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Maintenance Decision Support System (MDSS): Functional Specification Template and Procurement Guidance

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16. Abstract

This document is designed to provide guidance to state Department of Transportation (DOT) personnel preparing and evaluating specifications for weather forecasting services that include capabilities similar to those found in the Federal Highway Administration's (FHWA) prototype Maintenance Decision Support System (MDSS) and the Pooled Fund MDSS (PF-MDSS). This document includes:

a) Candidate functional requirements for MDSS products and services
b) Information that DOT personnel can use to evaluate prospective MDSS services
c) Questions that could be asked when interviewing prospective vendors

The main body of this document describes high-level functional requirements of MDSS products, data servers and display system. The appendices provide information that is designed to provide technical guidance to organizations planning to procure MDSS services.

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MAINTENANCE DECISION SUPPORT SYSTEM (MDSS): FUNCTIONAL SPECIFICATION TEMPLATE AND PROCUREMENT GUIDANCE

Final Report
July 2006

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1. PURPOSE

This document is designed to provide guidance to state Department of Transportation (DOT) personnel preparing and evaluating specifications for weather forecasting services that include capabilities similar to those found in the Federal Highway Administration's (FHWA) prototype Maintenance Decision Support System (MDSS) and the Pooled Fund MDSS (PF-MDSS). This document includes:

a) Candidate functional requirements for MDSS products and services
b) Information that DOT personnel can use to evaluate prospective MDSS services
c) Questions that could be asked when interviewing prospective vendors

2. SCOPE

The main body of this document describes high-level functional requirements of MDSS products, data servers and display system. The appendices provide information that is designed to provide technical guidance to organizations planning to procure MDSS services.

The MDSS functional requirements have been developed by analyzing user feedback collected to date for the MDSS and merging them with current scientific and engineering capabilities. The FHWA prototype MDSS, by design, does not include all the features and functions that a commercial MDSS should include. For example, a survey of personnel involved in the prototype demonstration indicated a desire to be able to view tactical information such as satellite and radar images of the local area, see contoured plots of predicted precipitation amounts and air temperature, and view NWS watches, warnings and advisories, etc. Because these are readily available from commercial weather service providers, they were not included in the prototype MDSS. Therefore, the person preparing a specification for road weather services should be aware of this limitation and augment the specification accordingly to include all the required capabilities while considering priorities and resource constraints.

The PF-MDSS is a partnership between several state DOTs and a commercial weather service provider (Meridian Environmental Technology) whereby several DOTs contribute funds toward the development of a commercial MDSS capability. The PF-MDSS was based on user requirements, technical components, and lessons learned from the FHWA prototype MDSS project. Because of its commercial nature, the PF-MDSS represents a more complete MDSS solution.

This document is not intended to be a turn-key MDSS procurement specification nor is it intended to specify specific design solutions. Nevertheless, to give the reader an idea of the design of the FHWA prototype products, several sample screen images are provided in Appendix A.

Each state DOT has different requirements, resources, and procurement guidelines; therefore, the information provided herein, where applicable, should be integrated into broader procurement specifications for the provision of road weather services. This document is designed to allow readers to cut and paste sections into a full specification for road weather services.

To support the procurement process for MDSS services, several recommendations are provided (see Appendix B) that summarize the pros and cons of the primary technical aspects of an MDSS system. In addition, a series of questions with desired answers were formulated that are designed to guide the procuring agency through the tender evaluation process. These are provided in Appendix C. One of the more difficult challenges of the tender specification preparation process is determining the evaluation criteria. This is particularly true for a system as complex as the MDSS where both weather prediction technologies and rules of practice algorithms are involved. Guidance for determining the evaluation criteria is provided in Appendix D.

3. DOCUMENT TERMINOLOGY

This document contains traceable requirements that are identified by “shall” statements and “goals”, which identify desirable capabilities.

The term **“**user selectable**”** means that the user can make a selection from the display user interface without altering the software or configuration files. The term **“**configurable**”** means the item can be altered by changing a configuration parameter(s) in a configuration file(s) and the change does not require modifications to the software source code. In a typical software system, only authorized personnel alter configuration files.

Italicized text indicates capabilities or requirements that are considered advanced and have the potential to increase the complexity of the MDSS (heretofore referred to as the System) and therefore the cost. They are highlighted to make them easy to identify and delete should the capability not be desired or required.

4. RELATED DOCUMENTS

For additional information on the MDSS Project, the reader is directed to related project documents listed in Table 1.

Table 1. Related documents

Document and/or Web Sites	Primary Source
STWDSR– Version 1.0 (User Needs Analysis): http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/9dc01!.pdf	Federal Highway Administration
STWDSR– MDSS Operational Concept Description (OCD): Version 2.0 http://www.itsdocs.fhwa.dot.gov/jpodocs/EDLBrow/401!.pdf	Federal Highway Administration
Maintenance Decision Support System (MDSS) Release-4.0 Technical Description, Version 1.1 Dated 13 February 2006: http://www.ral.ucar.edu/projects/rdwx_mdss/documents/MDSS_Tech_Description_13Feb06.pdf	National Center for Atmospheric Research
Maintenance Decision Support System (MDSS) Performance Assessment Report for 2004-2005 season: http://www.rap.ucar.edu/projects/rdwx_mdss/documents/MDSS_PAR_23Sep05_FINAL.pdf	National Center for Atmospheric Research
Maintenance Decision Support System (MDSS) Project Web Site at the FHWA: http://ops.fhwa.dot.gov/weather/mitigating_impacts/programs.htm#3	Federal Highway Administration
Maintenance Decision Support System (MDSS) Project Web Site at NCAR: http://www.rap.ucar.edu/projects/rdwx_mdss/index.html	National Center for Atmospheric Research

5. BACKGROUND

This MDSS Project is part of a federal procurement for research projects and deployment advocacy, which is funded through the USDOT Intelligent Transportation System (ITS) Joint Program Office (JPO).

Components of the prototype MDSS system developed by this project are now being further developed by commercial weather vendors, integrated with other operational components, and deployed by road operating agencies, including state DOTs. The manner in which the MDSS is being implemented throughout the country varies greatly due to the large variety of needs between DOTs and their general desire to ramp up the implementation schedule over a few seasons to give staff time to adapt to the technology and time for the vendors to configure the system to their road network.

Five national research centers have participated in the development of the prototype MDSS throughout the course of the project. The participating national research centers include:

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

NCAR has been the lead Laboratory for technical development.

6. SYSTEM REQUIREMENTS

The MDSS requirements described in this section are presented to provide guidance to state DOT personnel preparing specifications for weather forecasting services that include MDSS capabilities. This section was designed to allow DOTs to select the specific capabilities that they desire and paste them into their own Requests for Proposals (RFPs). Capabilities that are not desired can be ignored.

6.1 General System Requirements

The MDSS ("System") shall detect, diagnose, forecast, and display surface transportation weather phenomena, road condition information, and winter maintenance treatment recommendations (described herein) for supporting winter road maintenance operations (e.g., snow plowing, deicing, anti-icing, etc.).

The System shall include the capability to selectively archive data and display archived data and products. The System shall include the capability to routinely monitor the system status. The System shall be fault tolerant with high reliability. The System shall be designed in accordance with standard commercial practices for software development. The System shall be designed to make reasonable allowance for expansion of computing power. The System software shall be designed to ensure that it can run on commercial-off-the-shelf hardware commonly available in 2006; that is, no special hardware development will be necessary. The System shall be designed to ensure that it can incorporate weather and road data from disparate sources (e.g., National Weather Service (NWS), state DOTs, mesonetworks, etc.). The System (including all servers and displays) shall be synchronized using a time standard. The System shall include the capability to playback historical data for demonstration, training, and analysis purposes. To the greatest extent possible, the graphical user interface (GUI) design should be consistent with commonly available operating systems (e.g., Microsoft Windows, Linux). The System shall use Local Time (LT) for all displays.

The System displays shall be implemented in English with English units as the default setting. The System shall integrate environmental (weather), road condition and transportation operational data in a manner that allows it to provide predictions of pavement conditions (e.g., pavement temperature, precipitation accumulation, anti-icing chemical effectiveness, etc.) associated with winter road maintenance.

Using the pavement condition and environmental prediction information, the System shall provide decision support guidance to winter road maintenance practitioners and the guidance shall include information related to treatment options (e.g., plow, deice, anti-ice, etc.), timing of application, location of application, and amount of application) based on current and predicted weather conditions.

The System shall notify users when data updates (e.g., new forecasts) are available and the updates shall be loaded when the user selects to do so. The System shall allow the users to evaluate the results (outcome) of multiple treatment options. That is, it will provide a capability to allow the user to evaluate "What if?" scenarios.

