

Maintenance Decision Support System (MDSS)
Functional Prototype Development Project
FUNCTIONAL REQUIREMENTS DOCUMENT



Working Document

DRAFT: Version 0.2

22 January 2003

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Prepared for

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Version Notes

Version 0.0 (4 January 2002): Internal document version – rough draft.

Version 0.1 (6 March 2002): Revisions made by first internal review.

Version 0.2 (22 January 2002): Made minor revisions to reflect the current understanding user desires. This version is still not complete, that is there are additional features and functions that have been identified by the users that have not been captured herein. It should be noted that the MDSS FP does not include all the capabilities described in this document.

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Acronym Glossary

AGL – Above Ground Level
CRREL – U.S. Army Cold Regions Research and Engineering Laboratory
DOT - Department of Transportation
DSS – Decision Support System
ESRI – Environmental Systems Research Institute
ETL – NOAA, Environmental Technology Laboratory
FAA – Federal Aviation Administration
FHWA – Federal Highways Weather Association
FP – Functional Prototype
FSL – NOAA, Forecast Systems Laboratory
GUI – Graphical User Interface
HOTO - Office of Transportation Operations
IOC – Initial Operating Capability
LDADS – Local Data Acquisition and Dissemination System
MDSS - Maintenance Decision Support System
MDSS FP – Maintenance Decision Support System Functional Prototype
MIT/LL - Massachusetts Institute of Technology - Lincoln Laboratory
MOS – Model Output Statistics
NCEP - National Center for Environmental Prediction
NSF – National Science Foundation
NSSL – NOAA, National Severe Storms Laboratory
NOAA – National Oceanic and Atmospheric Administration
NCAR - National Center for Atmospheric Research
NWS – National Weather Service
OCD – Operational Concepts Description
RWFS – Road Weather Forecast System
RWMP - Road Weather Management Program
STWDSR - Surface Transportation Weather Decision Support Requirements
VAMS - Value Added Meteorological Services
WIST-DSS - Weather Information for Surface Transportation Decision Support System

1. Scope

In this document, the functional requirements for the Functional Prototype Maintenance Decision Support System (MDSS FP) are presented. This document describes the high-level functional requirements of the MDSS FP products, data servers and display system. The functional requirements have been developed by analyzing user feedback collected to date for the MDSS and merging them with current scientific and engineering capabilities.

Early versions of this document are intended for use by the MDSS development team (Labs). Frequent and perhaps significant changes in this document are expected over the course of development of the MDSS FP.

Some items described herein may not be implemented in the MDSS FP due to priorities and resource constraints. In addition, the MDSS FP software may contain additional features and functions that are not necessarily described in this document. This document was developed early in the development of the FP; therefore, it may not fully capture all the features and functions that will ultimately be part of the MDSS FP. In addition, it should be noted that the MDSS FP does not contain all the capabilities of a fully operational MDSS, which may be developed in the future by the VAMS. For example, the users expressed a desire to be able to view satellite and radar images of the local area, see contoured plots of predicted precipitation amounts, air temperature, and view NWS watches and warnings etc. Because these are readily available from the private sector, they were not included in the MDSS prototype since the Labs needed to focus their resources on new capabilities.

2. Document Terminology

This document contains traceable requirements that are identified by “shall” statements, “goals”, which identify desirable capabilities, and requirements that are levied against others that are identified by “will” type statements, and other explanatory information.

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 changed by changing a configuration parameter(s) in a configuration file(s) and the change does not require changes to the software source code. Only authorized personnel can reconfigure the system software. When configuration parameters are changed, the software processes involved in the change will need to be restarted, resulting in a few minutes of downtime for the processes involved.

