the selection of bridges for anti-icing system installation. Data sources included: Nebraska Department of Roads (NDOR) bridge inventory, NDOR state accident data, NDOR maintenance yard data, archived weather data from the High Plains Regional Climate Center and the National Weather Service, and commercially available Nebraska streets, rivers, and streams data. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| DECISION AID FOR PRIORITIZING BRIDGE DECK ANTI-ICING SYSTEM INSTALLATIONS | During winter conditions, moisture on bridge decks often freezes before the surrounding roadway surface. Automatic anti-icing systems spray chemicals that prevent or minimize ice bonding to the bridge deck. The Nebraska Department of Roads (NDOR) is interested in installing such systems on various bridges statewide. However, limited funding requires that bridges be prioritized for installtion based on relevant criteria. The factors considered in the prioritization of installing automatic anti-icing systems include accident history, bridge alignment, weather, traffic, and bridge distance from maintenance yard, among others. Four different decision-aid methods; namely benefit-cost ratio, cost effectiveness, utility index, and composite programming; were considered. Given it's flexibility and advantages over other methods, composite programming appears to be the most suitable method for bridge prioritization. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
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| DECISION SUPPORT SYSTEM FOR WINTER MAINTENANCE: FEASIBILITY DEMONSTRATION | This project reports on existing work in developing decision support tools to select chemical applications appropriate to winter weather conditions, to describe in detail those which are at or near an operational state, and to assess the feasibility of implementation as part of a RWIS. A literature review identified four DSS: an expert system development project by the Swedish National Road Administration (SNRA), a table-based menu for anti-icing developed by FHWA, a computerized adaptation of the FHWA menu, and an expert system development by Swedish Road and Transport Research Institute. | Aurora Program, Ontario Ministry of Transportation |
| DESIGN GUIDELINES FOR THE CONTROL OF BLOWING AND DRIFTING SNOW | This report describes how to design effective and economical measures for controlling blowing and drifting snow. These measures include various snow fence designs to accommodate land use and right-of-way considerations; considerations for pavement design and appurtenances; proper siting of snow fence to compensate for terrain; and ways to use trees and plants as natural snow fences. The field research and sources of information are presented. | http://gulliver.trb.org/publications/shrp/SHRP-H-381.pdf |
| DEVELOPING A DESIGN POLICY TO IMPROVE PAVEMENT SURFACE CHARACTERISTICS | The Maryland State Highway Administration (MDSHA) routinely measures friction on State highways to assist with decision making associated with road maintenance management. The MDSHA uses the Friction Tester to monitor the micro-texture of the pavement aggregate during the service life of the pavement surface. Micro-texture is a measure of the degree of polishing of a road aggregate and is the main factor in determining the peak level of dry and wet friction provided by a pavement surface. The MDSHA is attempting to better understand surface frictional requirements at approach to pedestrian crossing, traffic lights, etc during wet weather and to establish minimum friction levels for different types of roadways based on accident data. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| DEVELOPING THE FRAMEWORK OF A DYNAMIC TRAFFIC MANAGEMENT MODEL FOR HURRICANE EVACUATION: SUMMARY REPORT | Paper describes the development of a dynamic hurricane evacuation modeling framework, which can be used for planning and operational purposes. See also TRAFFIC MODELING FRAMEWORK FOR HURRICANE EVACUATION. | Transportation Research Board 79th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| DEVELOPMENT AND TESTING OF VARIABLE SPEED LIMIT LOGICS AT WORK ZONES USING SIMULATION | Variable speed limits (VSL) have been primarily used to display reasonable speed limits to drivers based on real time road and weather conditions. They are also used to dynamically respond to traffic conditions especially at work zones or incidents. This paper presents the development of VSL control logic that can consider both safety and mobility measures at work zones. A surrogate measure of crash, minimum safe distance equation (MSDE), is proposed and a method of finding the optimum with respect to MSDE (the safety measure) and travel time (a mobility measure) has been elaborated. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| DEVELOPMENT AND VALIDATION OF A MODEL TO PREDICT PAVEMENT TEMPERATURE PROFILE | To determine in-situ strength characteristics of flexible pavement, it is necessary to predict the temperature distribution within the hot-mix asphalt (HMA) layers. To determine the pavement temperature profile, the influence of ambient temperature and seasonal changes must be understood such that the effects of heating and cooling trends within the pavement structure can be quantified. It is possible to model daily pavement maxima and minima temperature by knowing the maximum or minimum ambient temperatures, the depth at which the pavement temperature is desired, and the day of year at a particular location. This paper extends that model to incorporate either the calculated daily solar radiation or latitude such that the model can be applied to any location. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| DEVELOPMENT OF ANTI-ICING TECHNOLOGY | Nine state highway agencies conducted anti-icing experiments to determine when anti-icing is effective and how to conduct anti-icing efficiently. Anti-icing is effective and how to conduct anti-icing efficiently. Anti-icing treatment requires less chemicals than most deicing procedures and makes it easier to achieve bare pavement conditions. A limited cost-benefit analysis was performed, comparing anti-icing effectiveness with deicing operations. The findings of Scandinavian countries that use anti-icing are reviewed. | http://gulliver.trb.org/publications/shrp/SHRP-H-385.pdf |
| DEVELOPMENT OF HYBRID MODEL FOR DYNAMIC TRAVEL TIME PREDICTION | This paper discusses a prediction model derived by integrating a path-based and link-based prediction models. Prediction results generated by the hybrid model and their accuracy are compared with those generated by the path-based and link-based models individually. The experimental results reveal that the predicted travel times with the path-based model are better than those predicted with the link-based model during peak-hours and vice versa. The hybrid model derives results from the best model at a given time, thus optimizing the performance. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

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| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| DEVELOPMENT OF ROAD SURFACE CONDITION SENSOR USING OPTICAL TEMPERATURE SENSOR AND WEATHER SENSOR | System is comprised of optical fiber embedded in the road and a temperature distribution measurement apparatus to measure longitudinal temperature distribution, ESS, and a judgment apparatus that classifies road conditions into five categories based on the various measurement data. | 8th World Congress on ITS, Ministry of Land Infrastructure and Transport, Japan |
| DEVELOPMENT OF ROAD TEMPERATURE SENSING SYSTEM USING OPTICAL FIBER | Road surface temperature distribution sensing using optical fiber sensor embedded in roadway and ESS data. Tests on two kilometer section of National Route No. 18 in Nagano Prefecture, Japan. | 7th World Congress on ITS, Ministry of Construction, Japan |
| DOCUMENTATION AND ASSESSMENT OF MN/DOT GATE OPERATIONS | Study conducted from March to August 1999 to assess new operational procedure prohibiting access to Interstates during unsafe driving conditions using mainline and ramp gates. Benefits and costs data. | www.dot.state.mn.us/guidestar/pdf/gatereport.pdf |
| DYNAMIC MESSAGING: A GUIDANCE DOCUMENT PROVIDING ADVISORY INFORMATION ON LOW-VISIBILITY WARNING SYSTEMS BASED ON RESEARCH AND ANALYSIS OF DEPLOYED SYSTEMS | The Enterprise program is multi-state pooled-fund study group with a focus on providing effective solutions for rural transportation applications. Enterprise, in cooperation with the Arizona DOT, is researching solutions for problems motorists face in limited visibility situations. Identifies components of low-visibility warning systems and the techniques deployed by various states that best address improving safety by detecting low visibility events and disseminating advanced information to motorists as well further evaluating low-visibility detection technologies during these conditions. | Castle Rock Consultants |
| ECONOMIC EVALUATION OF ADVANCED WINTER HIGHWAY MAINTENANCE STRATEGIES | Estimated potential savings in labor and equipment costs of using pavement temperature data to customize material type and application rates. | http://www.itsdocs.fhwa.dot.gov/jpodocs/proceedn/4hy01!.pdf |
| EFFECT OF ENVIRONMENTAL FACTORS ON FREE-FLOW SPEED | Use of Idaho Storm Warning System project data to determine the effects of various weather factors on free-flow speed during 1997/1998 and 1998/1999 winter. | Proceedings of the Fourth International Symposium on Highway Capacity |
| EFFECTS OF VARIABLE SPEED LIMIT SIGNS ON DRIVER BEHAVIOR DURING INCLEMENT WEATHER | On a two-mile test roadway in Salt Lake Valley, Utah; speed limits are varied based on visibility and traffic conditions using a weighted average algorithm and display via DMS. Reduction in speed deviation, reduction in crash frequency, and increase in overall mean speed resulted. | Institute of Transportation Engineers 2000 Annual Meeting, University of Utah |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| EFFECTS OF VARIOUS DEICING CHEMICALS ON PAVEMENT CONCRETE DETERIORATION | Study investigating the effects of different deicers on concrete deterioration. Deicers produce characteristic effects on concrete samples by physically and chemically altering the aggregate, the aggregate-past interface, and the cement paste. | http://www.ctre.iastate.edu/pubs/midcon/Lee.pdf |
| EFFECTS OF WEATHER-CONTROLLED VARIABLE MESSAGE SIGNING ON DRIVER BEHAVIOR | The purpose of the study was to investigate the effects of local and frequently updated information of adverse weather and road conditions on driver behavior. The information was transmitted by several DMS types including slippery road condition signs, minimum headway signs. Temperature displays and speed limits. | http://www.vti.se/nordic/1-02mapp/weather.htm |
| EFFICACY AND ECONOMIC EFFICIENCY FOR THAWING AGENTS SPRAY SYSTEMS - FINAL REPORT | With a length of 6 km, the thawing agents spray system used on the A45 (Sauerland line) is the longest installed in Germany. After the installation of this system, the number of crashes on the equipped road section and due to winter road conditions was reduced by more than 50 percent. | http://www.ops.fhwa.dot.gov/weather/Publications/GermanAnti-icingReport.pdf |
| ENHANCEMENTS TO THE VIRTUAL WEATHER STATION METHODOLOGY | Representative climatic conditions at any location can be estimated using data from nearby weather stations. The reasonableness of such estimates depends on the quality of weather data as well as method used in developing such estimates. This study investigates the possibility of improving the accuracy of climatic estimates. Four different methods of estimating the climatic parameters were studied and it was found that simple average of climatic parameters from nearby weather stations provides the most reasonable estimate. It was found that the elevation difference between the desired location and nearby weather stations significantly affects estimate bias. A relationship was developed to remove the bias due to elevation difference. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| ENVIRONMENTAL RESEARCH NEEDS CONFERENCE 2002 TRANSPORTATION ENVIRONMENTAL RESEARCH NEEDS STATEMENTS | Every five years the Transportation Research Board (TRB) conducts a Transportation Environmental Research Needs (ERN) Conference to select and draft top-priority statements of environmental research needs. These proceedings contains the top research needs identified at the conference, along with background papers. This report is published to assist those involved with government, university, and other research programs in selecting research projects that will have the greatest utility for the transportation environmental community. | http://gulliver.trb.org/publications/conf/reports/cp_28.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| ENVIRONMENTAL SENSOR STATIONS (ESS) ITS STANDARDS ADVISORY: ADVISORY NO. 2 | ITS Standards Advisories provide the transportation community with information and guidance on key activities related to ITS standards. Each Advisory focusing on a single ITS application and its corresponding standards. Standards Advisories highlight important, recent standards activities for the selected ITS application and provide links to more detailed information and resources. This advisory covers topics such as "The ESS Standard: What's New?", "Rolling Out ESS", "U.S. DOT Urges Use of ESS Standards", and "Standards Applicable to ESS Deployments". | http://www.its-standards.net/Documents/ess_advisory.pdf |