6.2 MDSS Coverage Area

The System shall be designed to operate (via configurable files) in any user-defined region (e.g., state, city, county, etc.) that has input data necessary to support its operations. The System shall generate weather forecasts for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.). The System shall provide weather and road condition products (via configurable files) for road routes (maintenance routes) identified by the user. The System shall be configured to provide weather and road condition products for user identified road maintenance routes.

6.3 Weather Forecast Products

Weather forecast products refer to weather elements above the ground. Road condition forecast products are described in section 0. Weather forecast products shall be provided out to at least 48 hours. Weather forecast products shall have a temporal resolution of at least one hour. Weather forecast products shall be updated no less than every three hours; that is, a new 48-hour forecast shall be provided every three hours.

The following weather forecast products shall be provided:

a) Surface air temperature (2 meter AGL)
b) Surface dew point (2 meter AGL)
c) Surface relative humidity (2 meter AGL)
d) Surface wind speed & direction (2 meter AGL)
e) Surface wind gust (2 meter AGL)
f) Precipitation type (2 meter AGL)
g) Precipitation rate (2 meter AGL)
h) Snowfall accumulation (e.g., 3-hr total, 6-hr total, and total accumulation during the forecast period)
i) NWS watches, warnings and advisories

The weather forecast products shall be geo-referenced to the DOT domain using map overlays that include roads, road designators, political boundaries, etc.

6.3.1 Surface Air Temperature Forecast Product

The output (content) of the Surface Air Temperature Forecast Product on the display shall have the following characteristics:

a) The surface air temperature shall be provided in degrees Fahrenheit by default (Celsius output shall also be available as a configurable item).
b) Time series information (text and graphical formats) of the surface air temperature shall be provided.
c). Reference lines (configurable) associated with frequent thresholds (e.g., freezing) shall be provided.

6.3.2 Surface Dew Point Temperature Forecast Product

The output (content) of the Surface Dew Point Temperature Forecast Product on the display shall have the following characteristics:

a) The surface dew point temperature shall be provided in degrees Fahrenheit (Celsius output shall also be available as a configurable item).
b) Time series information (text and graphical formats) of the surface dew point temperature shall be provided.

6.3.3 Surface Relative Humidity Forecast Product

The output (content) of the Surface Relative Humidity Forecast Product on the display shall have the following characteristics:

a) The surface relative humidity shall be provided in percent (range 0-100%).
b) Time series information (text and graphical formats) of the surface relative humidity shall be provided.

6.3.4 Surface Wind Speed & Direction Forecast Product

The output (content) of the Surface Wind Speed & Direction Forecast Product on the display shall have the following characteristics:

a) The wind speed shall be provided in statute miles per hour by default (Kilometers per hour shall be available as a configurable item).
b) The wind direction shall be provided in degrees with respect to true north.
c) Time series information (text and graphical formats) of the wind speed and direction shall be provided.

6.3.5 Surface Wind Gust Forecast Product

The output (content) of the Surface Wind Gust Forecast Product on the display shall have the following characteristics:

a) The wind gust speed shall be provided in statute miles per hour. (Kilometers per hour shall be available as a configurable item.)
c) Time series information (text and graphical formats) of the wind gust speed shall be provided.

6.3.6 Conditional Probability of Precipitation Type Forecast Product

The conditional probability of precipitation type is a product that describes the probability that a particular precipitation type (e.g., rain, snow, freezing rain, etc.) will occur if there is any precipitation at all.

The Precipitation Type Forecast Product shall include the conditional probability of precipitation type. That is, the user shall be able to view the probability of each type of precipitation as well as the predominant type.

The output (content) of the Precipitation Type Forecast Product on the display shall have the following characteristics:

a) The precipitation type shall be provided for at least the following:
(i) Rain
(ii) Snow
(iii) Ice (e.g., freezing rain, sleet)
(iv) Mixed (rain, snow, ice)
b) The predominant precipitation type (the type that the model selects as the most likely kind that will occur) shall be identified.
c) Time series information (text and graphical formats) of the predominant precipitation type shall be provided.

6.3.7 Precipitation Rate Forecast Product

The output (content) of the Precipitation Rate Forecast Product on the display shall have the following characteristics:

a) The liquid equivalent precipitation rate shall be provided in inches per hour (to a precision of a hundredth of an inch). Millimeters per hour shall be provided as a configurable option.
b) The snowfall precipitation rate shall be provided in inches per hour (to a precision of a tenth of an inch). Millimeters per hour shall be provided as a configurable option.
c) Time series information (text and graphical formats) of the precipitation rate shall be provided.

6.3.8 Snowfall Accumulation Forecast Product

The Snowfall Accumulation Product shall indicate the amount of snow that is expected to reach the surface (ground) over a specified period. Melting of precipitation due to warm surface conditions is not considered in this product.

The output (content) of the Snowfall Accumulation Forecast Product on the display shall have the following characteristics:

a) The snowfall accumulation shall be provided in inches (to a precision of a tenth of an inch). Millimeters per hour shall be provided as a configurable option.
b) Time series information (text and graphical formats) of the snowfall accumulation shall be provided.
c) Snowfall accumulation shall be provided at user-defined temporal increments out to 48 hours (e.g., 3-hour, 6-hour, 12-hour accumulation, etc.).

6.4 Weather Observation Products

Weather observation products shall be provided by the System. The weather observations products shall be geo-referenced to the DOT domain using map overlays that include roads, road designators, political boundaries, etc.

Weather observation products shall include, but not be limited to, observations from the following sources:

a) NWS
b) DOT
c) FAA
d) Other sources as available

Weather observation products shall include the following parameters, where available:

a) Air temperature (degrees F as default and degrees Celsius – configurable)
b) Relative humidity (percent)
c) Dew point (degrees F as default and degrees Celsius - configurable)
d) Wind speed & wind direction (miles per hour & degrees with respect to true north). Kilometers per hour shall be provided as a configurable option.
e) Wind gust (statute miles per hour). Kilometers per hour shall be provided as a configurable option.
f) Visibility (statue miles). Kilometers per hour shall be provided as a configurable option.
g) Satellite Imagery (visible and IR)
h) Radar Imagery (intensity and storm total)
i) Solar Radiation (short and long wave in watts per square meter)

The weather observation products shall update as new data arrive. The output (content) of the weather observation products on the display shall have the following characteristics:

a) The surface observation data shall expire off the screen after a configurable number of minutes.
b) The expiration time shall be independently configurable for each observation product.
c) Time series (text and graphical formats) shall be provided.
d) Animation of the observations shall be provided.

6.4.1 Satellite Product

The satellite product shall be based on satellite data provided by the NOAA GOES series satellite system. The satellite product shall include visible and infrared channel data. The satellite product shall update as new data arrive.

The output (content) of the satellite product on the display shall have the following characteristics:

a) The visible image (VIS) shall be displayed.
b) The infrared (IR) image shall be displayed.
c) Satellite image domains shall be configurable. For example, imagery may be provided for the following domains:
i) CONUS
ii) Region (e.g., multiple States centered on primary State)
iii) State
iv) Local region (sub state size grid)
d) The satellite product shall include animation capabilities.

6.4.2 Radar Product

The radar product shall be based on WSR-88D data provided by NOAA. Other radar data sources may be used if applicable (e.g., FAA Terminal Doppler Weather Radar, local media owned radars). The radar product shall be based on the reflectivity (intensity) field. The radar product shall update as new data arrive.

The output (content) of the radar product on the display shall have the following characteristics:

a) The radar reflectivity (intensity) field shall be displayed (plus color legend).
b) Radar products shall be provided for user-defined domains. For example, domains may include:
i) Single site radar data needed to cover DOT domain.
ii) Mosaic for a regional image covering entire DOT domain plus a boundary (~100 miles) around the DOT domain.
c) The radar product shall include animation capability.
d) The storm (echo) motion shall be provided.
e) Precipitation type (diagnosis) shall be provided.
e) Other storm attribute information (e.g., hail potential) may be provided, where applicable.

6.4.3 NWS Watch, Warnings and Advisories Product

NWS watch, warnings and advisories for the DOT domain shall be provided.

The NWS watch, warnings and advisories shall include, but not be limited to:

a) Winter storm watches and warnings
b) Flood watches and warnings
c) Flash flood watches and warnings
d) Severe thunderstorm watches and warnings
e) Hurricane/Tropical Storm watches and warnings (also include high wind warning for inland hurricane/tropical storm force winds)
f) Tornado watches and warnings
g) Special marine warnings and marine weather statements
h) High wind watches and warnings
i) Special weather statement
j) Freeze watches and warnings
k) Winter weather advisories
l) Dense fog advisories
m) Snow advisories

The NWS watch, warning and advisory product shall be provided in text format. Graphical depictions of NWS watches and warnings may be provided, where applicable.