3. 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
Presentations and documents for the Surface Transportation Weather Decision Support Requirements (STWDSR) Project: http://www.mitretek.org/its/stwdsrt/	Mitretek Systems, Inc.
STWDSR– Version 1.0 (Needs Analysis) http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/9dc01!.pdf	Federal Highway Administration
STWDSR– Operational Concept Description (OCD) Version 2.0 http://www.itsdocs.fhwa.dot.gov/jpodocs/EDLBrow/401!.pdf	Federal Highway Administration
STWDSR--Preliminary Interface Requirements (PIR), Version 2.0 http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@701!.pdf	Federal Highway Administration
Maintenance Decision Support System (MDSS) Project Prototype Development Plan, Abridged Version, 11 June 2001. http://www.rap.ucar.edu/projects/rdwx_mdss/mdss-plan-fy2001.pdf	National Center for Atmospheric Research
Maintenance Decision Support System (MDSS) Project Functional Prototype Development Plan For Fiscal Year 2002. Dated 3 August 2001. http://www.rap.ucar.edu/projects/rdwx_mdss/mdss-plan-fy2002.pdf	National Center for Atmospheric Research
Maintenance Decision Support System (MDSS) Technical Description – 5 November 2002 http://www.rap.ucar.edu/projects/rdwx_mdss/documents/index.html	National Center for Atmospheric Research

4. Background

This MDSS Project is part of a federal procurement for FY2001 and FY2002 research projects and deployment advocacy, which is funded through the Intelligent Transportation System (ITS) Joint Project Office (JPO) of the FHWA. The project Agreement Officer's Technical Representative (AOTR) is Rudy Persaud, FHWA Office of Operations Research and Development (HRDO).

It is envisioned that components of the prototype MDSS system developed by this project will be further developed, integrated with other operational components, and deployed by road operating agencies, including state departments of transportation (DOTs), and generally supplied by private vendors (often called Value Added Meteorological Services or VAMS).

Five national research centers are participating in the development of the MDSS FP. The participating national labs 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 Forecast Systems Laboratory (FSL)

The lead Laboratory for technical development is NCAR.

5. System Requirements

5.1 General System Requirements

5.1.1 The MDSS FP (“System”) shall be a software system for detection/diagnosis, forecast, quantification and display of specific surface transportation weather phenomena (described herein) and road condition information (described herein) for supporting winter road maintenance operations (e.g., snow plowing, deicing, anti-icing, etc.).

5.1.2 The System shall include the capability to selectively archive data and display archived data and products.

5.1.3 The System shall include the capability to routinely monitor the system status.

5.1.4 The System shall be a fault tolerant system with high reliability.

5.1.5 The System will be designed in accordance with standard commercial practices for software development, tailored for a prototype capability.

5.1.6 The System shall be designed to make reasonable allowance for expansion of computing power.

5.1.7 The System software shall be designed to ensure that it can run on commercial-off-the-shelf hardware commonly available in 2002; that is no special hardware development will be necessary.

5.1.8 The System shall be designed to ensure that it can incorporate weather and road data from disparate sources (e.g., NWS, DOTs, VAMS, mesonetworks, etc.).

5.1.9 The System (including all servers and displays) shall be synchronized using a time standard.

5.1.10 The System shall include the capability to playback historical data for demonstration and analysis purposes.

5.1.11 To the greatest extent possible, the GUI design should be consistent with commonly available interfaces (e.g., MS Windows).

5.1.12 The System shall use Local Time (LT) for all displays.

5.1.13 The System displays shall be implemented in English.

5.1.14 The System shall integrate environmental (weather), road condition and transportation operational data in a manner that allow it to provide predictions of road conditions (e.g., road

temperature, precipitation accumulation, anti-icing chemical effectiveness, etc.) associated with winter road maintenance.

5.1.15 Using the road 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.

5.1.16 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.

5.2 MDSS FP Coverage Area

5.2.1 The System shall be designed to operate (via configuration) in any user-defined region that has input data necessary for it to operate

5.2.2 The System shall provide a single consensus weather forecast or outlook for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.).

5.2.3 The System shall provide weather and road condition products (via configuration) for road routes (maintenance routes) identified by the user.

5.2.4 The System shall be configured for to provide weather and road condition products for user identified road maintenance routes throughout the State.

5.3 Weather Forecast Products

5.3.1 Weather forecast products shall be provided out to at least 48 hours unless otherwise noted in this document. [The user shall be able to view a 48 hour forecast.]

5.3.2 The following weather forecast products shall be provided:

- a) Surface air temperature (3 meter AGL)
- b) Surface Dew Point
- c) Surface Relative Humidity
- d) Surface Wind Speed & Direction
- e) Precipitation Type (predominant type if multiple types forecasted)
- f) Conditional Probability of Precipitation Type
- g) Precipitation Rate
- h) Snow Accumulation (e.g., 3 hr total, 6 hr total, 12 hr total)
- i) NWS watches and warnings

5.3.3 Surface Air Temperature Forecast Product

5.3.3.1 The Surface Air Temperature Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route

5.3.3.2 The update rate and forecast period associated with the Surface Air Temperature Forecast Product shall be 3 hours and 48 hours, respectively.