| ESTIMATING ADVERSE WEATHER IMPACTS ON MAJOR US HIGHWAY NETWORK | This paper presented a framework for estimating the impact, in terms of delay, of adverse weather events on travel in the United States. The Speed estimation methodology for travel in adverse weather was based on the Highway Capacity Manual. Using GIS and database tools, one can estimate travel delay and other relevant statistics at various resolutions including weather forecast zone, county, FHWA urbanized area, metropolitan area, state, and national levels. The estimation procedure employed NCDC's Storm Data and FHWA's HPMS and NHPN databases, which are all publicly accessible. The estimation procedure, which can be implemented repeatedly to assess the change from one year to the next, was used to estimate adverse weather impacts for the year of 1999. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| EVALUATION OF A FIXED ANTI-ICING SPRAY TECHNOLOGY (FAST) SYSTEM | This paper describes the development of Fixed Anti-Icing Spray Technology (FAST) systems to apply less corrosive liquid chemical freezing-point depressants on portions of the Brooklyn Bridge. During the first phase of the project, several operational parameters were investigated, including spray pattern, spray angle and spray pressure. Phase II of this project describes the proposed extension of the FAST system and integration of a RWIS. | Transportation Research Board 81st Annual Meeting, New York City DOT |
| EVALUATION OF CALTRANS DISTRICT 10 AUTOMATED WARNING SYSTEM: YEAR TWO PROGRESS REPORT | The Caltrans Automated Warning System (CAWS) entered service in November 1996. The system includes 36 speed monitoring sites, 9 weather stations, 9 DMS and TMC computer systems. The independent evaluation was carried out by researchers at the University of California. The report bibliography includes summaries of all highway fog warning systems for which published information was available. | http://www.path.berkeley.edu/PATH/Publications/PDF/PRR/99/PRR-99-28.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| EVALUATION OF MOTORISTS WARNING SYSTEMS FOR FOG-RELATED INCIDENTS IN THE TAMPA BAY AREA | Investigation to determine extent of fog patterns and fog-related incidents in the Tampa Bay area, and suitable countermeasures to detect and warn motorists of fog conditions. Fog warning systems in Alabama, Arkansas, Georgia, New Mexico, Tennessee, Idaho, New Jersey, South Carolina, Louisiana, Oregon, Utah and California are discussed. Types of fog, conditions conducive to formation, and visibility detection technologies are also covered. | www.cutr.eng.usf.edu/research/fog.pdf |
| EVALUATION OF SEASONAL EFFECTS ON SUBGRADE SOILS | This paper presents general expressions for the seasonal variations of average daily air temperature and variation of temperature and moisture in the fine-grained subgrade soil at the test site. An expression for the seasonal variation of resilient modulus was derived. Average monthly weighting factors that can be used for pavement design were computed. Other factors such as frost penetration, depth of water table and drainage conditions are discussed. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| EVALUATION OF THE FORETELL CONSORTIUM OPERATIONAL TEST: WEATHER INFORMATION FOR SURFACE TRANSPORTATION | Defines strategy for conducing an independent evaluation of the FORETELL project, a regional road and weather forecasting/dissemination system in Iowa, Wisconsin, and Missouri. | http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/7tr01!.pdf |
| EVALUATION OF THE FORETELL FIELD OPERATIONAL TEST | The FHWA supported development of an operational test of a multi-regional road and weather forecasting/dissemination system, known as FORETELL. The operational test in Iowa, Wisconsin, and Missouri has been completed. However, FORETELL continues as a private sector service in Iowa and is now being assessed in the Northeast states of Maine, New Hampshire, and Vermont. This flyer describes the capabilities of the map-based FORETELL system and summarizes evaluation results. | FHWA |
| EVALUATION OF THE OPERATION AND DEMONSTRATION TEST OF SHORT-RANGE WEATHER FORECASTING DECISION SUPPORT WITHIN AN ADVANCED RURAL TRAVELER INFORMATION SYSTEM | The Advanced Rural Traveler Information System (ARTIS) aims to provide en-route, operational decision support information including real-time and forecast weather conditions in rural areas. A three-year operational test was designed to measure user acceptance, use of the system for decision making, and use of weather-related data for maintenance operations. | www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@9301!.pdf |
| EVALUATION OF THE SEATTLE SMART TREK MODEL DEPLOYMENT INITIATIVE | Evaluation focused on institutional benefits, ATIS customer satisfaction, and ITS integration modeling. The impact of weather events was evident in the December 1998 web site usage levels. | Science Applications International Corporation (SAIC) |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| EVALUATION PROCEDURE FOR DEICING CHEMICALS AND IMPROVED SODIUM CHLORIDE | Encompasses a literature review of prior work, establishes a criteria for characterizing chemical deicers, and identifies potential test methods for evaluating candidate deicing chemicals. Identifies 62 tests. Describes in detail 12 methods specifically developed for chemical deicers. | http://gulliver.trb.org/publications/shrp/SHRP-H-647.pdf |
| EVALUATION REPORT FOR THE EVACUATION TRAVEL DEMAND FORECASTING MODEL: DRAFT | The TDFM is a web-based software tool designed to predict congestion levels on major evacuation routes and predict state-to-state traffic volumes to aid in effective hurricane evacuation planning. Evaluation of the model was based on performance during a tabletop exercise. | Science Applications International Corporation (SAIC) |
| EXTRACTION OF THE SLIPPERINESS COMPONENT FROM WEATHER AND TRAFFIC DATA FOR WINTER MAINTENANCE OPERATIONS | While traffic and weather information systems provide the current status of air and road surface temperatures, what many drivers really want to know is not the temperature but the degree of slipperiness. Although the friction coefficient is the best index for snow and ice maintenance operations, it is not so easy to manipulate. Some weather condition data are closely correlated with this friction coefficient. In this study, the substitutability of weather and traffic data is examined quantitatively through analysis of field data observed at an intersection. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| FEASIBILITY OF USING FRICTION INDICATORS TO IMPROVE WINTER MAINTENANCE OPERATIONS AND MOBILITY | NCHRP initiated Project 6-14 to evaluate the feasibility of using friction indications as tools for improving winter maintenance operations and mobility. This study has found that the use of friction measurements to improve winter maintenance operations and mobility is feasible (especially when deceleration devices are used), but devices with an extra wheel may not represent a practical solution to friction measurement. Therefore, direct friction measurements may not be a viable operational tool in winter maintenance (although they will and should be used as research tools). The study recommends a two-phase follow-up study to validate both scenarios and translate the findings into technology that improves the efficiency and effectiveness of snow and ice control operations, thereby reducing costs, increasing safety, and improving mobility of the driving public. | http://gulliver.trb.org/publications/nchrp/nchrp_w53.pdf |
| FIELD TESTS USING THE FREEZING POINT OF ROAD CHEMICALS IN WINTER MAINTENANCE OPERATIONS | The objective of this project was to field test a freezing point temperature sensor, as part of Phase IV of the Highway Maintenance Concept Vehicle Project. The project has performed field tests with a mobile monitoring system for freezing point temperature that detects the temperature at which materials on the road freeze. | 2002 Joint Meeting of the CAATS and the RATTS, http://www.caats.org/Press%20Releases/CRCD.htm |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| FINAL REPORT ON SIGNAL AND IMAGE PROCESSING FOR ROAD CONDITIONS CLASSIFICATION | This paper evaluates two systems for classifying road conditions by using cameras and microphones respectively. One determines the road condition from an image of the road. Another uses a similar method to classify the road condition by analyzing the characteristic sound signals from passing cars on different road conditions. The systems have been operational during the winter season 2000/2001 in addition to manual observations of the road. The results from the evaluation are very satisfying especially for icy and wet road conditions. | AerotechTelub and Dalarna University |
| FLOOD WARNINGS ON-LINE | In Queensland, Australia; remote sensors are used to monitor creek and river water levels to warn motorists. The Queensland Department of Main Roads and the Royal Automobile Club of Queensland (RACQ) provide road condition information via web page (www.racq.com.au/journey) and toll-free telephone system with interactive voice response (IVR) technology. | ITS International, March/April Issue |
| FREE AND OPEN EXCHANGE OF ENVIRONMENTAL DATA | The primary purpose of this Statement is to reassert the American Meteorological Society's commitment to a policy of free and open international exchange of environmental data, while at the same time endeavoring to draw critical distinctions among different types of environmental information. | http://www.ametsoc.org/AMS/policy/freeopenexch_final.html |
| FRICTION AS A TOOL FOR WINTER MAINTENANCE | Considers how friction measuring devices might be used operationally. They will likely be used as a measure of quality, as a source of traveler information, and as a means of controlling chemical application. | http://www.ctre.iastate.edu/pubs/crossroads/86friction.pdf |
| GETTING CLEAR ON FOG-RELATED CRASHES IN TAMPA BAY | Paper discusses a four-step process employed to evaluate advanced fog-detection technologies and suggest possible strategies to address fog-related incidents in the Tampa Bay Area. See also EVALUATION OF MOTORISTS WARNING SYSTEMS FOR FOG-RELATED INCIDENTS IN THE TAMPA BAY AREA. | www.path.berkeley.edu/~leap/itsdecision_resources/articles/S_ite_0200_fog_warning.pdf |
| GUIDELINES FOR SNOW AND ICE CONTROL MATERIALS AND METHODS | Snow and ice control strategies and tactics that employ solid and liquid chemicals, abrasives, and mechanical methods--individually or in combination--have been used by many highway agencies. This report describes the results of a study conducted under the National Cooperative Highway Research Program (NCHRP) Project 6-13 to evaluate five snow and ice control strategy and tactic combinations under various ranges of weather, site, and traffic conditions. A pavement snow and ice condition index was developed for rating effectiveness of a given strategy. Field test results were used to develop a set of guidelines for use by maintenance managers. | NCHRP Transportation Research Board, National Research Council |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| HANDBOOK OF TEST METHODS FOR EVALUATING CHEMICAL DEICERS | Contains sixty-two test methods for the evaluation of chemical deicers in eight principal property performance areas, from physicochemical characteristics to health and safety aspects. Evaluations range from ice-melting tests to corrosion tests of reinforcement bar in concrete. | http://gulliver.trb.org/publications/shrp/SHRP-H-332.pdf |
| HAPPY MOTORING ON SAFER INTERSTATE HIGHWAY: HIGH-TECH FOG WARNING SYSTEM DEVELOPED AT GEORGIA TECH WILL ISSUE ADVISORIES TO MOTORISTS | An automated fog and smoke warning system will be deployed on 14 miles of Interstate 75 near Adel, Georgia. The system includes 19 fog sensors, ESS, speed detectors and CCTV. System software at GDOT's Atlanta TMC analyzes field data and decides which messages to display on four DMS and when to illuminate streetlights. A three-year evaluation is being planned. | http://gtresearchnews.gatech.edu/reshor/rh-ss01/fog.html |