When an NWS watch, warning or advisory is in effect for an area (configurable) that covers the DOT domain, the display shall provide an indicator (e.g., highlighted button).

There is a goal to graphically highlight the watch and warning areas on the screen to make it

easier for the user to note the impacted geographical area.

6.5 Road Condition Observation Products

Road condition observation products shall be provided and shown on the display.

Road condition observation products may include, but not be limited to, observations or measurements from the following sources:

a) Environmental Surface Stations (ESS)
b) Road Weather Information Systems (RWIS)
Advanced Capabilities:
c) Other measurements that convey road conditions (e.g., GPS/Automated Vehicle Location (AVL)
d) Links to other information sources for road conditions (e.g., highway patrol)
e) Vehicle data

Road condition observation products shall include the following parameters, where available:

a) Road temperature (degrees F as default and degrees Celsius as configurable)
b) Subsurface temperature (degrees F as default and degrees Celsius as configurable)
c) Chemical concentration on road (percent by weight)
d) Freeze point temperature (degrees F as default and degrees Celsius as configurable)
e) Pavement condition as:
Wet
Dry
Chemically wet
d) Snow, frost, and ice depth (inches as default and millimeters as configurable)
e) Blowing snow (yes/no)
f) Visibility (miles or fractions of miles as default and kilometers or fractions of kilometers as configurable
g) Mobility (index from zero to one, where zero represents no mobility and one represents normal – dry road – mobility).

The road condition observation products shall update as new data arrive. The output (content) of the road condition observation products on the display shall have the following characteristics:

a) The surface observation data shall expire off the screen after a configurable number of minutes.
b) The expiration time shall be independently configurable for each observation product.
c) Viewing of the product shall be user selectable.
d) Time series (text or graphical formats) of the observations shall be provided.
e) Animations of the road condition products shall be provided.

6.6 Road Condition Prediction Products

The road condition prediction products shall be provided out to at least 48 hours. The road condition prediction products shall have a temporal resolution of at least one hour. The road condition prediction products shall be updated every three hours; that is, a new 48-hour forecast shall be provided no less than every three hours.

The following road condition prediction products shall be provided:

a) Road temperature
b) Road chemical concentration
c) Road mobility
d) Snow depth on road
e) Blowing snow potential
f) Pavement frost potential
g) Pavement condition

6.6.1 Road Temperature Prediction Product

The Road Temperature Prediction Product shall be provided at predefined (configurable) locations associated with each DOT maintenance route. The Road Temperature Prediction Product shall be based on a thermal energy balance model and/or empirically based model.

The output (content) of the Road Temperature Prediction Product on the display shall have the following characteristics:

a) The road temperature shall be provided in degrees F as default and degrees Celsius as configurable.
b) The road temperature shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
c) Time series information (text and graphical formats) shall be provided.

6.6.2 Chemical Concentration Prediction Product

The Chemical Concentration Prediction Product shall provide information on the evolution (dilution) of concentration after application of the following chemicals as selected by the user:

a) NaCl (sodium chloride or salt)
b) $MgCl_2$ (magnesium chloride)
c) $CaCl_2$ (calcium chloride)
d) Ca Mg Acetate
e) K Acetate
f) Commercial chemical blends (e.g., Caliber®, IceSlicer®, Ice Ban®, etc.)

The Chemical Concentration Prediction Product shall be provided at predefined (configurable) locations within each DOT maintenance route. The Chemical Concentration Prediction Product shall be based on models (algorithms) that calculate chemical dilution and eutectic properties of the named chemicals.

The output (content) of the Chemical Concentration Prediction Product on the display shall have the following characteristics:

a) The chemical concentration shall be provided in percent by weight.
b) The chemical concentration shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
c) Time series information of the chemical concentration shall be provided.

6.6.3 Road Snow Depth Prediction Product

The Road Snow Depth Prediction Product shall provide information that describes the amount of snow that is predicted to accumulate on a road surface without traffic and for specific winter maintenance treatments as defined in section 0.

Calculation of the Road Snow Depth Prediction Product shall take into account (at a minimum) the forecasted precipitation type and rate, and road temperature to estimate the amount of snow that will accumulate on the road surface.

The Snow Depth Prediction Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

Calculation of the Snow Depth Prediction Product shall take into account treatment options including the amount of snow expected to accumulate on the road when; a) no treatment is performed, b) the recommended treatment is performed, and c) a user-defined treatment is performed.

The output (content) of the Snow Depth Product on the display shall have the following characteristics:

a) The snow/ice amount shall be given in inches by default (to a tenth of an inch) and by centimeters if configured as such.
b) The snow depth shall be shown for various treatment options including: no treatment, recommended treatment, and user-defined treatment.
c) The road snow depth shall be presented graphically at each forecast location associated with the chosen (configurable) maintenance routes.
d) Time series information (text and graphical formats) of the road contamination accumulation shall be provided.

6.6.4 Blowing Snow Potential Product

The Blowing Snow Potential Product shall provide information that describes the likelihood for blowing snow (e.g., low, medium, high). Calculation of the Blowing Snow Potential Product shall take into account (at a minimum) recent snowfall characteristics, the forecasted precipitation type and rate, predicted wind speed, local topography, and predicted air temperature. The Blowing Snow Potential Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

The output (content) of the Blowing Snow Potential Product on the display shall have the following characteristics:

a) The likelihood value for blowing snow (e.g., low, medium, high or as a percentage) shall be provided.
b) Likelihood values shall be provided at hourly increments.
c) Likelihood values shall be provided for each road forecast segment (e.g., plow route).
d) Time series information (text and graphical formats) shall be provided.

6.6.5 Pavement Frost Potential Product

The Pavement Frost Potential Product shall provide information that describes the likelihood for frost on the pavement surface (road and/or bridges) (e.g., low, medium, high or as a percentage). Calculation of the Pavement Frost Potential Product shall take into account (at a minimum) predicted pavement temperature, predicted precipitation type and rate, predicted wind speed, predicted relative humidity (considerations of dew point/frost point), and predicted air temperature.

The Pavement Frost Potential Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

The output (content) of the Pavement Frost Potential Product on the display shall have the following characteristics:

a) The likelihood value for pavement frost (e.g., low, medium, high or as a percentage) shall be provided.
b) Likelihood values shall be provided at hourly increments.
c) Likelihood values shall be provided for each road forecast segment (e.g., plow route).
d) Time series information (text and graphical formats) shall be provided.

6.6.6 Road Mobility Prediction Product

The Road Mobility Prediction Product shall provide information that describes the overall degradation in service level of a road.

The Road Mobility Product shall be indexed between zero (0) and one (1) where zero indicates a road that is impassable due to heavy snow or loss of friction (no mobility) and one indicates dry pavement (nominal mobility), respectively.

The Road Mobility Prediction Product shall use a 2-wheel drive passenger sedan with multi-season (mud and snow) tires as a default reference vehicle for the mobility algorithm.

The Road Mobility Prediction Product shall be provided at predefined (configurable) locations associated with each DOT maintenance route.

The Road Mobility Prediction Product (algorithm) shall take into account the following factors:

a) Snow depth on road
b) Presence of ice
c) Presence of frost
d) Wetness of road

The output (content) of the Road Mobility Prediction Product on the display shall have the following characteristics:

a) The road mobility shall be given as a non-dimensional value (index) between zero and one.
b) The road mobility shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.

c) Time series information of the road mobility shall be provided and a reference level of service (LOS) (configurable) shall be plotted along with the mobility index.
d) The user shall be able to view multiple (time series) road mobility curves (user selectable) that indicate the results using different treatment options (e.g., no treatment, recommended treatment, and user-defined treatment).

6.6.7 Pavement Condition Prediction Product

The Pavement Condition Prediction Product shall provide information on the predicted state of the pavement and include:

a) Wet
b) Dry
c) Chemical wet
d) Percent coverage of snow and ice
e) Snow, frost, and ice depth (inches as default and millimeters as configurable)

The output (content) of the Pavement Condition Prediction Product on the display shall have the following characteristics:

a) The pavement condition shall be presented in text format indicating the pavement condition (e.g., wet, dry, chemical wet, etc.) for each road forecast location (e.g., plow routes).
b) Time series information shall be provided.

Calculation of the Pavement Condition Prediction Product shall take into account the pavement condition when; a) no treatment is performed, b) the recommended treatment is performed, and c) a user-defined treatment is performed.