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

- a) The surface air temperature shall be provided in degrees Fahrenheit.
- b) The surface air temperature shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The surface air temperature shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the surface air temperature shall be provided.
- e) The prediction confidence (Ref. Section 5.7) corresponding to the product shall be available for viewing (user selectable) as part of the time series view.
- f) The time period of interest (forecast time) shall be user selectable using a time bar.
- g) A legend corresponding to the color-coded values of the surface air temperature shall be provided.

5.3.4 Surface Dew Point Temperature Forecast Product

5.3.4.1 The Surface Dew Point Temperature Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.4.2 The update rate and forecast period associated with the Surface Dew Point Temperature Forecast Product shall be 3 hours and 48 hours, respectively.

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

- a) The surface dew point temperature shall be provided in degrees Fahrenheit.
- b) The surface dew point temperature shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The surface dew point temperature shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the surface dew point temperature shall be provided.
- e) The prediction confidence (Ref. Section 5.7) corresponding to the product shall be available for viewing (user selectable) as part of the time series view.
- f) The time period of interest (forecast time) shall be user selectable.

g) A legend corresponding to the color-coded values of the surface dew point temperature shall be provided.

5.3.5 Surface Relative Humidity Forecast Product

5.3.5.1 The Surface Relative Humidity Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.5.2 The update rate and forecast period associated with the Surface Relative Humidity Forecast Product shall be 3 hours and 48 hours, respectively.

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

- a) The surface relative humidity shall be provided in percent (range 0-100%).
- b) The surface relative humidity shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The surface relative humidity shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the surface relative humidity shall be provided.
- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the color-coded values shall be provided.

5.3.6 Surface Wind Speed & Direction Forecast Product

5.3.6.1 The Surface wind Speed & Direction Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.6.2 The update rate and forecast period associated with the Surface Wind Speed & Direction Forecast Product shall be 3 hours and 48 hours, respectively.

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

- a) The wind speed shall be provided in miles per hour
- b) The wind direction shall be provided in degrees true north
- c) The wind speed shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- d) The wind speed shall be graphically represented by vectors at each forecast location.
- e) If vectors are used to graphically display wind direction, the speed shall be given at the root of the vector. The vectors representing the wind direction shall be fixed length and the vector arrow shall point in the direction the wind is blowing toward.
- f) Time series information of the wind speed shall be provided.

- g) The time period of interest (forecast time) shall be user selectable.
- h) A legend corresponding to the color-coded values shall be provided.

5.3.7 Precipitation Type Forecast Product

5.3.7.1 The Precipitation Type Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.7.2 The update rate and forecast period associated with the Precipitation Type Forecast Product shall be 3 hours and 48 hours, respectively.

5.3.7.3 The Precipitation Type Forecast Product shall represent the predominant type expected. For example, if there is a 30% chance of rain and a 60% chance of snow, the system shall indicate snow as the precipitation type.

5.3.7.4 The Precipitation Type Forecast Product shall include, if calculated, 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.

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

- a) The precipitation type shall be provided for the following types:
 - (i) Rain
 - (ii) Snow
 - (iii) Ice (freezing rain)
 - (iv) Mixed (rain, snow, ice)
- b) The predominant precipitation type shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The predominant precipitation type shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the predominant precipitation type shall be provided.
- e) The probability of precipitation type shall be available for viewing (user selectable) as part of the time series view.
- f) The time period of interest (forecast time) shall be user selectable.
- g) A legend corresponding to the color-coded values shall be provided.

5.3.8 Precipitation Rate Forecast Product

5.3.8.1 The Precipitation Rate Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.8.2 The update rate and forecast period associated with the Precipitation Rate Forecast Product shall be 3 hours and 48 hours, respectively.

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

- a) The precipitation rate shall be provided in inches per hour.
- b) The precipitation rate shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The precipitation rate shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the precipitation rate shall be provided.
- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the color-coded values shall be provided.

5.3.9 Snow Accumulation Forecast Product

5.3.9.1 The Snow Accumulation Forecast Product shall be provided for each DOT zone and at predefined (configurable) locations within each DOT maintenance route.