| HIGHWAY DEICING: COMPARING SALT AND CALCIUM MAGNESIUM ACETATE (SPECIAL REPORT 235) | Deicing chemicals are important tools for highway snow and ice control. The National Research Council conducted a study to examine the full economic costs of using salt and CMA for highway deicing. The report defines the true cost of salt; estimates of monetary costs involved in mitigating environmental damage from road salt; summaries of the field performance, infrastructure and environmental impacts, production technologies and costs of CMA. | http://gulliver.trb.org/publications/sr/sr235.html |
| I-35W & MISSISSIPPI RIVER BRIDGE ANTI-ICING PROJECT: OPERATIONAL EVALUATION REPORT | A bridge that spans the Mississippi River on US Interstate 35W in Minneapolis, Minnesota has been fitted with a computerized system that sprays potassium acetate, an anti-icing chemical, on the bridge deck when data from environmental sensors indicate that hazardous winter driving conditions are imminent. | http://www.dot.state.mn.us/metro/maintenance/Anti-icing%20evaluation.pdf |
| I-90 AUTOMATED GATE OPERATIONS SYSTEM | The Minnesota DOT is currently using 65 manually operated gates in three of eight Districts for directing traffic off rural interchanges and prohibiting access during unsafe driving conditions. The I-90 Automated Gate Operations system is comprised of four subsystems: traffic management, detection and sensor, communications (including wireless, landline, and internet access), and control and monitoring. | 2002 Joint Meeting of the CAATS and the RATTS, http://www.caats.org/Press%20Releases/CRCD.htm |
| ICE-PAVEMENT BOND DISBONDING--FUNDAMENTAL STUDY | Illuminations the ice-pavement bond structure and the mechanics of its formation to provide a basis to develop techniques for destroying or disrupting the ice-pavement bond. The report characterizes the physical and chemical processes that cause deterioration in the bond formed between ice and asphalt and portland cement concretes. | http://gulliver.trb.org/publications/shrp/SHRP-H-643.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| ICE-PAVEMENT BOND DISBONDING--SURFACE MODIFICATION AND DISBONDING | Explores the research into new techniques for disbonding ice. Noncontact and contact methods are tested. Methods such as additives to alter surface texture; electromagnetic radiation; and abrasive air and liquid jets applied directly to ice pavement interface are discussed. | http://gulliver.trb.org/publications/shrp/SHRP-H-644.pdf |
| ICE-PAVEMENT BOND PREVENTION: FUNDAMENTAL STUDY | States the findings of an investigation of the freezing of water on portland cement concrete and asphalt concrete pavements. Surface analysis and mechanical testing techniques were used, as well as computer simulation of the crystallization process. Models, reference substrates, and actual pavements were used to isolate and control experimental variables. The ice-pavement system was studied as an adhesive joint in order to address the factors important to determining the ice adhesive strength. | http://gulliver.trb.org/publications/shrp/SHRP-92-606.pdf |
| IDAHO STORM WARNING SYSTEM OPERATIONAL TEST | Two phased test conducted on I-84 in southeastern Idaho between 1998 and 1993 to (1) determine accuracy of visibility sensors and (2) whether DMS reduce vehicle speed during low visibility conditions. | http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@cc01!.pdf |
| IDAHO'S ROAD WEATHER INFORMATION SYSTEM (RWIS) INTEGRATION PROJECT | The Idaho Transportation Department is spearheading a project to develop a web site that provides maintenance personnel with a "one-stop" access point for weather and road condition data in Idaho and within a 100 mile boundary of neighboring states. The project anticipates using existing data sources such as the NWS forecasts, Mesowest (University of Utah integrated weather system), and RWIS data from neighboring states. This paper details Idaho's approach to RWIS integration an the Challenges encountered. | 2002 Joint Meeting of the CAATS and the RATTS, http://www.caats.org/Press%20Releases/CRCD.htm |
| IDENTIFICATION AND DOCUMENTATION OF WEATHER AND ROAD CONDITION DISSEMINATION DEVICES AND DATA FORMATS | This project identifies means for improving consistency and usability of road and weather information presentation through identification of current and planned road and weather information dissemination systems and synthesis of various means for presenting information to end users. | www.aurora-program.org/pdf/standardinforpt.pdf |
| IDENTIFICATION OF TRIGGER WIND VELOCITIES TO CAUSE VEHICLE INSTABILITY | Study to determine the critical wind velocity and angle that would overturn different vehicles. A variety of road surface conditions, vehicle types and profiles, vehicle speeds, and vehicle loads are considered to identify the most critical condition. | Nevada DOT District II |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| IMPACT OF HIGHWAY ILLUMINATION ON TRAFFIC FATALITY IN VARIOUS ROADWAY AND ENVIRONMENTAL CONDITIONS | This paper investigates the impact of roadway illumination on traffic fatalities over a large geographic area. This research develops a systematic approach to assess the quality of service provided by the existing lighting system to traffic safety. Other factors, such as roadway design, traffic, and environmental conditions at the time of crash, can also be considered in the study. | Transportation Research Board 81nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| IMPLEMENTATION GUIDELINES FOR LAUNCHING 511 SERVICES, VERSION 1.1 | The 511 Deployment Coalition has developed this document to assist implementers in their efforts to develop quality systems and to lay the foundation for ultimately establishing a consistent nationwide 511 service. These guidelines are designated as Version 1.1 and represent a thoughtful update of the original Implementation Guidelines published in November 2001. The Coalition plans to continue monitoring and reviewing the guidelines, producing updates as warranted. The Coalition intends to improve and expand these guidelines as implementers collectively march towards mature systems. The guidelines focus on two main areas: service content and service consistency. | http://www.its.dot.gov/511/511ver11.htm |
| IMPLEMENTATION AND OPERATIONAL GUIDELINES FOR 511 SERVICES, VERSION 2.0 | Version 2.0 was specifically designed to support the establishment and ongoing operations of 511 services. This document provides updated guidelines on content, cross-cutting issues and lessons learned, an overview of key national policy issues and informational resources available to support existing and future 511 deployers. Specific information new to Version 2.0 includes a national vision for 511, additional guidelines for roadway content, guidelines for transit information, weather information in the basic service, examples and lessons learned, as well as usage monitoring guidelines. | http://www.itsa.org/resources.nsf/Files/Implementation_and_Operational_Guidelines_for_511_Services_pdf/$file/Implementation_and_Operational_Guidelines_for_511_Services_pdf.pdf |
| IMPROVED CUTTING EDGES FOR ICE REMOVAL | Laboratory tests were performed with a hydraulic ice-cutting rig to determine the effects of the geometry of the cutting edge of a snow plow blade on the force required to remove ice from a highway pavement surface. Test results indicated that the most important parameter was the clearance angle, and the associated flat width. Using this information, a prototype cutting edge was designed and fabricated for field testing during the winter of 1991-1992. Three different cutting edges were tested: the prototype cutting edge, and two commercially available cutting edges. The prototype cutting edge was shown to be clearly superior to the other two edges, cutting more ice with less downforce and thus resulting in greater vehiclecontrol. | http://gulliver.trb.org/publications/shrp/SHRP-H-346.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| IMPROVED VISIBILITY FOR SNOWPLOWING OPERATIONS | This digest describes several means, identified in NCHRP Project 6-12, that could improve visibility for snowplowing operations. The project included a review of existing and proposed approaches for improving visibility for snowplowing operations, the identification and development of potential means for improving these operations, and the conduct of limited field tests to evaluate the potential benefits of these means. | http://www.sicop.net/nchrp_rrd_250.pdf |
| IMPROVING PUBLIC RESPONSE TO HURRICANE FLOODING | Operational procedures include forecasts of the storm-total area average rainfall and its location in south Florida by the Miami Weather Forecast Office (WFO). If guidance from the Southeast River Forecast Center (RFC) indicates potential for flooding, a flood watch is issued. If flooding is imminent a flood warning is issued. | Proceedings of the American Meteorological Society (AMS) Symposium on Precipitation Extremes |
| INFORMATION ON THE PLANNING, CONSTRUCTION AND OPERATION OF CHEMICAL THAWING AGENT SPRAYING INSTALLATIONS | Chemical thawing agent spraying systems are fixed equipment of the winter service. Road surface and weather condition detectors detect the ice formation of a road and trigger a thawing agent spraying system into operation. A spraying system allows the timely prevention of icing on hazardous places and assists a conventional (usually mechanical) winter service, by preventing the packing down of the snow layer. | http://www.ops.fhwa.dot.gov/weather/Publications/GermanAnti-icingGuidance.pdf |
| INTELLIGENT AND LOCALIZED WEATHER PREDICTION | Provides design details of a 24-hour weather prediction system for snow and ice control operations in road maintenance. The system accounts for detailed terrain effects. The system can produce weather maps at 6-hour intervals for meteorological users, or easy-to-read icons indicating rain, snow, temperature, and wind conditions laid on top of terrain and road network displays. Local weather observations can be incorporated into some forecasts. | http://gulliver.trb.org/publications/shrp/SHRP-H-333.pdf |
| INTELLIGENT TRANSPORTATION SYSTEMS AND WINTER OPERATIONS IN JAPAN | The FHWA, AASHTO, and NCHRP sponsored a scanning study of Japan to investigate advanced technologies for winter maintenance operations and implementation of those advances in Japan's ITS architecture. The U.S. delegation reviewed advances in winter operations procedures, winter maintenance equipment development, road weather data collection, as well as communications systems and protocols used between RWIS sensors and operations centers. | http://international.fhwa.dot.gov/links/pubs.cfm?link_ID=10 |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| INTELLIGENT VEHICLE INITIATIVE - SPECIALTY VEHICLE PLATFORM RESULTS FROM MINNESOTA'S FIELD OPERATIONAL TEST | In November 1999, the United States DOT FHWA awarded a major Intelligent Vehicle Initiative (IVI) grant to the Minnesota Department of Transportation. The intent of the project was to identify the safety and operational impacts of the technology, to guide future decisions regarding installation on specialized vehicles, and to encourage the development and appropriate deployment of such systems on all vehicle platforms. The technologies were tested in four snowplows, a State Patrol squad car, and an ambulance on a fifty-mile rural highway. This paper provides an overview of the project including technologies, evaluation, and findings. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| INTERNET TECHNOLOGY-BASED ROAD INFORMATION SYSTEMS | A method of using eXtensible Markup Language (XML) technology, Road Web Markup Language (RWML) in the road information field is proposed. | http://rwml.its-win.gr.jp/papers-pdf/RWML-ITSWC1998Seoul.pdf |
| IOWA DOT WEATHER INFORMATION SYSTEM TO SUPPORT WINTER MAINTENANCE OPERATIONS | Understanding and interpreting weather information can be critical to the success of any winter snow and ice removal operation. Knowing when, where and what type of deicing material to use for a particular winter weather event can be a challenge. Knowing where to find the weather information needed to make decisions and what information to use can also be difficult. The Maintenance Division of the Iowa DOT has taken a number of steps to provide supervisors and operators with the weather information and training they need to make better operational decisions. A fifty-site RWIS coupled with a satellite delivered weather information system at nearly every maintenance garage have been sources for real-time weather information. | http://www.ctre.iastate.edu/pubs/midcon/Burk.pdf |
| ITS APPLICATIONS FOR SNOW AND ICE CONTROL | Paper describes potential applications of ITS for winter maintenance and provides case studies. | 7th World Congress on ITS (1026.pdf), Michigan State University |
| ITS INSTITUTIONAL ISSUES: A MAINTENANCE/OPERATIONS PERSPECTIVE | Details challenges of using advance technology to optimize resources. Personnel, training, and cost issues are discussed. The Aurora-sponsored project found that, particularly with RWIS, the proprietary nature of new technologies tends to hold public agencies to using equipment from a single vendor. | http://www.ctre.iastate.edu/pubs/midcon/Smithso2.pdf |