6.7 Forecast Confidence Product

A measure of confidence shall be provided for the following weather forecast and road condition prediction products:

a) Snow accumulation
b) Precipitation type
c) Road temperature

The calculation of prediction confidence shall take into account recent statistical performance of each parameter and other appropriate metrics.

The output (content) of the Prediction Confidence Product on the display shall have the following characteristics:

a) The prediction confidence shall be given as a non-dimensional value (index) between zero and one, which could be mapped (configurable) to confidence values of “low”, “medium”, or “high” or as a percentage, or
b) Error statistics shall be calculated that reflect recent skill.
b) Time series information of the prediction confidence or error statistics shall be provided for the above-mentioned products.

6.8 Generation of Treatment Recommendation Predictions

The System shall provide treatment recommendation predictions for winter road maintenance at user defined (configurable) locations (e.g., plow routes).

The System shall provide treatment recommendation predictions out to no less than 24 hours into the future.

The winter maintenance rules of practice used in the System shall be based on the Manual of Practice for Effective Anti-Icing Program (http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm) and the new NCHRP report #526 - Snow & Ice Control: Guidelines for Materials and Methods (see: http://www4.trb.org/trb/onlinepubs.nsf), and be configurable, as necessary, to reflect local DOT practices.

Treatment recommendations shall include the following for each user defined route:

a) Recommended initial treatment start time
b) Recommended subsequent treatment start time
c) Recommended treatment type (e.g., chemical, abrasives, plow)
d) Recommended chemical type based on available chemicals as identified by the user (NaCl, MgCl2, CaCl2, etc.) and configured in the System
e) Recommended material rate (e.g., amount per lane mile)
f) Recommended pre-treatment type (solid or liquid), where applicable

The System shall have a capability to incorporate constraints (configurable) for each route so that irrelevant treatment recommendations are not provided. For example, the use of NaCl should not be recommended if the user does not use that chemical. Constraints may include:

a) Available materials (e.g., NaCl, $MgCl_2$, $CaCl_2$, abrasives etc.)
b) Application rate limits (based on truck spreading limits)
c) Route cycle limits (minimum turn around time to repeat treatments)

Treatment recommendations shall be calculated, to the greatest extent possible, using a combination of current observational data on the state of the roadway and predicted weather and road conditions.

Treatment recommendation calculations should consider, to the greatest extent possible, factors that impact treatment effectiveness (e.g., chemical scatter, splatter, traffic impacts, spreader characteristics, etc.).

Users shall have a capability to review and edit, if necessary, the initial state of road conditions for each route, and the System shall have the ability to utilize new initial conditions information when calculating subsequent treatment plans. Road initial state variables shall include, but are not limited to:

a) Road temperature
b) Snow depth on road
c) Chemical concentration (estimated residual chemical)

A time series of road condition data that correspond to the predicted treatment recommendations

shall be provided. The user shall be able to view the predicted road condition results based on the treatment recommendations. Time series data to be viewable for various treatment plans include:

a) Road temperature
b) Road snow depth
c) Road chemical concentration
d) Road mobility

6.9 System Alert Function

The System shall provide a capability to alert the user when specific data thresholds (configurable) have been exceeded. Users shall be able to query the System and view the information related to an alert.

The System shall indicate that an alert is active by one or more of the following methods:

a) Highlighting an alert button
b) Changing the color of an alert button
c) Flashing an alert button
d) Audible alert (finite series of beeps or tones)

Alerts shall be categorized into the following and a separate indicator shall be provided for each category:

a) Weather related alerts
b) Road condition related alerts
c) Treatment option related alerts

Advanced: The System shall include a capability to send e-mail notices or cell phone calls (to a configurable list of aliases) when specific alerts (configurable) are generated.

6.9.1 Tactical Alerts

Tactical Alerts shall be provided for user defined locations (e.g., winter maintenance routes). Tactical Alerts are defined as alerts for conditions that are occurring or expected to occur in the next 3 hours (configurable). Tactical Alerts may be based primarily on observational data or short-term extrapolations of observational data.

Tactical Alerts shall be provided for the following conditions, but are not limited to just these conditions:

a) When the road temperatures are expected to drop below freezing
b) When frozen precipitation (e.g., snow and ice) is imminent (timeframe configurable)
c) When road frost is present or imminent (timeframe configurable)
d) When fog is present

6.9.2 Forecast Based Alerts

Forecast Based Alerts shall be provided for user defined locations (e.g., winter maintenance routes). Forecast Based Alerts are defined as alerts for conditions that are occurring or expected

to occur in the next 48 hours (configurable). Forecast Based Alerts may be based on both observational data and predictions.

The System shall indicate an alert when the following conditions (configurable) are met or thresholds (configurable) are exceeded for specific forecast locations (configurable) for a specific forecast period (configurable):

a) When frozen precipitation (snow and/or ice) is predicted.
b) When precipitation of any type is predicted and the road temperature is predicted to be at or below freezing.
c) When the wind speed is predicted to be above a configurable threshold.
d) When there is a NWS watch, warning or advisory (configurable) in effect for a specific region (configurable) that may impact road conditions.
e) When mobility is predicted to be below a (configurable) threshold.
g) When the System recommends a treatment plan.

6.10 Display

The display shall have the following general capabilities:

a) Ability to view plan-view graphics
b) Ability to view time-series information
c) Animation
d) Time selection whereby the user can select the time period for data viewing
e) Print function
f) Alert function
g) Ability to review historical data (e.g., weather and road condition data, recommended and actual treatments) by selecting date and time of archived data
h) Ability to select viewing area (e.g., entire State, local routes, regional area, etc.)
i) Ability to select products for viewing
j) Ability to view current time
k) Help function
l) Ability to combine data on time series plots
m) Ability to configure data ranges (scale) for each time series plot
n) Ability to overlay and combine graphical products

6.10.1 Map Overlays

The System shall make it straightforward (e.g., via configuration files) to incorporate new map data.

Map overlays shall be available for the following:

a) Roads (State and local highways and secondary roads)
b) Road designators (e.g., route numbers, etc.)
c) Political boundaries (e.g., States, counties, maintenance zones, etc.)
d) Geographical features (e.g., lakes, rivers, streams, etc.)
e) Cities
f) DOT sites (e.g., garages, sheds, depots, etc.)
g) Road features (bridges, cuts, passes, plow segments, etc.)

h) Weather and road condition observation sites

6.10.2 Animation

The display animation function shall include the following features:

a) Ability to select stop and end times
b) Ability to adjust animation speed
c) Ability to select the number of animation frames

6.11 Data Archive and Historical Data Review

The System shall include a short and long-term data storage capability. The process of saving data shall not interfere with the normal operation of the System.

6.11.1 Short-Term Archive

The short-term archive shall consist of the latest seven (7) days of data. The oldest stored data shall be routinely (scrubbed) overwritten by new incoming data, such that the integrity of incoming data is preserved. Data in the short-term archive shall be stored to the local disk. Data within the short-term archive shall be viewable by selecting the date and time of interest from the display interface.

6.11.2 Long-Term Archive

The long-term archive shall consist of data sets specifically saved by the user. The long-term archive may utilize removable media (e.g., optical disks, tape, etc.) The System shall not delete (scrub) data within the long-term archive. The user shall have the capability to select the date, time, and filename for the long-term archive. The System shall provide a capability for the user to review data from the long-term archive. This review shall not interfere with the operation of the real-time system. This requirement could be met by having a separate System available to view data from the historical archive.

6.11.3 Historical Data Viewer

The system shall have a capability to view (recent) historical weather and road condition prediction products together with actual observational data to give the user an indication of the performance of the weather and road condition predictions.

Users shall have the ability to select any of the forecasts from the previous 24-hour period. For example, the user shall be able to select a forecast 6 hours previous and compare the predicted conditions to the actual conditions.

The following parameters shall be available for viewing:

a) Air temperature
b) Relative humidity or dew point
c) Windspeed

d) Pavement temperature

The product shall be displayed in either textual format (data table) and/or in time-series format.