5.3.9.2 The Snow Accumulation Product shall indicate that amount of snow that is expected to reach the surface (ground) over a specified period. Melting of precipitation due to warm (> 32 F) surface conditions is not considered in this product.

5.3.9.3 The update rate and forecast period associated with the Snow Accumulation Forecast Product shall be 3 hours and 48 hours, respectively.

5.3.9.4 The output (content) of the Snow Accumulation Forecast Product on the MDSS FP display shall have the following characteristics:

- a) The snow accumulation shall be provided in inches.
- b) The snow accumulation shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The snow accumulation shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the snow accumulation shall be provided.
- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the color-coded values shall be provided.
- g) Snow accumulation shall be provided at 3-hour increments out to 48 hours.
- h) The total snow accumulation since the beginning of the forecast period shall be provided.

5.4 Weather Observation Products

5.4.1 Weather observation products shall be provided and displayed on the MDSS FP display.

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

- a) METARS (NWS aviation observations)
- b) Environmental Surface Stations (ESS)
- c) Road Weather Information Systems (RWIS)
- d) NOAAPort products (including satellite, radar, etc.)

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

- a) Air temperature (degrees F)
- b) Relative humidity (percent)
- c) Dew point (degrees F)
- d) Wind speed & wind direction (miles per hour & degrees true north)
- e) Visibility (miles)
- f) Satellite (visible and IR)
- g) Radar (intensity)

5.4.4 The weather observation products shall update as new data arrive.

5.4.5 The output (content) of the weather observation products on the MDSS FP display shall have the following characteristics:

- a. A data block in text format shall be used.
- b. The location of the text data block shall correspond to the observation location referenced to the road network (plan view).
- c. The product shown on the plan view shall default to the latest observations.
- d. The surface observation data shall expire off the screen after a configurable number of minutes.
- e. The expire time shall be independently configurable for each observation product.
- f. Viewing of the product shall be user selectable.
- g. Time series and or animation of the observations shall be provided.

5.4.6 Satellite Product

5.4.6.1 The satellite product shall be based on satellite data provided by the NOAA GOES satellite system.

5.4.6.2 The satellite product shall include visible and infrared channel data.

5.4.6.3 The satellite product shall update as new data arrives (e.g., every 15-minutes).

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

- a) The visible image (VIS) shall be displayed.
- b) The infrared (IR) image shall be displayed.
- c) Satellite images shall be provided for the following domains:
 - i) CONUS
 - ii) Region (e.g., multiple States centered on primary State)
 - iii) State
- d) The satellite product shall include the capability to animate.

5.4.7 Radar Product

5.4.7.1 The radar product shall be based on WSR-88D data provided by the NOAA.

5.4.7.2 The radar product shall be based on the reflectivity (intensity) field.

5.4.7.3 The radar product shall update as new data arrives (e.g., every 10-minutes).

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

- a) The radar reflectivity (intensity) field shall be displayed.
- b) Radar products shall be provided for the following domains:
 - i) Single sites for each radar 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 the capability to animate.
- d) The storm (echo) motion shall be provided.

5.4.8 NWS Watches and Warnings Product

5.4.8.1 NWS watches and warnings for the DOT domain shall be provided.

5.4.8.2 The NWS watches and warnings shall include, but not be limited to:

- a) Winter storm
- b) Flood
- c) Flash Flood
- d) Severe
- e) Thunderstorm
- f) Hurricane
- g) Tornado
- h) Special Marine

5.4.8.3 The NWS watches and warning product shall be in text format.

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

5.4.8.5 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.

5.5 Road Condition Observation Products

5.5.1 Road condition observation products shall be provided and displayed on the MDSS FP display.

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

- a) Environmental Surface Stations (ESS)
- b) Road Weather Information Systems (RWIS)
- c) Other measurements that convey road conditions
- d) Links to information sources for road conditions (e.g., highway patrol)
- e) Intelligent (concept) vehicles

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

- a) Road temperature (degrees F)
- b) Chemical concentration on road (percent by weight)
- c) Pavement condition (wet/dry)
- d) Snow or ice depth (desired)

5.5.4 The road condition observation products shall update as new data arrive.

5.5.5 The output (content) of the road condition observation products on the MDSS FP display shall have the following characteristics:

- a) A data block in text format shall be used.
- b) The location of the text data block shall correspond to the observation location referenced to the road network (plan view).
- c) The product shown on the plan view shall default to the latest observations.
- d) The surface observation data shall expire off the screen after a configurable number of minutes.
- e) The expire time shall be independently configurable for each observation product.
- f) Viewing of the product shall be user selectable.
- g) Time series and or animation of the observations shall be provided.