| LOSS OF LIFE IN THE UNITED STATES ASSOCIATED WITH RECENT ATLANTIC TROPICAL CYCLONES | Freshwater floods caused more than half of US deaths directly associated with tropical cyclones or their remnants during the 30-year period from 1970 to1999. Most fatalities occurred in inland counties. Statistical summary of casualties, reasons for losses, and review of efforts to mitigate threats. | http://ams.allenpress.com/amsonline/?request=get-pdf&file=i1520-0477-081-09-2065.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| MAINTENANCE DECISION SUPPORT SYSTEM | The MDSS is part of a progressive FHWA program designed to respond to changing weather conditions and their impacts on the highway system. The MDSS was designed with the needs of state Departments of Transportation (DOTs) in mind and allows state winter maintenance managers to view predicted weather conditions throughout the state; become aware of the potential for deteriorating road conditions before they occur; predict impacts of weather on road conditions; plan treatment scenarios based on available resources; and receive treatment recommendations based on proven rules of practice. The beauty of the MDSS is its modularity. States can pick and choose from the different strengths of the modules to make a tailored system that best fits their needs. The MDSS has been developed by several U.S. Government Laboratories for FHWA, and is being made available to state DOTs and the private sector to customize and meet the demands of local conditions. | http://www.itsdocs.fhwa.dot.gov//JPODOCS/BROCHURE/13695.html |
| MANAGEMENT OF ROADS IN WINTER USING CCTV CAMERA | A snowfall forecast system collecting and analyzing numerical data has been installed in Sapporo. A System for Managing Frozen Road Surface Using CCTV Camera enables real time monitoring of remote conditions. A system using CCTV images and ESS was developed to complement patrols and support efficient winter maintenance. | 8th World Congress on ITS; Office Community Service Bureau, City of Sapporo, Japan |
| MANUAL OF PRACTICE FOR AN EFFECTIVE ANTI-ICING PROGRAM: A GUIDE FOR HIGHWAY WINTER MAINTENANCE PERSONNEL | Highway anti-icing is the snow and ice control practice of preventing the formation or development of bonded snow and ice by timely applications of a chemical freezing-point depressant. This manual provides information for successful implementation of an effective highway anti-icing program. It is written to guide the maintenance manager in developing a systematic and efficient practice for maintaining roads in the best conditions possible during a winter storm. It describes the significant factors that should be understood and must be addressed in an anti-icing program, with the recognition that the development of the program must be based on the specific needs of the site or region within its reach. The manual includes recommendations for anti-icing practices and guidance for conducting anti-icing operations during specific precipitation and weather events. | http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| MEASUREMENT OF MOTORIST'S RELATIVE VISIBILITY INDEX (MRVI) THROUGH VIDEO IMAGES | This paper introduces a new road visibility index referred to as the motorists' relative visibility index (MRVI). This index represents the amount of visual information lost to the view of motorists due to atmospheric conditions in relation to the visual information available on an ideal clear day. MRVI is computed using readily available video images of roadways using relatively simple image processing techniques. MRVI is a road condition indicator and can be used for control of DMS, analysis of visibility effects on motorists, road closure decisions, and for fast identification of low visibility areas or time periods from a very large set of images collected from multiple video cameras. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| METEOROLOGICAL DATA AND XML | XML (eXtensible Markup Language) is a standard for communicating structured data. Use of XML is rapidly expanding, but the World Meteorological Organization (WMO) has not as yet taken a leading role in developing XML standards for meteorological information. This document analyzes the present use of XML in Meteorology and proposes options for WMO actions with a view to recommend a WMO standard for the exchange of data and metadata in XML. | http://www.wmo.ch/web/www/DPS/ET-DR-C-PRAGUE-02/Doc6(1).doc |
| MOBILITY AND SAFETY IMPACTS OF WINTER STORM EVENTS IN A FREEWAY ENVIRONMENT: FINAL REPORT | The main goal of the research project summarized in this report was the investigation of winter storm event impacts on the volume, safety and speed characteristics of interstate traffic flow. A literature review of weather related speed and trip choice factors, RWIS and traveler information dissemination was completed. . The models that resulted from this research can be applied in conjunction with each other to produce expected winter storm event volume and speed reductions (i.e., event travel and delay impacts), and crash increases (i.e., event safety impacts). | http://www.ctre.iastate.edu/pubs/midcon/Knapp1.pdf |
| MODEL OF HOUSEHOLD TRIP CHAIN SEQUENCING IN AN EMERGENCY EVACUATION | This paper presents an evacuation modeling framework that bridges the gap between observed household behavior and traditional evacuation models. The gap between observed behavior and theoretical models leads to longer-than-expected evacuation times. Through a series of two linear integer programs, this paper provides an expression for the household behavior in evacuation conditions. The first formulation determines the meeting location for the household members. The second formulation determines which drivers pick up each of the family members and the sequence of the collection. Tying these linear programs to traffic simulation software allows for a more complete evacuation simulation. Furthermore, information supply strategies may be incorporated into the simulation. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| MODIFYING SIGNAL TIMING DURING INCLEMENT WEATHER | The largest decrease in vehicle performance occurs when snow and slush begins to accumulate on the road surface. Saturation flows (capacity) decrease by 20 percent, speeds decrease by 30 percent, and start-up lost times increase by 23 percent. | University of Utah, Transportation Research Board 80th Annual Meeting |
| MULTI-FUNCTIONAL DEPLOYMENT OF AHS KEY TECHNOLOGY | Overview of state of development of key technologies for Advanced Cruise-Assist Highway System (AHS). Users services of AHS include support for road surface condition information. The functions required from road surface condition sensors are dry, wet, water film, new snow, packed snow, slush, packed snow ice sheet, and ice film. Laser radar sensors and millimeter wave radio meters are non-contact sensors able to detect road condition states. | Ministry of Construction, Japan |
| NATIONAL REVIEW OF HURRICANE EVACUATION PLANS AND POLICIES | This report includes information on the application of evacuation strategies and technologies, such as the use of reverse flow operations and intelligent transportation systems (ITS). It also summarizes current evacuation management policies, methods of information exchange, and decision-making criteria. The intent of this report is to provide a broad perspective on the current state of evacuation practices, while also presenting similarities and differences in individual state practices. | http://www.hurricane.lsu.edu/&EvacuationReview.pdf |
| NIGHTTIME VISIBILITY AND RETROREFLECTANCE OF PAVEMENT MARKINGS UNDER DRY, WET, AND RAINY CONDITIONS | The objective of this research was to determine the nighttime visibility of flat pavement marking tape, patterned pavement marking tape, and wet weather pavement markings tape under dry, wet (just after rainfall), and simulated rain conditions (ongoing one inch per hour rainfall). The measures of effectiveness were detection distances, eye fixation distributions, and the pavement marking retroreflectance. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| OPERATOR INTERFACE DESIGN OF A LANE AWARENESS SYSTEM FOR SNOW REMOVAL OPERATIONS | Research conducted on a two-lane, rural state highway in Minnesota in low visibility conditions. Vehicle-mounted, magnetic, lane-tracking system displaying lane position through a prototype user interface with continuous visual reference to centerline or shoulder line, as well as peripheral modalities (i.e., directional seat vibration, peripheral visual displays in windshield corners, and an optional auditory warning). Could result in improved safety of operator and public, improved service levels (mobility) and reduced cost for snow removal operation operations and reduced economic impact on region. (productivity) | 7th World Congress on ITS, University of Iowa |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| OPTIMAL CONTROL OF VARIABLE SPEED LIMITS AND ROAD LIGHTING BASED ON PREDICTED SHORT TERM SOCIO-ECONOMIC IMPACTS | In research conducted on a 6 km rural, two-lane road section in Finland during low visibility and winter weather conditions, information on traffic and weather conditions is input to a control system that executes the optimal decision (varying speed limits and roadway lighting intensity) on each road sections. The control system minimizes socio-economic costs (vehicle, time, environmental, lighting and crash costs), while maintaining an acceptable level of service. | 7th World Congress on ITS; Helsinki Traffic Information Centre of FinnRA, Finland |
| ORGANIZING FOR REGIONAL TRANSPORTATION OPERATIONS | Regional Operating Organizations (ROOs) are partnerships among transportation and public safety agencies to provide coordinated transportation operations on a regional basis. This Executive Guide provides an overview of the key features and critical elements impacting the development and long-term sustainability of ROOs. The guide is intended to serve as a resource for transportation management and operations leaders and decision makers. It highlights the findings and lessons learned from six case studies developed in conjunction with the National Dialogue on Transportation Operations. These six case studies are TRANSCOM in New York, New Jersey, and Connecticut; TransLink in Vancouver, British Columbia; the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area; the ITS Priority Corridor in Southern California; TranStar in Houston; and AZTech in Phoenix. | http://www.ite.org/library/ROOExecutiveGuide.pdf |
| PATTERNS OF CHLORIDE DEPOSITION NEXT TO A ROAD AS INFLUENCED BY SALTING OCCASIONS AND WINDS | Bulk deposition was collected in a field adjacent to highway E4 in SE Sweden in order to describe the deposition pattern of deicing salt. The result was related to wind characteristics and deicing activities on the road. Chloride was shown to be transported several hundreds of meters away from the road. The amount of air-borne chloride deposited in the roadside environment was well correlated to the road-salting intensity. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| PERCOSTATION FOR REAL TIME MONITORING MOISTURE VARIATIONS, FROST DEPTH AND SPRING THAW WEAKENING | This paper presents the findings of the research and product development project, in which percostation (the road structure moisture, frost depth and spring law weakening monitoring station) was installed on a road in Rovaniemi, Finland. Percostation can be used to assist road officials in tracking real-time moisture levels, depth of the frost and especially the risk for the permanent deformations in the road structure during the spring thaw season. Based on the percostation measurement results, road officials can make decisions about measures to preserve the state of the road during critical conditions, for example by imposing weight restrictions during the worst thaw softening period. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