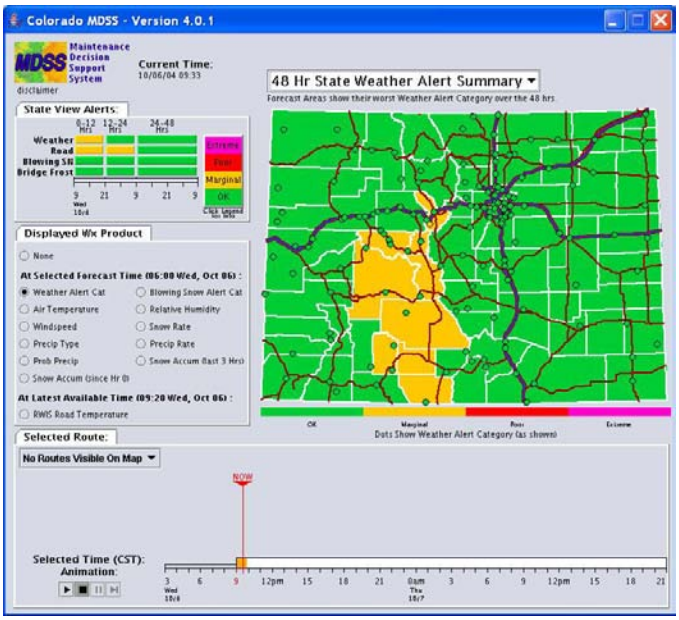
6.12 Security

Means shall be provided to prevent the unauthorized use or misuse of the facilities provided in the System. This particularly applies to those functions that can be used to reconfigure or change the operating status of the System or subsystems.

Security shall be provided (e.g., password protection) to ensure that the System cannot be accidentally disabled from any display device or network system.

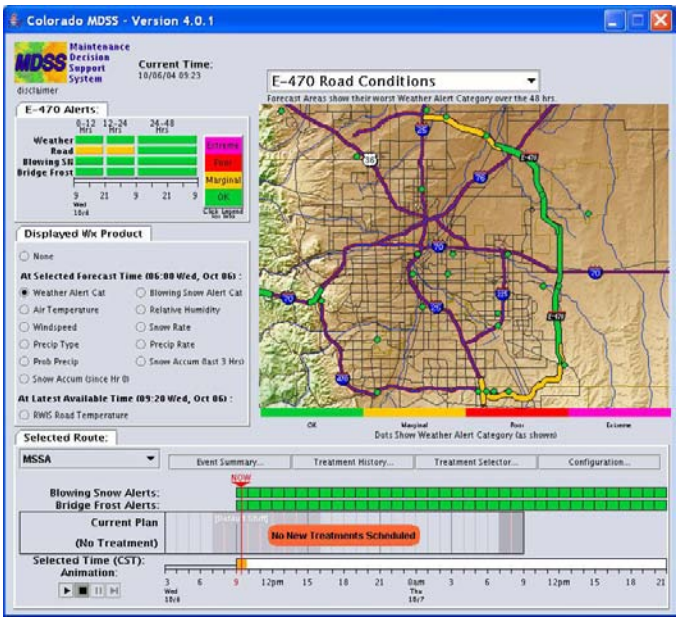
APPENDIX A:

Sample Screen Images from the FHWA Prototype



MDSS State View Page

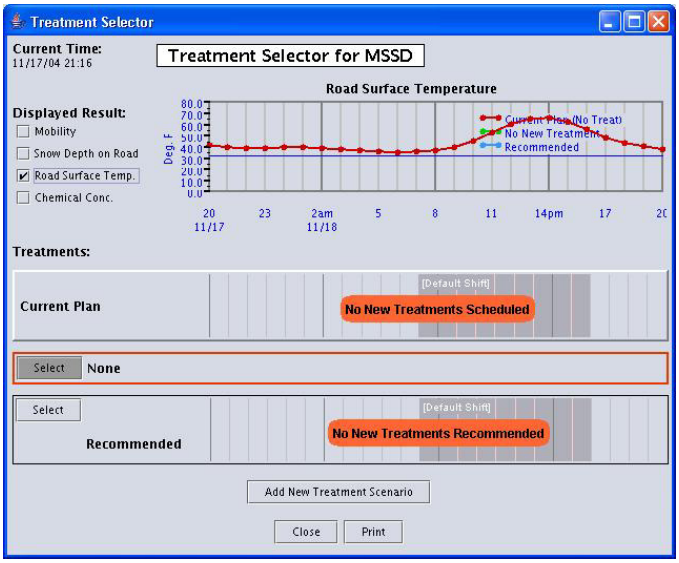
Provides a summary of weather and road condition information across a broad region. Users can animate through the forecast period to assess weather and road condition threats. Weather and road condition alerts are also provided when weather and road conditions threaten the region within the next 48 hrs.

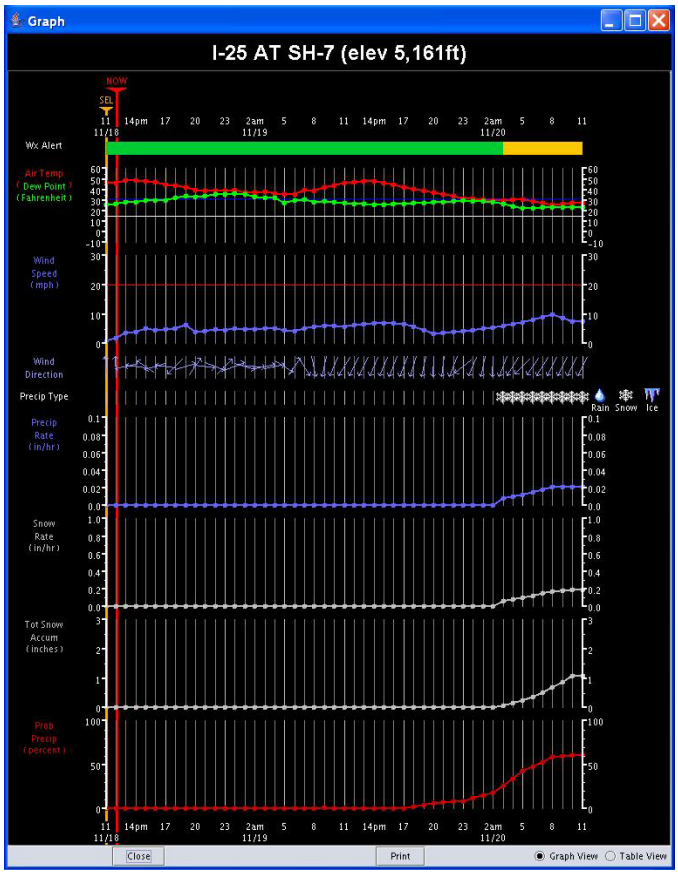


MDSS Route View Page

Provides a summary of weather and road condition information across a local region. Users can animate through the forecast period to assess weather and road condition threats. Weather and road condition alerts specific to the region are also provided when weather and road conditions threaten the region within the next 48 hrs.

Users can also view treatment recommendations from this page and perform "what if" scenarios.



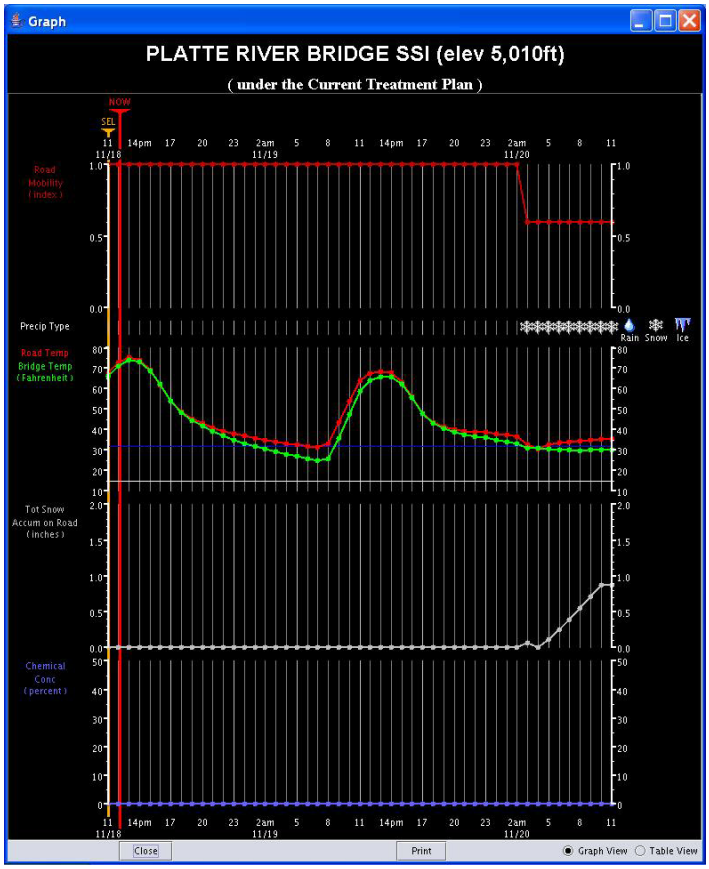


Treatment Selector Page

Allows user to view specific road condition prediction information for user selected routes. Users can view recommended treatment plans and perform “what if” scenarios and view alternate treatment plans.