5.6 Road Condition Prediction Products

5.6.1 Road condition products shall be provided out to 48-hours (configurable) unless otherwise noted in this document. [The user shall be able to view 48-hour forecast data.]

5.6.2 The following road condition prediction products shall be provided:

- a) Road Temperature
- b) Road Chemical Concentration (NaCl, MgCl₂, CaCl₂)
- c) Road Mobility
- d) Snow or ice depth

5.6.3 Road Temperature Prediction Product

5.6.3.1 The Road Temperature Prediction Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

5.6.3.2 The Road Temperature Prediction Product shall be based on a thermal energy balance model and/or empirically based model.

5.6.3.3 The update rate and forecast period associated with the Road Temperature Prediction Product shall be 3 hours and 48 hours, respectively.

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

- a) The road temperature shall be provided in degrees Fahrenheit.
- b) The road temperature shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- c) The road temperature shall be graphically represented by color-coded circles associated with forecast location and/or segments representing the road segments.
- d) Time series information of the road temperature shall be provided.

- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the values of the road temperature shall be provided.

5.6.4 Chemical Concentration Prediction Product

5.6.4.1 The Chemical Concentration Prediction Product shall provide information on the evolution of concentration after application of the following chemicals:

- a) NaCl (Sodium Chloride or salt)
- b) MgCl₂ (Magnesium Chloride)
- c) CaCl₂ (Calcium Chloride)

5.6.4.2 The Chemical Concentration Prediction Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

5.6.4.3 The Chemical Concentration Prediction Product shall be based on a chemical dilution models.

5.6.4.4 The update rate and forecast period associated with the Chemical Concentration Prediction Product shall be 3 hours and 48 hours, respectively.

5.6.4.5 The output (content) of the Chemical Concentration Prediction Product on the MDSS FP 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.
- f) A reference indicator showing solution failure concentration (too diluted) (configurable) shall be plotted along with the chemical concentration.
- g) The user shall be able to view multiple time series dilution curves (user selectable) for each chemical for different application amounts.
- h) The time period of interest (forecast time) shall be user selectable.
- i) A legend corresponding to the values of the chemical concentration shall be provided.

5.6.5 Snow/Ice Accumulation Product

5.6.5.1 The Snow/Ice Accumulation Product shall provide information that describes the amount of material (snow and/or ice) that is predicted to accumulate on the road surface.

5.6.5.2 Calculation of the Snow/Ice Accumulation Product shall take into account (as a minimum) the forecasted precipitation type and rate, and road temperature to estimate the amount of snow/ice that will accumulate on the road surface.

5.6.5.3 The Snow/Ice Accumulation Product shall be provided at predefined (configurable) locations within each DOT maintenance route.

5.6.5.4 The update rate associated with the Snow/Ice Accumulation Product shall be 3 hours and 48 hours, respectively.

5.6.5.5 The output (content) of the Snow/Ice Accumulation Product on the MDSS FP display shall have the following characteristics:

- a) The snow/ice amount shall be given in inches.
- b) The amount shall be accumulated from the start of each update cycle associated with the forecasts where zero indicates the initial state at the update time. Snow/ice amount shall be accumulated through the forecast period.
- c) The snow/ice accumulation shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- d) Time series information of the road contamination accumulation shall be provided.
- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the values of road contamination accumulation shall be provided.

5.6.6 Road Mobility Prediction Product

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

5.6.6.2 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 and one indicates dry pavement.

5.6.6.3 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.

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

5.6.6.5 The Road Mobility Prediction Product shall take into account the following factors:

- a) Snow depth on road
- b) Presence and type of contaminants on road (ice, snow)
- c) Wetness of road

5.6.6.6 The update rate associated with the Road Mobility Prediction Product shall be 3 hours and 48 hours, respectively.