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| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| PERFORMANCE MEASURES FOR WINTER OPERATIONS | New winter maintenance vehicles are being equipped with DGPS receivers and numerous sensors that collect environmental data (e.g., pavement and air temperature), equipment status data (e.g., plow up / plow down), and material usage data (e.g., salt application rate). This paper describes a comprehensive set of performance measures for winter maintenance that can be computed from data collected by DGPS receivers and sensors on winter maintenance vehicles. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| PREDICTING WEATHER AND ROAD CONDITIONS: AN INTEGRATED DECISION SUPPORT TOOL FOR WINTER ROAD MAINTENANCE OPERATIONS | Winter road maintenance practitioners have expressed a strong interest in obtaining weather and road condition forecasts and treatment recommendations specific to winter road maintenance routes. These user needs led the Federal Highway Administration (FHWA) Office of Transportation Operations Road Weather Management Program to support the development of a prototype winter road Maintenance Decision Support System (MDSS). The system integrates weather and road data, weather and road condition model output, chemical concentration algorithms, and anti-icing and deicing rules of practice. This paper describes technical aspects of the MDSS (e.g., technologies, data fusion techniques, architecture) and how the ongoing consideration of stakeholder feedback has benefited the development effort. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| PREDICTION OF DAILY TEMPERATURE PROFILE IN FLEXIBLE PAVEMENTS | The majority of previously published research on pavement temperature prediction has focused on predicting the annual maximum or minimum pavement temperature so as to recommend a suitable asphalt binder performance grade. However, modeling the pavement temperature on a daily or hourly basis has only been recently investigated. To determine the pavement temperature profile, the influence of ambient temperature and seasonal changes must be understood such that the effects of heating and cooling trends within the pavement structure can be quantified. In addition, the influence of different pavement structures on the temperature distribution within the pavement structure must be determined. This paper presents the temperature profile monitoring of flexible pavements on the Virginia Smart Road from March 2000 through May 2001. Developed models to predict the daily maximum and minimum temperature at depths to 0.188m within the pavement structure are presented. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| PROCEEDINGS FOR THE WEATHER INFORMATION FOR SURFACE TRANSPORTATION: DELIVERING IMPROVED SAFETY AND EFFICIENCY FOR TOMORROW | Symposium attended by a cross-section of transportation and weather professionals to establish national needs and requirements for weather information associated with decision-making actions involving surface transportation. See also WEATHER INFORMATION FOR SURFACE TRANSPORTATION (WIST): ESTABLISHING THE NATIONAL NEEDS AND REQUIREMENTS. | www.ofcm.gov/wist_proceedings/pdf/toc.pdf |
| PROCEEDINGS OF THE WORKSHOP ON STRATEGY FOR PROVIDING ATMOSPHERIC INFORMATION | The purpose of the workshop was to address issues identified in studies conducted by OFCM and the National Research Council (NRC). The workshop examined how the ever increasing inventory of atmospheric information could be accessed and used by those who need it. The issue was divided into two parts: getting the information to where it is needed, and insuring that users can read and understand that information. | http://www.ofcm.gov/sai/proceedings/pdf/00_opening.pdf |
| REAL TIME FLOOD MODELING DUE TO THE SEVERE RAINFALL DURING A HURRICANE: THE WEST FORK OF THE CALCASIEU RIVER, CALCASIEU AND BEAUREGARD PARISHES, LOUISIANA | Flooding resulting from hurricanes is a major cause of loss of life and property. A new tool in understanding the nature and extent of flooding is now available to local emergency management and other personnel. This tool links hydrologic and hydraulic modeling programs, geographic information systems, and real time weather data. The tool provides local officials information to be used in selecting evacuation routes, buildings to be used as shelters, and areas to be impacted by rising flood waters. In addition, the technology provides local officials with information to mitigate flooding damage. | Louisiana State University |
| REAL TIME FORECASTING OF HURRICANE WINDS AND FLOODING | Forecasting system developed to support emergency preparedness, evacuation and sheltering decisions in Louisiana. | Louisiana State University |
| REDUCTIONS IN TRAFFIC SIGN RETROREFLECTIVITY CAUSED BY FROST AND DEW | A study of in-service traffic signs was undertaken to quantify the average effects of frost and dew on their retroreflective capabilities. Average reductions in retroreflectivity levels of 79 and 60 percent were found, respectively. Jurisdictions subject to frequent cycles of frost/dew should review usage guidelines governing the grade of sign materials used allowed for expected loss of retroreflectivity. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| RELATIONSHIP BETWEEN WINTER ROAD SURFACE CONDITIONS AND VEHICULAR MOTIONS MEASURED BY GPS-EQUIPPED PROBE VEHICLES | Taxis, which move around ceaselessly over a wide area, have great potential as a sensor for detecting what the road surface conditions are like across a given area. In order to establish a method to estimate road conditions based on the vehicular motion of taxis, some field experiments were conducted using probe vehicles that fitted with vehicular motion sensors and a GPS device. The slip ratio, defined as the relative difference in speed between vehicle and tire wheel, was effective in indicating how slippery roads surfaces were. Some features of vehicular motion specific to slippery roads were identified and the discriminability of road conditions, whether icy or dry, without using wheel speed data, was also examined. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| REMOTE SENSING AND EMERGENCY MANAGEMENT FOR COASTAL ENVIRONMENTAL DISASTERS | Natural coastal hazard include inundation events, erosion events, circulation and depositional processes, and biological hazards. | http://www.hurricane.lsu.edu/paper2A.htm |
| REMOTE SENSING FOR TRANSPORTATION: REPORT OF A CONFERENCE | Proceedings summarize highlights from the conference held in December 2000. Sponsors include USDOT RSPA, NASA, AASHTO & National States Geographic Information Council. Themes of university consortia include Traffic Surveillance, Monitoring and Management; Environment Assessment, Integration and Streamlining; Transportation Infrastructure Management; and Disaster Assessment, Safety, and Hazards (DASH). The DASH theme includes flood, fog, snow, tornado and earthquake events. | http://gulliver.trb.org/publications/conf/reports/remote_sensing_1.pdf |
| RESEARCH NEEDS FOR WEATHER-RESPONSIVE TRAFFIC MANAGEMENT | Weather-responsive traffic management views weather events as non-recurring incidents that can be predicted, observed, and mitigated. This paper reports weather impacts on traffic flow and describes an emerging concept of operations for a system-wide approach to traffic management in adverse weather. The paper discusses this structured approach to assess weather impacts and implement operational strategies that improve safety, mobility, and productivity. Finally, research needs to advance the state-of-the-practice in weather-responsive traffic management are enumerated. | Transportation Research Board 83rd Annual Meeting (2004), FHWA and Mitretek Systems, ITS Division |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| REUNION ISLAND'S MERLIN PROJECT: AN ITS IMPLEMENTATION SUCCESS STORY | In response to rock falls triggered by torrential rains and high winds over a coastal road on Reunion Island (a French territory) in the Indian Ocean, traffic managers use automatic lane closure barriers on lanes near cliff and movable barriers to delineate travel lanes on remainder of road. From the TCC, they collect traffic and weather data and disseminate information via DMS. This technique increases safety by separating opposing traffic flows, reducing speed limits, and reducing incident response times. | 7th World Congress on ITS, Direction Departementale de l'Equipement, France |
| REVIEW OF THE INSTITUTIONAL ISSUES RELATING TO ROAD WEATHER INFORMATION SYSTEMS (RWIS): FINAL REPORT | This project, funded by the Aurora Program, aimed to identify and document institutional issues relating to the implementation and development of Road Weather Information Systems (RWIS). The project comprised two main phases. The first phase involved performing a review of existing documentation of RWIS institutional issues, and summarizing these findings. The intent of the project was to explore the coordination and standardization issues of RWIS taking place within and between agencies, for example, rather than the technical aspects of RWIS. Using the literature review findings as background information, the second phase involved gathering information on the status of RWIS developments in a variety of agencies with responsibilities for RWIS, and also documenting first-hand experiences in implementing and deploying RWIS. | http://www.aurora-program.org/pdf/inst_issues.pdf |
| ROAD FLOOD WARNING SYSTEM | The Road Flood Warning System provides predictive road flooding information on Queensland (Australia) river crossings. The system obtains river height forecasts from the Bureau of Meteorology. It generates predictive information based on a set of pre-determined river height criteria of the concerned roads. The system improves the current road closure process by providing timely alerts for traffic managers to respond. At the locations that the Bureau does not monitor, regression and artificial neural network technology are used to correlate local condition with upstream river height stations. Predictive information is to be published in the Internet and used to activate roadside advisory devices as the additional elements to the existing traveler information service. | Queensland Department of Main Roads (Australia) |
| ROAD WEATHER INFORMATION SYSTEM (RWIS): ENABLING PROACTIVE MAINTENANCE PRACTICES IN WASHINGTON STATE | Washington State DOT's "rWeather" program has integrated and expanded the capabilities of RWIS in the state, enabling proactive winter maintenance practices and better informed winter travel decisions. Report reviews potential benefits of a comprehensive, integrated RWIS; examines use and opinions of RWIS by maintenance personnel; identifies barriers to expanded use of RWIS technologies; and evaluates public response to the "rWeather" traveler information website. | http://www.wsdot.wa.gov/PPSC/Research/CompleteReports/WARD529_1RWISEval.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
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| ROAD WEATHER INFORMATION SYSTEMS (RWIS) DATA INTEGRATION GUIDELINES | The goal of the RWIS Data Sharing and Integration Guidelines is to provide agencies with a tool to fully utilize all of the road and weather data that is a avalible to them. This project, sponsored by the ENTERPRISE and Aurora consortium, was conducted in two phases. Phase one involved the composing of a survey for DOTs on their current RWIS practices and their thoughts on the benefits of and barriers to RWIS integration and data sharing. Phase two of this project utilized past research into RWIS practices and successfully integrated systems along with the survey results of phase one to present a discussion of the various issues involved in the deployment of a data integration project. This final report combines the two technical memoranda to present a comprehensive view of the state-to-practice for the deployment and integration of RWIS, and how an integrated system, capable of sharing information with other agencies, may be successfully established. | Castle Rock Consultants, Inc. |
| ROAD WEATHER INFORMATION SYSTEMS VOLUME 1: RESEARCH REPORT | Reviews current snow and ice control practices, communication of road weather information, and the potential uses of such information in roadway snow and ice control within highway agencies. Presents considerations regarding the location of road weather information systems and discusses possible cost-reduction ranges for implementation. Offers conclusions and recommendations for state and local highway maintenance agencies. | http://gulliver.trb.org/publications/shrp/SHRP-H-350.pdf |
| ROAD WEATHER INFORMATION SYSTEMS VOLUME 2: IMPLEMENTATION GUIDE | Supplements Volume 1. Describes the current technology, information sources, communication requirements, and proper siting of sensors. Includes sample requests for proposals for the necessary equipment and services. | http://gulliver.trb.org/publications/shrp/SHRP-H-351.pdf |