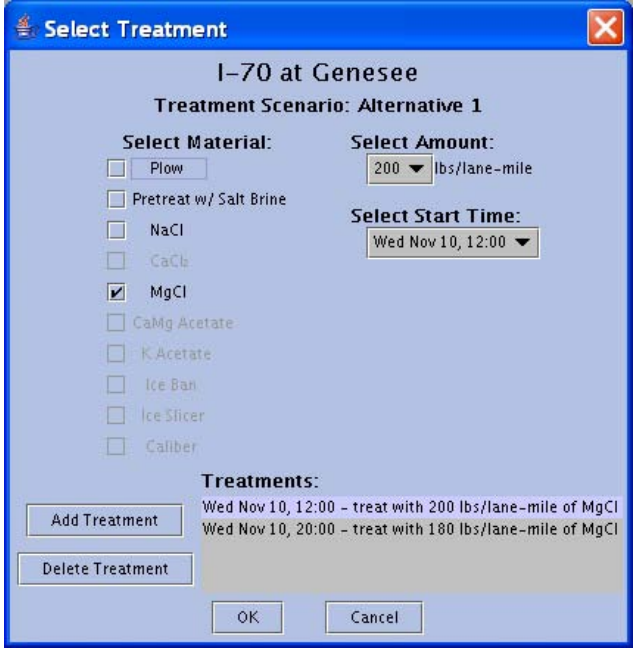
Weather Time Series

Users can view time series data of critical weather parameters over the 48-hr period for each route. Parameters include air temperature, wind speed and direction, snowfall rate, relative humidity, precipitation type, total snow accumulation, and probability of precipitation.



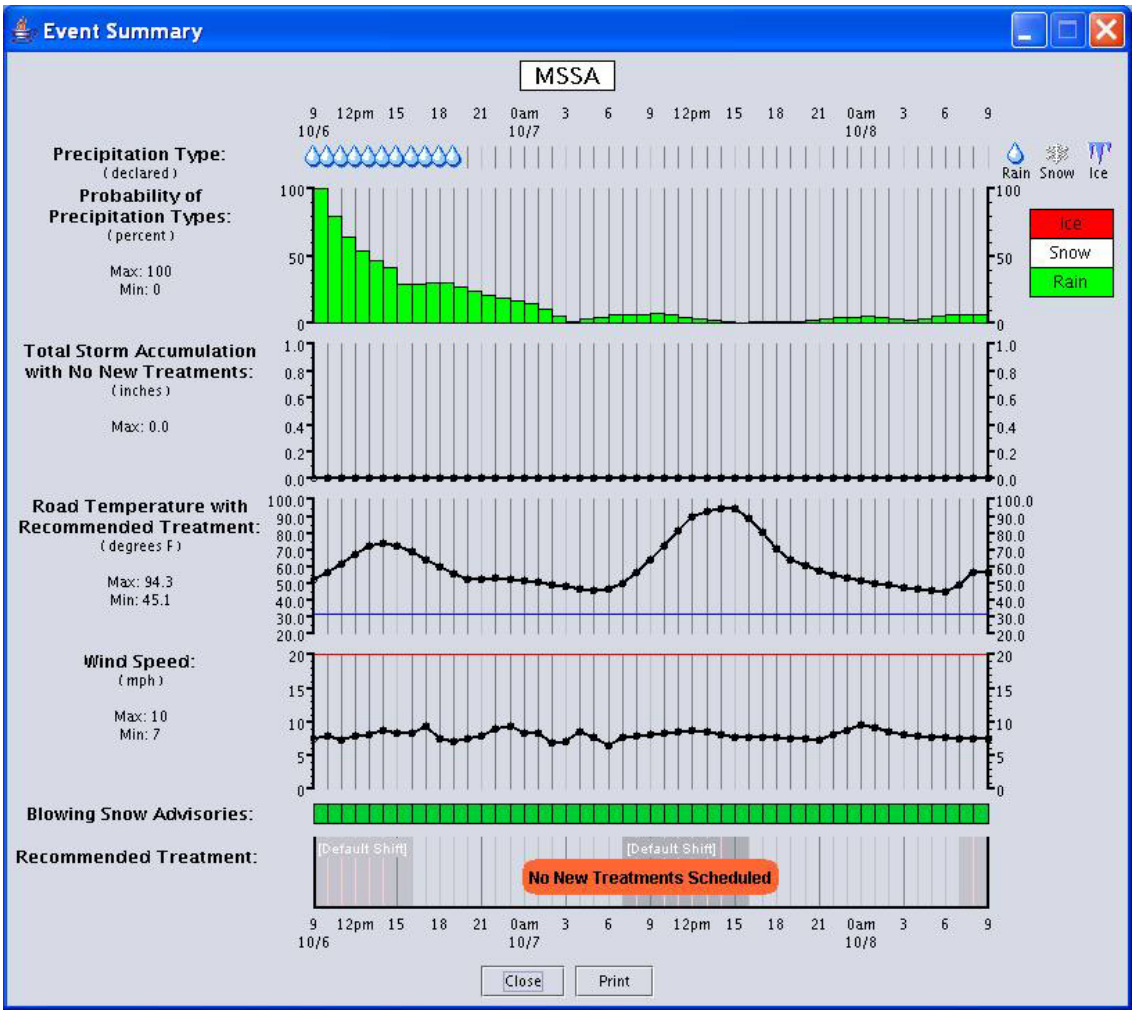
Road Condition Time Series

Users can view time series data of critical road condition parameters over the 48-hr period. Parameters include road temperature, mobility total snow accumulation on the road, and estimated chemical concentration based on selected treatment plans.



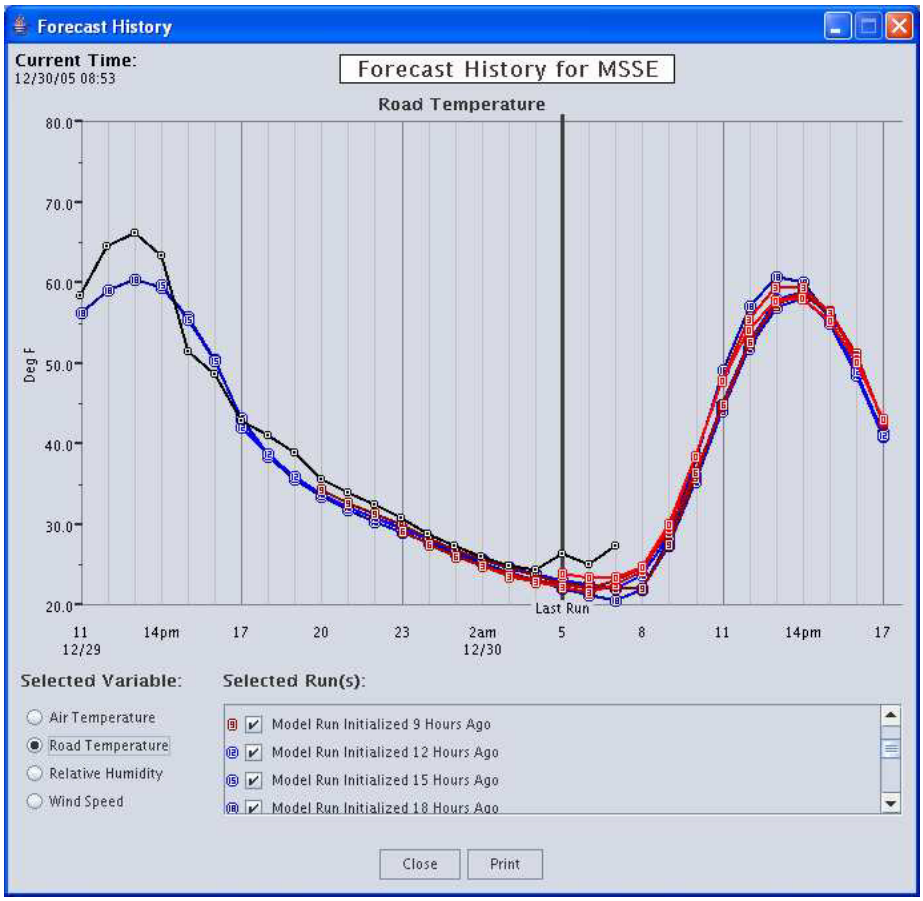
Alternative Treatment Page

This page allows users to input alternative treatments from the recommended treatments and view resulting road temperatures, snow accumulation, and chemical concentration. Users can select chemical types, application times and amounts.



Storm Summary Page

This page shows storm event summary data for each plow route in graphical form. Products include maximum and minimum predicted road temperatures, wind speed, and snow accumulation on the road (with no treatment). The probability of precipitation is also shown. It is divided into precipitation type categories to give the user an indication of how the precipitation will change over the course of the storm event. Periods when blowing snow are likely, are also provided.