5.6.6.7 The output (content) of the Road Mobility Prediction Product on the MDSS FP 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.
- f) The user shall be able to view multiple (time series) road mobility curves (user selectable) that indicate the results using different treatment options. (See Section 5.8.5)
- g) The time period of interest (forecast time) shall be user selectable.
- h) A legend corresponding to the color-coded values of road mobility shall be provided.

5.7 Prediction Confidence Product

5.7.1 A measure of prediction confidence shall be provided for the following prediction products:

- a) Surface Air Temperature

- b) Surface Wind Speed & Direction
- c) Precipitation Accumulation
- d) Precipitation Type (Conditional Probability)

5.7.2 The calculation of prediction confidence shall take into account statistical data (e.g., spread of predictions for each forecast module) and recent performance information of the forecasts.

5.7.3 The update rate and forecast period associated with the Prediction Confidence Product shall be 3 hours and 48 hours, respectively.

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

- a) The prediction confidence shall be given as a non-dimensional value (index) between zero and one.
- b) The prediction confidence shall be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
- d) Time series information of the prediction confidence shall be provided for the above-mentioned products.
- e) The time period of interest (forecast time) shall be user selectable.
- f) A legend corresponding to the color-coded values of prediction confidence shall be provided.

5.8 Operational Flow

5.8.1 The System shall automatically generate weather and road condition products on a regular schedule (e.g., every 3 hours) for predetermined locations.

5.8.2 The System shall generate winter road maintenance recommendations automatically for user predetermined locations (winter road maintenance routes).

5.8.3 Users shall have a capability to review and edit, if necessary, the initial state of road conditions for each route, and regenerate the recommended treatment plans.

5.8.4 Variables that may need to be adjusted include road temperature, snow/ice depth on road, and chemical concentration on road.

5.8.5 The System shall allow the user to initiate and view the road condition products (Road Temperature, Chemical Concentration, Road Mobility, and Road Snow-Ice Accumulation) for the following modes:

- a) When no road treatment is performed (no chemicals present)
- b) When the recommended treatment is performed
- c) When user-selected treatments are performed

5.9 System Alert Function

5.9.1 The System shall provide a capability to alert the user when specific data thresholds (configurable) have been exceeded.

5.9.2 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)

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

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

5.9.4 The user shall be able to query the System and view the information related to the alert.

5.9.5 The System shall indicate an alert when the following criteria (configurable) 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 below freezing (32 degrees F).
- c) When the wind speed is predicted to above a configurable threshold (default = 20 mph).
- d) When the surface relative humidity is predicted to be above a configurable value (default = 95 %).
- e) When there is a NWS watch or warning (configurable) in effect for a specific region (configurable). (Default = winter storm watch and warning).
- f) When mobility is predicted to be below a threshold (configurable)
- g) When the System recommends a treatment plan.

5.9.6 There is a goal to include a capability to send e-mail notices (to a configurable list of aliases) when specific alerts (configurable) are generated.

5.10 Treatment Recommendations

5.10.1 The System shall provide treatment recommendations for winter road maintenance when certain conditions exist at user defined (configurable) forecast locations (described herein).

5.10.2 Treatment recommendation shall be based on standard accepted rules of practice common in the industry and tailored, if required, to reflect local rules of practice.

5.10.3 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 material rate (e.g., amount per lane mile)

5.10.4 The System shall have a capability to incorporate constraints (configurable) for each route (configurable) 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, MgCl₂, CaCl₂, abrasives etc.)
- b) Application rate limits (based on truck spreading limits)
- c) Route cycle limits (minimum turn around time to repeat treatments)

5.10.5 Treatment recommendations shall be initialized, to the greatest extent possible, using a combination of current observational data on the state of the roadway and predicted weather and road conditions. [The intent of this requirement is to avoid excessive drift in the solution should only numerical predictions be used for initialization.]

5.10.6 The System shall allow the user to review initialization data, edit the data, and rerun the treatment plan.

5.10.7 Treatment plan initialization data shall include (if applicable), but is not limited to the following:

Road State Parameters:

- a) Current road temperature
- b) Current pavement state (e.g., dry, wet)
- c) Current depth of snow on the road

5.10.8 If there are multiple forecast locations where treatment recommendations are provided within a single maintenance route, all the available treatment plans within a maintenance route shall be combined into a single (concatenated) treatment plan. This is to reduce the need to scan each route to view all the recommended treatment plans.