| ROAD WEATHER INFORMATION SYSTEMS: SOME FINDINGS ON HOW RWIS INFORMATION SHOULD BE DISSEMINATED TO THE TRAVELING PUBLIC | Survey of four potential user groups of RWIS information: commuters, recreational travelers, long distance travelers, and truckers. Results show that DMS, commercial radio and HAR are the most popular delivery methods. Road condition information (e.g., accumulating snow, fog, ice, wind and road closures) is preferred over information on alternate routes, travel times, or travel speeds. Preferred delivery times are one hour before departure and while en-route. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| ROCKFALL HAZARD ASSESSMENT AND REMEDIATION AT HANO VILLAGE HOPI INDIAN RESERVATION, POLACCA, AZ | In November 2001, personnel from the Central Federal Lands Highway Division FHWA, began working with the Bureau of Indian Affairs (BIA) and Hopi tribe to mitigate pending rockfall hazards at First Mesa, AZ. This report describes the factors contributing to rockfall hazards at First Mesa, the various construction, environmental, and cultural limitations on remediation, alternative recommendations for hazard mitigation, and the expected results of the rock removal effort | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| RURAL FREEWAY MANAGEMENT DURING SNOW EVENTS - ITS APPLICATION | Based upon visibility, road surface conditions, and capacity of towns to accommodate motorists; the Minnesota DOT and law enforcement personnel activate warning sign, lower (or swing) gate arm, and activate gate lights to prohibit access to rural interstate freeways. Law enforcement personnel are positioned at gate location during closing and reopening. Systematic and well-coordinated plan for closing and reopening has reduced delay (mobility), accident frequency (safety), and lowered DOT costs to clear and reopen by 15 percent (productivity). Significant time savings result in less overtime pay. Future plans include the addition of fixed and portable VMS, CCTV cameras, and an electronic map. | 7th World Congress on ITS, Minnesota DOT |
| RURAL ITS APPLICATIONS FOR SNOW MAINTENANCE AND WINTER HAZARD MITIGATION | Presents emerging ITS concepts and products for winter maintenance safety developed from the Ideas Deserving Exploratory Analysis (IDEA) program managed by Transportation Research Board. Includes fleet management, avalanche detection and gateway management system, fiber-optic-based visibility information system, and road condition sensor system concepts/products. | Transportation Research Board, Search TRIS http://199.79.179.82/sundev/search.cfm |
| SAFETY APPLICATIONS OF ITS IN RURAL AREAS | Report examines infrastructure-based technology applications aimed at reducing the frequency and/or severity of rural crashes. The main focus is on variable speed limit (VSL) systems and warning systems. | www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//13609.htm |
| SIGNS OF RAIN | The New South Wales Roads and Traffic Authority has expanded DMS use to warn motorists during wet weather conditions. | 8th World Congress on ITS |
| SIMULATION OF A GEOTHERMAL BRIDGE DECK ANTI-ICING SYSTEM AND EXPERIMENTAL VALIDATION | The design of heated bridge deck anti-icing systems requires assessment of long-term performance under expected future weather conditions. A method of simulating the performance of such a system has been developed. The system studied in this work uses a bridge deck with embedded hydronic tubing and a ground-coupled heat pump system with vertical borehole heat exchangers as a heat source. The models of each component and their integration into the simulation of the whole system are described. Validation of the simulation method has been attempted by making use of operating data collected from an experimental heated bridge deck installation. The collection of data, estimation of the model parameters, and comparison of the simulation results with the measured data are discussed. Results indicate that the system simulation of the heated bridge deck is able to predict performance with reasonable accuracy under a range of weather and operating conditions. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| SMART CONTROL OF A GEOTHERMALLY HEATED BRIDGE DECK | This manuscript describes the "smart" control system designed for a geothermal bridge deck heating system. The control system integrates concepts of model predictive control with a first-principles bridge deck model and hourly computerized National Weather Service (NWS) forecasts to prevent bridge icing without the use of salt or other chemical deicing materials. The proactive nature of the control system maximizes motorists safety and bridge life while minimizing system operating costs. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| SNOW & ICE CONTROL OPERATIONS | Describes various aspects of Caltrans' methods of controlling snow/ice on mountainous highways, including chain controls, materials, environmental concerns, equipment, personnel management, communications, forecasting, enforcement, and avalanche control. | www.dot.ca.gov/hq/roadinfo/snwicecontrol.pdf |
| SNOW EMERGENCY VEHICLE ROUTING WITH ROUTE CONTINUITY CONSTRAINTS | This paper summarizes new results from continuing research dealing with development of a decision support system for assisting the Maryland State Highway Administration Office of Maintenance staff in designing snow emergency routes for Calvert County. By taking into account some of the more realistic constraints, we try to solve two problems. One involves minimizing the total number of trucks and, the second one involves minimizing the total deadhead distance given the number of trucks. The two problems do not result in identical solutions in general. Some application results are also reported which indicate using such a system can achieve improvements in service and savings in operational costs. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| SNOW FENCE GUIDE | This guide provides construction plans and guidelines for placement of snow fence for maximum effectiveness and cost-efficiency. It also explains ways to work with landowners to obtain cooperation with a snow fence program, and it discusses considerations involved with use of trees and shrubs to block blowing snow. | http://gulliver.trb.org/publications/shrp/SHRP-H-320.pdf |
| SOCIOECONOMIC IMPACTS OF HEAVY PRECIPITATION IN THE UNITED STATES | Flood losses rank just behind hurricane losses as the second greatest cause of economic losses from weather, and flood losses continue to grow. The number of lives lost due to flooding is decreasing but still ranks as the third highest cause of death ranking behind heat waves and lightning. Heavy rain in the Chicago metro area create rain-slick streets and highways causing three times the number of crashes than occur in light rain conditions. They also cause a 25 percent increase in the number of fatalities. | American Meteorological Society Conference Proceedings |

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| SOUTHEAST MICHIGAN SNOW AND ICE MANAGEMENT (SEMSIM) | The Southeast Michigan Snow and Ice Management (SEMSIM) partnership includes the Detroit Department of Public Works, the Road Commission of Macomb County, the Road Commission for Oakland County, and Wayne County Department of Public Services. The purpose of the partnership is to develop an AVL (Automatic Vehicle Location) system that will allow the partners to fight a snowstorm in a cooperative effort. This report provides an evaluation of the first season, the winter of 1999-2000. The evaluation centered on determining if the system (1) provided the tracking and reporting tools that the SEMSIM partners wanted and (2) improved efficiency and impacted standard ITS measures in a positive way. | Road Commission for Oakland County |
| SOUTHEAST UNITED STATES HURRICANE EVACUATION TRAFFIC STUDY | Study to address problems during the Hurricane Floyd evacuation. The study documents behavioral analysis, Evacuation Travel Demand Forecast Model, reverse lane standards, and ITS strategies. | www.fhwaetis.com/etis |
| SPATIAL VARIABILITY OF THAW DEPTH | Statistical and spatial analyses were used to determine the variability of thaw using existing thaw depth datasets from various sites with a variety of climatic and terrain conditions. Results from the statistical and spatial analysis can be used to develop an approach to characterizing the spatial variability of thawing soil, to spatially distribute soil properties based on point data or one-dimensional models, or to populate sparse data sets with terrain properties. They are also useful for analyzing impact of thaw distribution on predictive models, such as for predicting vehicle mobility or surface runoff. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| STATE OF THE PRACTICE AND REVIEW OF THE LITERATURE: SURVEY OF FOG COUNTERMEASURES PLANNED OR IN USE BY OTHER STATES | DOTs from 49 states (all but Virginia) were contacted in an effort to document the fog countermeasures that are currently in use or being planned by the other states. The results are presented in the report, along with the contact name and phone number or email address for each state. | Virginia Tech Research Council |

# Best Practices for Road Weather Management
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| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| SURFACE TRANSPORTATION SAFETY AND OPERATIONS: THE IMPACTS OF WEATHER WITHIN THE CONTEXT OF CLIMATE CHANGE | This paper examines weather impacts on roadways, operational practices of transportation managers and road users, and the weather parameters with the greatest effects on roadways. Finally, a discussion of how possible climate change may affect these parameters during the next century is presented. | Mitretek Systems |
| SURFACE TRANSPORTATION WEATHER APPLICATIONS | Weather threatens surface transportation nationwide and impacts roadway mobility, safety, and productivity. There is a perception that traffic managers can do little about weather. However, three types of mitigation measures—control, treatment, and advisory strategies—may be employed in response to weather threats. Road weather data sharing, analysis, and integration are critical to the development of better road weather management strategies. Environmental information serves as decision support to traffic, maintenance, and emergency managers; and allows motorists to cope with weather effects through trip deferrals, route detours, or driving behavior. | Institute of Transportation Engineers 2002 Annual Meeting, Mitretek Systems ITS Division |
| SURFACE TRANSPORTATION WEATHER DECISION SUPPORT REQUIREMENTS | This series of documents presents the latest findings of the ongoing Surface Transportation Weather Decision Support Requirements (STWDSR) project. STWDSR Draft Version 1.0 documents the weather information requirements of all road users and operators. STWDSR Draft Version 2.0 focuses on the decision support requirements of a particular stakeholder group--winter road maintenance engineers. It also presents an operational concept for a Weather Information for Surface Transportation Decision Support System (WIST-DSS). | http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/94f01!.pdfhttp://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/9dc01!.pdfhttp://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/9db01!.pdfhttp://www.itsdocs.fhwa.dot.gov/jpodocs/EDLBrow/401!.pdfhttp://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@701!.pdf |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| SYNTHESIS OF BEST PRACTICES FOR INCREASING PROTECTION AND VISIBILITY OF HIGHWAY MAINTENANCE VEHICLES | The purpose of this research project is to study current practices in enhancing visibility and protection of highway maintenance vehicles involved in moving operations such as snow removal and shoulder operations, crack sealing, and pothole patching. This project report provides the most recent information on current moving operation practices throughout the country and the state of Iowa. It will enable the maintenance staff to adequately assess the applicability and impact of each strategy to their use and budget. The report's literature review chapter examines the use of maintenance vehicle warning lights, retroreflective tapes, shadow vehicles and truck-mounted attenuators (TMAs), and advanced vehicle control systems (AVCSs), as well as other practices to improve visibility for both snowplow operators and vehicles. | http://www.ctre.iastate.edu/reports/visibility.pdf |
| SYNTHESIS OF ROAD WEATHER FORECASTING | Survey to document relationships between national surface transportation agencies and meteorological agencies. The countries of Canada, Denmark, Finland, Germany, Japan, New Zealand, Norway, Sweden and the United Kingdom were surveyed. | www.aurora-program.org/pdf/synthesis_weather.pdf |