Forecast History Page

This page allows users to view previous weather and road condition predictions for selected forecast periods and compare them to actual observations. The prototype is configured to allow users to compare air temperature, road temperature, relative humidity, and windspeed for user selected maintenance routes.

APPENDIX B:

Technical Considerations for Evaluating MDSS Services

1. Weather Forecasting Capabilities

Weather Model Selection: Predicting weather at road scales (few miles to tens of miles resolution) is pushing the limits of weather predictability. While weather forecast models are becoming more sophisticated, the ability to know the current state of the atmosphere in three dimensions around the earth and predict future conditions remains a significant challenge. The primary shortcoming is the lack of global atmospheric (surface and aloft) and earth surface condition observations at the resolutions required to support the new high resolution models. Model systems must make educated guesses about the state of the atmosphere between observations and in space and time.

Radar and global satellite data have great potential to improve the situation, but these data have only recently been incorporated into research models, so it will be a few years before they are fully incorporated into the operational models. Short-term forecasts (0-48 hours), have improved significantly over the last decade as operational and research weather models have improved, but the forecast skill drops significantly beyond 48 hours. Precipitation prediction remains one of the biggest challenges as very small perturbations in the atmosphere can make a very large difference in precipitation prediction. Forecast skill for precipitation has also improved in the last decade, but models still have difficulty with the timing and placement of precipitation events. Precipitation prediction skill falls after 6 hours, but there is forecast skill out to several days.
The availability of new and more frequent observations allows models to be run more frequently, which provides opportunities for more frequent forecast updates.

MDSS research has shown that predicting weather and road conditions requires weather data at hourly resolution to properly characterize rapidly changing conditions associated with sunrise, sunset, frontal passages, and precipitation episodes. Road temperature models are particularly sensitive to the solar cycle as road temperatures rise and fall quickly at dawn and dusk, respectively. The temporal resolution of weather model data provided by the NWS is only three hours. Therefore, anyone using the standard NWS models will only be able to provide forecast information at this resolution. They may interpolate to hourly resolution, but the true resolution will remain three hours.

Recommendation 1

In general, weather and road condition forecasts and the characterization of the event (e.g., short or long event, intermittent precipitation, heavy or light precipitation etc.) will be more accurate when they are based on high temporal and spatial resolution models; therefore it is recommended that vendors providing MDSS services utilize high resolution models with the following characteristics:

Temporal resolution: Hourly data out to at least 24 hours; 3 hourly or more

	frequent beyond 24 hours
Spatial resolution:	20 km (~12 miles) or less (10 km is preferred)
Update rate:	6 hours or less (3 hours is preferred)

Vendors that operate their own weather prediction models tend to have better performance as they have the flexibility to modify model characteristics (e.g., domain size, update rate, resolution, physics packages, etc.) to optimize the systems for specific applications. For example, models can be tuned for winter precipitation.

It is well known in the weather community that different weather models have different skill at predicting the weather. For example, some models are better at temperature, while others are better at precipitation. Some may be better at summer precipitation (thunderstorms), while others are better at winter storms. If multiple models are used and the data are intelligently blended (called ensembles), there is a higher probability that the overall forecast will be improved over either of the individual models.

Recommendation 2

Vendors supplying road weather services have a better opportunity to provide more accurate forecasts if they utilize more than one weather model; therefore this capability should be considered positively.

Model Post Processing: Post processing of model data generally involves applying statistical techniques to forecast data that improve the accuracy of the predictions by taking advantage of observations. For example, local terrain characteristics, which are not typically captured by weather models, may systematically influence wind and temperatures near a road corridor. If an observation system (e.g., RWIS, NWS observation, etc.) was located along the route, data from the RWIS could be used to correct or tune the model data. Applying statistical corrections will, in general, improve the forecasts.

Recommendation 3

In general, weather and road condition forecasts will be more accurate when statistical techniques are applied based on actual local weather and road condition observations. Vendors supplying road weather services should utilize local observations and apply post processing methods.

Advanced Data Assimilation: Operational NWS models have always begun with a “dry” atmosphere. That means they do not contain any clouds or precipitation at the initial time even though there may be clouds and storm systems in progress. Until recently, no techniques were available to integrate radar and satellite directly into weather models. Current operational weather models generate their own clouds and precipitation and this typically takes 2-3 forecast hours. This process is called the “spin up” time. This limits model skill for the first several hours of the forecast period.

The term “hot start” or “observational nudging” refers to model initialization methods that provide weather models with a starting point that includes clouds and precipitation based on

actual observations. These new advanced data assimilation techniques show significant promise in improving the prediction of precipitation (start, end, type and rate), particularly in the first 6 hours of the forecast period.

Recommendation 4

Advanced data assimilation methods are new and are not yet widely used by the NWS or the commercial weather service community. Because advanced data assimilation techniques do improve forecasts, particularly in the first 6 hours of the forecast period, vendors that utilize these techniques should get extra consideration.

Land Surface Modeling: The characteristic of the land surface makes a large difference in the weather, particularly near the ground in the atmospheric boundary layer, which is loosely defined as the lowest part of the atmosphere where surface friction influences atmospheric thermodynamics and motion. In the last five years, the weather modeling community has made significant strides in characterizing the land surface and coupling the surface characteristic data to the weather models. Surface conditions that influence the weather include soil moisture and temperature, vegetation type, vegetation greenness fraction, terrain, lake or sea surface temperatures, snow cover, etc. It is well known by many that a moist or snow covered surface will impact daily high temperatures and the likelihood for frost or fog. Operational weather models have traditionally been initialized with climatological (average) surface condition data. That means that if at a certain time of year the ground is free of snow on average, traditional models will assume that condition as they initialize even though there may actually be snow on the ground. This lack of knowledge of the true condition can lead to forecast errors.

This limitation is now being addressed in both research and operational weather models. The NWS and other research models (e.g., WRF) have started to utilize land characteristic data analyzed on a daily basis. In addition, research models are now coupled with land surface models so that the predicted impact of the weather on the surface can be accounted for. These capabilities are still evolving and will take several years to become fully operational at the NWS, but they are now being utilized in research models.

Recommendation 5

Research indicates that weather forecast models that take advantage of current land surface characterization data in their initialization process produce better forecasts than those that use average conditions. Weather service vendors that utilize this model initialization technique should be given extra consideration.

Human versus Fully Automatic Forecast Generation: Great advances in weather modeling, data assimilation, and data post processing have occurred in the last decade; however, there are times, particularly during extreme or rare events, when human forecasters can add significant value to a forecast. This is particularly true in the first 6 hours of the forecast period when the forecaster can compare model results with observations and fine tune the forecast.

Recommendation 6

Vendors that utilize human forecasters to quality control and fine tune weather and road condition forecasts should get extra consideration.

2. Road Temperature Forecasting Capabilities

Numerous road temperature models have been developed and are utilized by the road weather community. Some of the models have been developed openly at universities and national labs, while others have been developed by the private sector and are proprietary. The majority of the models used operationally are heat balance models that predict the temperature profile from the pavement surface down several feet into the subsurface layer. The major differences are in how the models handle precipitation, snow and ice accumulation, and subsurface moisture. There is no simple way of judging the skill between the models, as there has not been any comprehensive scientific review of the available models, primarily due to the proprietary nature of the models used by the commercial weather services. A review of the literature suggests that, in general, the models' performance is similar when given similar weather and road characteristic data.

The best ways to improve road temperature predictions are to: 1) provide the road temperature model with more accurate weather data, and 2) ensure that the model includes accurate road characteristic data. Recommendations for improving weather forecasts were discussed above. The next most important factor is the road characteristic data. Accurate data about pavement type and depth and subsurface type and depth should be part of the road temperature model configuration. Some vendors use "generic" road characteristics for their road temperature model while others incorporate actual "as-built" data.

Another research result from the MDSS project is that the road temperature models utilizing direct and indirect solar radiation data directly from the weather models perform better than models that use cloud coverage data from weather models and then derive direct and indirect solar radiation.

Recommendation 7

Road temperature prediction models should be configured to utilize road characteristic data (a.k.a., as-built data) specific to each road temperature forecast site (e.g. route). In addition, road temperature models should utilize solar radiation data output from the weather models rather than having the pavement heat balance models derive insolation from cloud field data.