5.11 Display

5.11.1 The display shall have the following general capabilities:

- a) Ability to present time-series information
- b) Ability to allow the user to edit initialization parameters (as described elsewhere)
- c) Animation
- d) Mouse-over (to view data (text) blocks at user-selected locations)
- e) Time selection (e.g., time bar) whereby the user can select the time period for data viewing
- f) Print
- g) Alert function (alert notification when certain predefined thresholds are exceeded)
- f) Ability to review historical data by selecting date and time of archived data
- g) Ability to select viewing area (e.g., entire State, local routes, regional area, etc.)
- h) Ability for user to save and return to personal display settings (e.g., domain, colors, products, etc.).
- i) User login page that utilizes personal settings (e.g., zoom state, initial pages)

5.11.2 The display shall consist of a main page, control panel, and pop-up windows for selected products.

5.11.3 The main graphics page of the display shall be reserved for viewing plan view graphics of weather and road condition information reference to the road network.

5.11.4 The display shall return to a default state (predefined views and settings) when requested to do so by the user (e.g., when a “default” button is pushed).

5.11.5 The user shall have the ability to select the weather and road condition products from the GUI control panel.

5.11.6 A time-bar shall be provided that indicates the following:

- a) Forecast period and past history (default = 12 hrs of history)
- b) Current time reference
- c) Times in forecast period when “events” are predicted. Events shall correspond to alert items listed in Section 5.9.

5.11.7 Pop-up windows may be used for the following items:

- a) Time series products

- b) Treatment selector
- c) Setting configurations
- d) Help function

5.11.8 Locations within routes (forecast points) where treatment recommendations are active during any time within the forecast period shall be highlighted.

5.11.9 Time Series Products

5.11.9.1 Time series plots shall be presented for the following prediction data:

- a) Air temperature (3 meter AGL) (degrees F)
- b) Dew point (degrees F)
- c) Relative humidity (percent)
- d) Wind speed (miles per hour)
- e) Wind direction (degrees true)
- f) Precipitation type
- g) Precipitation rate (liquid equivalent) (inches per hour)
- h) Precipitation amount (3-hour accumulation) (inches)
- i) Snow depth (running total of 48-hour accumulation) (inches)
- j) Road temperature (degrees F)
- k) Chemical concentration (percentage by weight)
- l) Frost point (degrees F) – Not included in MDSS FP (2003)
- m) Confidence (described elsewhere)
- n) Snow/ice accumulation (inches)

5.11.9.2 Parameters presented in time series may be combinable into a single time series and the selection of parameters to combine shall be configurable.

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

- a) Road temperature
- b) Road snow/ice accumulation depth
- c) Road chemical concentration
- d) Road mobility

5.11.9.4 The range of values (scale) for the time series data shall be configurable.

5.11.9.5 Time series data for surface weather observations (see section 5.4) corresponding to forecast sites shall also be available for viewing.

5.11.9.6 The System shall allow the user to view surface weather observation time series data together with forecast data on the same plot. The junction of the two data sets shall occur at the time corresponding to the latest available observation back 12-hours (configurable).

5.11.10 Map Overlays

5.11.10.1 Map overlays shall be available for the following:

- a) Roads (highways (State and local) 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.)

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

5.12 Data Archive

5.12.1 The System shall include a short and long term data storage capability.

5.12.2 The process saving data shall not interfere with the normal operation of the System.

5.12.3 Short Term Archive

5.12.3.1 The short-term archive shall consist of the latest 7 days of data.

5.12.3.2 The oldest stored data shall be routinely (scrubbed) overwritten by new incoming data, such that the integrity incoming data is preserved.

5.12.3.3 Data in the short-term archive shall be stored to the local disk.

5.12.3.4 Data within the short-term archive shall be viewable by selecting the date and time of interest from display interface.

5.12.4 Long Term Archive

5.12.4.1 The long-term archive shall consist of data sets specifically saved by the user.

5.12.4.2 The System shall not delete (scrub) data within the long-term archive.

5.12.4.3 The user shall have the capability to select the date, time, and filename for the long-term archive.

5.12.4.4 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.

5.13 Security

5.13.1 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.

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

5.13.3 Security measures (password protection) shall be implemented to prevent the System from being accidentally disabled or altered from the Internet server or through Internet connections.