| SYNTHESIS OF STUDIES ON SPEED AND SAFETY | Paper examines previous studies on the relationship between speed an safety and gives an overview of research interests. Weather affects safety through impaired visibility, decrease stability and reduced controllability. One study found that drivers appear to compensate for increased injury risks in that injuries are more frequent but less severe in adverse weather crashes. Another study found that speed variance is also impacted by weather. The standard deviation doubles during fog events and triples during snow. This study also found an average reduction of 0.7 mph for every mph that wind speed exceeds 25 mph. Another study estimated that wind speed above 30 mph reduced free flow speed by 5.6 mph. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| SYNTHESIS OF THE EFFECTS OF WET CONDITIONS ON HIGHWAY SPEED AND CAPACITY | Wet and rainy conditions impact drivers, vehicles, and roadways. These effects cause a reduction in speed and/or density, which in turn, cause a reduction in highway capacity. This paper is a synthesis of 26 studies relating wet conditions to speed and capacity. If the results from all reveiwed studies after 1980 are averaged, assuming equal weights, then the average speed reduction is 4.7 mph in light rain (11 studies) and 19.6 mph in heavy rain (2 studies). The average capacity reduction is 8.4% in light rain (7 studies) and 20.0% in heavy rain (1 study). Much additional research is needed for reducing the wide variance of observations in past studies. | University of Hawaii at Manoa, Department of Civil Engineering |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| SYSTEM MONITORS FLOOD-PRONE CREEKS | The City of Palo Alto, California maintains a "Creek Level Monitor" website that displays water levels at five bridge locations. The system detects water levels with ultrasonic devices under bridges and transmits data to the communication system that controls storm pump stations. City residents receive advanced warning of flood conditions. | www.civic.com/civic/articles/2001/0122/web-flood-01-26-01.asp |
| TEMPERATURE AND HUMIDITY EFFECTS ON THE CO-EFFICIENT OF FRICTION VALUE AFTER APPLICATION OF LIQUID ANTI-ICING CHEMICALS | Experiment conducted in Canada to establish the reliance of various anti-icing chemicals based on temperature and humidity; specifically to determine what roll they play on road co-efficient of friction. Research showed that when most anti-icing chemicals transition from liquid to solid, and solid to liquid, a "slurry" phase is formed; producing relatively short-lived reductions in friction co-efficient. | http://www.wsdot.wa.gov/partners/pns/pdf/slicknessrpt.pdf |
| TESTING THE ADVERSE VISIBILITY INFORMATION SYSTEM EVALUATION (ADVISE) - SAFER DRIVING IN FOG | There are many advisory systems to warn drivers of fog. However, warning drivers that there is fog ahead does not instruct them on what to do. During the 1995-2000 winter seasons, a new technology known as the Adverse Visibility Information System Evaluation (ADVISE) was tested. ADVISE uses visibility sensors to determine current sight distance and corresponding safe speed for the prevailing conditions. DMS instruct drivers of safe speed. This research measures the effectiveness of the system in reducing the variability between speeds. ADVISE successfully reduced speed variability by an average 22 percent. | University of Utah, Transportation Research Board 81st Annual Meeting |
| THE ADVANCED TRANSPORTATION WEATHER INFORMATION SYSTEM (ATWIS) | The Advanced Transportation Weather Information System (ATWIS) project was designed to provide a current road and forecasted weather report to the traveling public and commercial vehicles within North and South Dakota. This prototype project was to investigate how to merge information and current technologies from both state and private industry to provide in-vehicle decision support data for the traveler. The ATWIS was conceived and designed to provide information specifically for ground transportation, its users and maintainers. This paper examines the development and operational history of the multi-state ATIS. | http://www.ctre.iastate.edu/pubs/midcon/Owens.pdf |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| THE EFFECT OF VARIABLE MESSAGE SIGNS ON THE RELATIONSHIP BETWEEN MEAN SPEEDS AND SPEED DEVIATIONS | This research studies the effect of DMS on the relationship between hourly cross-sectional mean speeds and speed deviations. This section of I-90 in the vicinity of Snoqualmie pass, Washington is a rural freeway location subject to adverse weather conditions, and experiences over seventy-five reported vehicle crashes annually. DMS were installed to reduce crash potential by effective speed and traffic flow management. Aggregate results on vehicle speeds and vehicle speed deviations at the hourly level show that there is a significant decrease in mean speed when the DMS are on, along with a significant increase in speed deviation. | Transportation Research Board 81st Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| THE EFFECT OF WEATHER ON FREE FLOW SPEED | Free flow speed is affected by pavement conditions, visibility and wind speeds. The effects of poor weather should be considered in such cases as part of capacity and level-of-service analyses. | Transportation Research Board 80th Annual Meeting, University of Idaho |
| THE MEASUREMENT AND THEORY OF TIRE FRICTION ON CONTAMINATED SURFACES | Summarizes results of various studies related to friction characteristics of wet, snowy and icy pavement. Preliminary project showed that modeling constants can be used to differentiate contaminates (water, snow, ice), and that friction levels can be monitored for salting control. | http://www.ctre.iastate.edu/pubs/crossroads/94measurement.pdf |
| THE MIXED EFFECTS OF PRECIPITATION ON TRAFFIC CRASHES | This paper investigates the relationship between precipitation and traffic crashes in the U.S. from 1975 to 2000. A surprising negative and significant relationship between monthly precipitation and monthly fatal crashes is found. However, in the daily level analysis, a strong positive relationship is estimated, as in prior studies. The source of the contrasting results appears to be a substantial and negative lagged effect of precipitation. In other words, if it rained a lot yesterday, then on average today there are fewer crashes. Additional analysis shows that the risk imposed by precipitation increases dramatically as the time since last precipitation increases. This basic pattern holds for nonfatal crashes as well. The lagged effects of precipitation across days may be explained by the clearing of oil on the road that accumulates during dry periods or by the conditioning of people to drive more safely in wet conditions. Either way, policy interventions that prepare drivers more adequately for the risks of precipitation following dry periods are likely to be beneficial. | http://ist-socrates.berkeley.edu/~daniel7/papers/precipitation.pdf |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| THE ROLE OF GROUND-BASED GPS METEOROLOGICAL OBSERVATIONS IN NUMERICAL WEATHER PREDICTION | A significant effort has been expended to develop new or improved remote sensing systems to observe moisture fields (including water vapor and clouds). One such system uses ground-based GPS receivers to make accurate all-weather estimates of atmospheric refractivity. The first and most mature use of GPS for this purpose is in the estimation of integrated (total column) precipitable water vapor. NOAA/FSL has shown that GPS integrated water vapor data can be used effectively in objective and subjective weather forecasting. | http://www-frd.fsl.noaa.gov/pub/papers/Gutman2001a/p.pdf |
| THE ROLE OF NEW DATA COLLECTION TECHNOLOGY IN PERFORMANCE SPECIFIED MAINTENANCE CONTRACTS | This paper shall describe the form of contract and the role that technology developments have played in allowing clients to specify performance and contractors the ability to manage to them. The paper shall refer to long-term road maintenance contracts that have been in operation in Australia for the past seven years and New Zealand for four years and developments seen in the latest generation of contract documents. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| THE USE OF ABRASIVES IN WINTER MAINTENANCE: FINAL REPORT OF PROJECT TR 434 | Report reviews the state of the practice of abrasive usage in Iowa counties and classifies usage according to effectiveness. | www.sicop.net/Abrasives%20report.pdf |
| THE USE OF MOBILE VIDEO DATA COLLECTION EQUIPMENT TO INVESTIGATE WINTER WEATHER VEHICLE SPEEDS | Research involves traffic and weather data (i.e., visibility, roadway snow cover, volume, speed, and headway/gap data) collected by a trailer-mounted video data collection/monitoring system. Collected data used to predict vehicle speed and speed variability. Results indicate that average winter weather speed was 16 percent lower than that in speed under dry conditions. In winter weather, speed variation was 307 percent higher than variation during dry conditions. The resulting model predicted that off-peak winter weather speeds would decrease by 3.9 mph when visibility fell below one-quarter mile, and decrease by 7.3 mph when snow began to cover roadway lanes. | Transportation Research Board 79th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| THE USE OF SELECTED DEICING MATERIALS ON MICHIGAN ROADS: ENVIRONMENTAL AND ECONOMIC IMPACTS | This report analyzes the performance, environmental effects and economic costs of seven deicing materials including sodium chloride (road salt), calcium magnesium acetate (CMA), a potassium chloride product (CMS-B) patented by Motech, a patented corrosion-inhibiting salt (CG-90 Surface Saver), calcium chloride, a patented concrete road surface containing calcium chloride pellets (Verglimit), and sand. | http://www.michigan.gov/mdot/0,1607,7-151-9622_11045_21847---,00.html |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| THE WINTER MAINTENANCE DECISION SUPPORT SYSTEM (MDSS): DEMONSTRATION RESULTS AND FUTURE PLANS | The Federal Highway Administration (FHWA) has sponsored development of a winter Maintenance Decision Support System (MDSS) functional prototype. During the winter of 2002-2003, the prototype was deployed at several maintenance garages in central Iowa for a field demonstration. This paper documents the implementation of the demonstration, summarizes the lessons learned, includes verification statistics and discusses technology transfer activities. The paper also describes plans for a longer, more comprehensive demonstration during the winter of 2003-2004. | American Meteorological Society 83rd Annual Meeting (2003); FHWA, Mitretek Systems & National Center for Atmospheric Research |
| THERMAL ASPECT OF FROST-THAW PAVEMENT DIMENSIONING: IN SITU MEASUREMENT AND NUMERICAL MODELING | The thermal behavior of pavements in winter has a major influence on their dimensioning. The Paris-based Laboratories Central Des Ponts et Chauss'ees (LCPC) and the ministe're des Transports du Quebec (MTQ) have models to forecast the propagation of frost, frost heave and thaw phenomena. They have developed a collaborative project to validate these models on an experimental pavement. This pavement was constructed in Quebec in 1998 and its thermal behavior was monitored for three years. This paper presents the assessments of the thermal models. It describes the models, site and the temperature conditions of the three winters, pavement structures and their physical properties, instrumentation set up, and the analysis and comparison of the results of the models among themselves and in relation to the observations conducted on the pavements. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| TRAFFIC MODELING FRAMEWORK FOR HURRICANE EVACUATION | Development of computer-based incident management decision aid system (IMDAS). | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| TRAVELAID | Report discusses effectiveness of DMS and in-vehicle traffic advisory systems (IVUs) on a mountainous pass for changing driver behavior. DMS and VSL signs were installed on I-90 to provide speed limit, weather, and roadway information to motorists in order to reduce the number and severity of crashes. Report includes analysis of mean speeds and speed deviation based upon a driving simulator study. | www.itsdocs.fhwa.dot.gov//jpodocs/repts_te//13610.html |

# Best Practices for Road Weather Management

## Version 2.01

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| TRUCKING INDUSTRY PREFERENCES FOR DRIVER TRAVELER INFORMATION USING WIRELESS INTERNET-ENABLED DEVICES | If truck drivers could use Internet-enabled wireless devices to access traveler information, what type of information would they most want to have? We analyzed preferences for traveler information from managers of 700 trucking companies to determine how they valued information. Using a factor-analytic model with regressor variables, we found clear differences in preferences across types of trucking operations. "Locations of freeway incidents and lane closures," "weather information," and "travel times on alternative routes" were evaluated as important by the greatest number of carriers. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| USE OF EXPERT SYSTEMS FOR ROADWAY WEATHER MAINTENANCE DECISIONS | Automated systems for forecasting frost and fog on roads and bridges using expert systems were deployed in Iowa. | http://www.ctre.iastate.edu/pubs/semisesq/session5/takle/ |
| USE OF PAVEMENT TEMPERATURE MEASUREMENTS FOR WINTER MAINTENANCE DECISIONS | Analyzed pavement temperature data from urban and rural sites on bridges and roads to evaluate nighttime trends and differences of temperature at different locations under different weather conditions. Using RWIS pavement temperature data and cloud cover data from Jan. 1997, temperature differences, cooling rates, and lag times between urban and rural sites were computed. | http://www.ctre.iastate.edu/pubs/crossroads/33use.pdf |