3. Rules of Practice

It is well known that there is no "one-size-fits-all" Rules of Practice for effective winter maintenance due to local regulations, historical practice, and policies; however, there are some well documented strategies that are based, on chemistry and physics and these considerations are well captured by the most common references, namely:

- Manual of Practice for Effective Anti-Icing Program

  http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm

- NCHRP report #526 - Snow & Ice Control: Guidelines for Materials and Methods.

  http://www4.trb.org/trb/onlinepubs.nsf

The coded Rules of Practice used in the prototype MDSS started with logic described in the Manual of Practice for Effective Anti-Icing Program and was augmented based on experiences gained during the course of the MDSS project. These documents provide the basic framework and should be the foundation for commercial MDSS systems.

Another consideration is the flexibility of the rules across the DOT operation. Rules of Practice can vary between States, garages, and routes. It is important that the rules be configurable on a route-by-route or at least garage-by-garage basis.

Recommendation 8

Commercial MDSS systems should base their Rules of Practices on the FHWA *Manual of Practice for Effective Anti-Icing Program* and/or NCHRP report #526 - *Snow & Ice Control: Guidelines for Materials and Methods* or derivatives thereof. Flexibility to extend the Rules of Practice and tailor them for specific users is desired. The Rules of Practice code should be flexible enough to be configured on a route-by-route basis.

4. Generation of Treatment Recommendations

An important feature of the MDSS system is the capability to automatically generate treatment recommendations. This will allow the users to generated treatment recommendations for various user-defined treatment scenarios ("what-ifs"). The system should also take into account the actual treatments performed so that it can properly characterize the road conditions before generating the next set of recommendations. A capability to automatically ingest the actual treatments is desired, but few DOTs have the capability to download, process, and archive the actual treatments from the maintenance vehicles in real time. Additional research is required to determine the best methods and techniques for including vehicle-based data as this capability holds great promise because it will reduce or eliminate the workload associated with entering the data by hand. This capability may be more common in the future, so future MDSS systems should be designed to take advantage of this database.

The MDSS system should also have a feature that allows users to manually 'clear' the roads of snow and ice off specific routes. This is important because if the actual treatments have to be entered manually, it is easy to fall behind, particularly during intense storms. At the end of the storm when the roads are clear, the MDSS may not 'know' that treatments were performed and it will continue to recommend additional treatments.

Recommendation 9

MDSS specifications should include the following capabilities:

a) Automated generation of treatment recommendations
b) Ability to generate user-defined treatment recommendations
c) Ability to utilize actual treatment data either manually entered or automatically from vehicles
d) Ability to manually ‘reset’ or ‘clear’ the roads of snow and ice

APPENDIX C:

Questions to ask to prospective MDSS providers

Weather Forecasting Systems

Item	Question	Desired Answer
1	What is the true temporal resolution of the weather model(s) that are used to generate the forecasts?	Hourly out to at least 24 hours
2	What is the true spatial resolution of the weather model(s) that are used to generate the forecasts?	20 km (~12 miles) or less (10 km is preferred)
3	Do you run your own models or do you rely solely on the NWS models?	Run own model(s) as well as use NWS models
4	Do you take advantage of local surface observations in a manner that improves your forecasts (i.e., post processing methods)?	Yes, use them to adjust (tune) the forecasts
5	What is the update rate of your forecast system? How often will we get a new forecast?	At least once every 6 hours. Every 3 hours is desired.
6	Do you rely on a single weather model or blend (ensemble) multiple models to generate the forecasts?	Multiple models are blended to generate the forecasts
7	Do your models utilize advanced data assimilation techniques (e.g., observational data nudging – "hot start", variational analysis, etc.) that handle clouds and precipitation data fields in the model initialization process or does the proposed weather model start out "dry" (without clouds and precipitation.	A "hot start" capability is desired as it will improve the forecasts of cloud and precipitation in the first 6 hours of the forecast period.
8	Does your forecast process include a "human-in-the-loop" that can quality control and refine the forecasts when actual conditions deviate from the forecasted conditions?	A human forecasting element is desired.
9	Does your MDSS solution include a capability to compare recent forecasts and observations?	This capability is desired as it provides a real-time indication of prediction skill.

Road Temperature Prediction

Item	Question	Desired Answer
1	Do you configure your system to utilize "as-built" data for each road segment or is a generic road construction profile used?	As-built data are used for each road temperature forecast location
2	Where does the road temperature model get its solar (short and long wave) radiation data?	Solar radiation data are taken directly from the weather models
3	Are RWIS data used to initialize the pavement temperature model at each update time?	Actual pavement surface and subsurface data should be used in the pavement temperature model initialization process; otherwise the model solution may drift.
4	Does the pavement temperature model have the ability to handle snow and ice layers?	Some pavement temperature models do not create snow and ice layers and convert frozen precipitation to liquid. This is a simplification that assumes that winter maintenance actions are sufficient to keep the pavement clear. This can lead to errors if the pavement is not instantaneously cleared during precipitation events.

Rules of Practice

Item	Question	Desired Answer
1	What are the rules of practice based on?	FHWA *Manual of Practice for Effective Anti-Icing Program* and/or NCHRP report #526 - *Snow & Ice Control: Guidelines for Materials and Methods*
2	Can the rules be tailored for our specific operation?	Yes
3	Can the rules be tailored on a route-by-route basis or garage-by-garage basis?	Yes
4	Do the rules of practice take into account the effects of traffic?	Yes (but impact not well documented)
5	What chemicals are supported by the system?	The supported chemicals should cover the chemicals used by the

		DOT.
6	How does the system deal with blowing snow?	At a minimum, the system should provide an indicator of potential blowing snow conditions for each hour of the forecast period. A desired feature is to have the system adjust the treatment recommendations when blowing snow conditions are likely.
7	Is pavement frost handled by the system, and if so, how is it handled?	At a minimum, the system should provide an indicator of the potential for road and/or bridge frost conditions for each hour of the forecast period.

Generation of Treatment Recommendations

Item	Question	Desired Answer
1	Does the system automatically generate treatment recommendations?	Yes
3	Does the system have the ability to generate user-defined treatment recommendations (“what ifs”)?	Yes
	Does the system have the ability to utilize actual treatment data?	Yes
4	Can the user manually ‘reset’ or ‘clear’ the roads of snow and ice after a storm?	Yes

Alert Functionality

Item	Question	Desired Answer
1	Does the system automatically generate alerts for when user-defined thresholds are exceeded?	Yes
3	Does the system have the capability to provide the alerts via e-mail, telephone, or other means?	Yes

APPENDIX D:

Guidance for Determining the Evaluation Criteria

The process used to determine the evaluation criteria and scoring weights for tender responses is subjective and generally based on the importance given to each major element of the tender. Each agency's tender will include different components, so there is no one-size-fits-all answer for selecting criteria and setting scoring weights. The scoring process usually includes technical aspects of the proposed solution as well as criteria designed to reflect other aspects of a tender response such as the responder's ability to perform the work, experience, staff qualifications, etc. The guidance presented herein, only covers the technical aspects of the proposed solution.

In this appendix, a generalized set of criteria are presented along with scoring weights that reflect the relative importance of the selected criteria. Because the MDSS relies heavily on accurate weather forecasts as input, the proposed technical components that contribute to the weather forecast process and current weather presentation are given the most weight. Other aspects of the MDSS system, although important, are given less weight. As mentioned previously, the evaluation criteria and scoring weights must be tuned for each tender and reflect the specific requirements of the tender.

Item	Weather Forecasting Process & Presentation Component	Weight (100 total)
1	Human forecaster in the forecasting process	25
2	Utilization of mesoscale model data with hourly temporal resolution and grid spacing of 20 km or finer	15
3	Utilization of a data assimilation process that utilizes relevant observations (e.g., radar, RWIS, satellite data, etc.)	15
4	Forecast verification efforts – Can recent results or lessons learned be incorporated into the forecasting process to improve future output?	15
5	Utilization of multiple forecast members (ensemble of models, datasets, etc.) and the ability to generate a consensus-optimized forecast	10
6	Ability for users to compare predictions and actual observations in near real time	10
7	Latency period for processing DOT data and generating forecasts	10

Item	Road Condition Prediction Process Component	Weight (100 total)
1	Actual road construction data (as built data) utilized in pavement temperature model	40
2	Pavement temperature observations are used to initialize pavement temperature model.	35
3	Pavement model able to handle snow and ice layers	25

Item	Rules of Practice Component	Weight (100 total)

1	Rules of practice based on the FHWA *Manual of Practice for Effective Anti-Icing Program* and/or NCHRP report #526 - *Snow & Ice Control: Guidelines for Materials and Methods*	25
2	Ability to tailor the rules for the sponsoring agency	20
3	Mechanism used to utilize actual treatment data (manual data entry, GPS/AVL, etc.)	20
4	Ability to process user-defined treatment scenarios	15
5	Ability to add additional chemical formulations	10
6	Ability to clear or reset the road conditions based on actual conditions	10