| UTILIZING ROAD WEATHER INFORMATION SYSTEM (RWIS) DATA TO IMPROVE RESPONSE TO ADVERSE WEATHER CONDITIONS | The advent and expanded use of Road Weather Information Systems (RWIS) shows potential for improving the identification of weather-related factors contributing to low levels of safety and for improving guidance provided to response personnel during or preceding times of adverse weather. This investigation revealed several significant issues associated with the use of RWIS data for improving adverse weather-related crash prediction and response: (1) the categorical nature of some RWIS-reported data elements limits its usefulness in guiding response actions, (2) RWIS data is limited in historical timeline and ease of accessibility, and (3) RWIS data are highly localized spatially (i.e., reporting the pavement surface status only at the location of the in-road sensor) which results in substantial discrepancies between officer-reported and RWIS-reported crash data. | Kimley-Horn and Associates |
| VARIABLE SPEED CONTROL: TECHNOLOGIES AND PRACTICE | Static speed limit signs fail to provide accurate information on speed selection when traffic and environmental conditions are less than ideal. Paper documents findings from a state-of-the-practice review on VSL systems. Paper reviews and compares characteristics of VSL systems, and discusses potential benefits and limitations associated with their deployment. | ITS America 11th Annual Meeting Proceedings, Michigan State University |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| VIDEO CAMERAS FOCUS ON VISIBILITY | A researcher has developed a technique for automatically measuring visibility with video cameras. The camera is aligned to detect contrasting portions of targets in order to generate a signal indicative of contrast levels. A processor uses the signal to compute visibility. Prototype system was installed on northbound Highway 35 near Duluth, Minnesota. | www.its.umn.edu/news/visibility.html |
| WASHINGTON STATE DEPARTMENT OF TRANSPORTATIONS MAINTENANCE ACCOUNTABILITY PROCESS: AN ONGOING EXPERIMENT IN PERFORMANCE MEASUREMENT | The Washington State Department of Transportation (WSDOT) has utilized its current system of highway maintenance performance measures since 1996. This system is called the Maintenance Accountability Process (MAP) and has generally been successful since its inception. The MAP has provided WSDOT maintenance the tools to clearly communicate to legislators and policymakers the outcomes of investments in the maintenance program. This paper describes the performance measure lessons we have learned while using the MAP and some associated improvements in performance measure processes; some implemented and other being considered for future implementation. | Transportation Research Board 82nd Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| WEATHER BASED TRAFFIC MANAGEMENT APPLICATIONS IN NEVADA | Maintenance operations dealing with inclement weather occur at almost all levels of government across the United States. Several operational strategies and technologies have been developed to assist in the forecasting and detection of roadway conditions associated with inclement weather. RWIS technologies have become a cornerstone to several traffic management applications in northern Nevada. Detection of road and weather conditions allow for the development of detection and warning systems to alert motorists of potential driving difficulties of intermittent hazards. | Institute of Transportation Engineers 2002, Nevada DOT |
| WEATHER IMPACTS ON ARTERIAL TRAFFIC FLOW | This paper synthesizes literature regarding weather effects on traffic flow along signalized arterial roadways. Generally, weather impacts traffic by reducing visibility, decreasing pavement friction, as well as impacting driver behavior and vehicle performance (e.g., traction, stability, maneuverability). Weather effects on roads and traffic are presented, relevant literature is reviewed, and findings from the literature are summarized in the conclusion. | Mitretek Systems, ITS Division |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| WEATHER IN THE INFO-STRUCTURE | This paper addresses the Weather Response component of the Infostructure. It's primary purpose is to discuss the fundamental data needs of the weather infostructure component, and to estimate an aggregate cost for national deployment of road weather data collection systems. It does this by first documenting a methodology for determining the number of Road Weather Information System (RWIS) sensors (or ESS) needed across the country to support basic road weather needs, and then documenting a methodology for determining the cost. | Cambridge Systematics, Inc. and Mitretek Systems |
| WEATHER INFORMATION FOR SURFACE TRANSPORTATION (WIST I): ESTABLISHING THE NATIONAL NEEDS AND REQUIREMENTS | OFCM and FHWA initiated a project, within the federal meteorological community, to identify the nation weather needs and requirements for all surface transportation modes. Establishing initiatives, the Joint Action Group for WIST, database records, and plans for 2000 WIST Symposium are discussed. | http://www.ofcm.gov/wist_proceedings/proceedings.htm |
| WEATHER INFORMATION FOR SURFACE TRANSPORTATION (WIST II): ESTABLISHING THE NATIONAL NEEDS AND REQUIREMENTS | OFCM and FHWA initiated a project, within the federal meteorological community, to identify the national weather needs and requirements for all surface transportation modes. In this venue, surface transportation consists of roadways, rail, waterways, and pipelines. Noted shortcomings were the absence of definitive information on the spatial and temporal scales required for decision processes, and the lack of any specific threshold for identified weather elements. | http://www.ofcm.gov/wist2/proceedings2000/wist2startup.htm |
| WEATHER INFORMATION FOR SURFACE TRANSPORTATION (WIST): NATIONAL NEEDS ASSESSMENT REPORT | This report provides a complication of weather information needs across the six surface transportation sectors--roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations--and an analysis of these needs. The findings in the report provide a framework for actions to substantially improve surface transportation operations in the future. | http://www.ofcm.gov/wist_report/wist-report.htm |
| WEATHER: A RESEARCH AGENDA FOR SURFACE TRANSPORTATION OPERATIONS | Weather crosscuts almost every goal, use, and operation of highways, and yet, meteorology, from a transportation perspective, is focused mostly on the flight operations. To make weather issues an important part of highway programs, people who manage highway operations must seek new techniques and ITS that complement the amazing system of weather-information collection, analysis, and forecasting that exists in the US. | http://www.tfhrc.gov/pubrds/02mar/05.htm |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| WEATHER: MAKING IT A NATIONAL PRIORITY IN SURFACE TRANSPORTATION | Includes "A National Program for Surface Transportation Weather Applications" by Pisano & Nelson; " An Advanced Winter Road Decision Support System" by Mahoney; "Research Needs in Weather Information for Surface Transportation--The Perspective of the User Community" by Nixon; "Utilizing FAA-Developed Automated Weather Algorithms for Improving Surface Transportation Operations in Adverse Weather" by Hallowell; "Foretell--Some Findings and their Research Implications" by Davies, Choudhry & Canales; "Future Growth of Surface Transportation Weather: An Academic Question" by Osborne; and "Private Sector Meteorology and ITS" by Smith. | www.ops.fhwa.dot.gov/weather/publications/its_america.pdf |
| WEATHER-RESPONSIVE TRAFFIC MANAGEMENT CONCEPT OF OPERATIONS: DRAFT | The purpose of this paper is to provide a concise summary of a concept of operation and associated research needs pertaining to weather-responsive transportation management. The primary focus of this paper is on the needs and activities of freeway and arterial transportation managers, and how these needs change or differ during Adverse weather. However, the concept of operations also involves transportation-related activities or others including public transportation managers, public safety personnel, highway maintenance personnel, and emergency response personnel. | Cambridge Systematics, Inc. |
| WHITE PAPER: AN INTEGRATED NETWORK OF TRANSPORTATION INFORMATION | The integrated network is the "infostructure" that facilitates monitoring, management, and operation of the entire transportation network. The integrated network will enable Road Weather Information and offer the opportunity (1) to detect and respond to regional crises, (2) for fewer and less severe crashes, (3) for better operator and user information, and (4) to reduce energy consumption and negative environmental impacts. | www.itsa.org/ITSNEWS.NSF/4e0650bef6193b3e852562350056a3a7/927cd5cae21c0ff085256b190049bd4e?OpenDocument |
| WINTER MAINTENANCE IN THOMPSON FALLS (MEMORANDUM) | A winter storm event, beginning 12/14/00 in the Thompson Falls area, resulted in numerous complaints regarding driving conditions on MT 200 (P-6) between the Plains section (Missoula Division) and the Thompson Falls section (Kalispell Division). The Plains section had bare road while the Thompson Falls section had snow and ice pack when the storm had passed. At the request of the Kalispell Area Maintenance Engineer, Maintenance Review was assigned the task of finding out why this happened. The Review team went to the area on a fact-finding tour and documented different treatment strategies and resulting roadway outcomes. | Montana DOT |

| TITLE | ABSTRACT | SOURCE(S) |
|---|---|---|
| WINTER MAINTENANCE VIRTUAL CLEARINGHOUSE: TECHNICAL BRIEFS | This web site contains technical briefs of weather-responsive strategies used in 28 states. Titles include "Making Snow-Covered Roads Easier to Open" (AK), "Protecting a National Forest with New Snow Removal Methods" (CA), "Anti-Icing Saves Time and Money" (CO), "Road and Weather Data Give Colorado DOT a Jump on Snow Storms and Avalanches" (CO), "New Weather System Keeps Routes Open in the Nation's Capitol" (DC), "Protected by Snow Fences, Idaho Road Stays Open to Traffic" (ID), "Better Weather and Pavement Information Mean Faster Storm Cleanup" (IL), "Snow and Ice Control: The New Generation", "Iowa Gets a Jump on Storms with New Technology" (IA), "Snow Fences Increase Visibility and Reduce Drifts" (IA), "Anti-Icing Improves Road Safety" (KS), "Beating Winter Storms to the Punch with an Advance Warning System" (KS), "Timing Is Key to Effective Winter Maintenance in Maryland" (MD), "Clearer Roads at Less Cost" (MA), "Michigan Finds a Solution for Icy Bridges" (MI), "Monitoring System Gives Highway Crews the Edge in Winter Maintenance" (MN), "Snow Fences Spell End of Blocked Highways" (MN) "Weather Monitoring Stations Improve Maintenance Operations" (MN), "Anti-Icing Techniques: Key to Safer Roads" (MO), "Weather System Saves Money and Improves Service" (MO), "Weather Monitoring Stations Improve Maintenance Operations" (MT), "Keeping the Snow at Bay" (NE), "A Cleaner, Safer Way to the Slopes" (NV), "Snow Fences Prove To Be a Valuable Maintenance Tool" (NV), "Advanced Cutting Edge Clears More Ice in New Hampshire" (NH), "Real-Time Data Slashes Winter Maintenance Costs" (NJ), "No More Snow Drifts on Upstate Road" (NY), "Weather Information System Helps Keep North Dakota Roads Clear" (ND), "Saving Money and the Environment" (OR), "Timing is Everything with Winter Maintenance" (SD), "Information Helps Schedule Operations Year-Round" (TX), "Making Better Use of Snow Fences", "New Technology Slashes Winter Maintenance Costs" (WV), "A Preemptive Strike on Ice" (WA), "Clear Roads Ahead for Wisconsin Counties" (WI), and "Snow Fences Save Money and Lives" (WY). | http://www.fhwa.dot.gov/winter/briefs/briefs.html |
| WINTER OPERATIONS WEATHER FORECASTS: DO THEY WORK FOR THE MAINTENANCE SHED SUPERVISOR? | An evaluation of Utah DOT's RWIS included validation of NWS forecasts and Northwest Weathernet forecasts for specific interstate corridors, and satisfaction surveys completed by maintenance supervisors. | Transportation Research Board 80th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |
| WINTER STORM EVENT VOLUME IMPACT ANALYSIS USING MULTIPLE SOURCE ARCHIVED MONITORING DATA | Paper discusses how data from several information management systems in Iowa were used to analyze the volume impacts of winter storms. Analysis indicated that winter storms decrease traffic volumes by 29 percent on average (range from 16 percent to 47 percent). Analysis revealed a relationship between percent volume reduction and total snowfall, minimum average wind speed and the square of maximum wind gust speed. | Transportation Research Board 79th Annual Meeting, Search TRIS http://199.79.179.82/sundev/search.cfm |

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