

# Deploying the Winter Maintenance Support System (MDSS) in Iowa

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## **ABSTRACT**

Adverse weather conditions dramatically affect the nation's surface transportation system. Each year, 6,600 people die, 470,000 people are injured and 544 million hours of time are lost on the nation's highways because of adverse weather conditions, according to the Federal Highway Administration. The development of a prototype winter Maintenance Decision Support System (MDSS) is part of the FHWA's effort to produce a prototype tool for decision support to winter road maintenance managers to help make the highways safer for the traveling public. The MDSS is based on leading diagnostic and prognostic weather research capabilities and road condition algorithms, which are being developed at national research centers.

It is anticipated that components of the prototype MDSS system developed by this project will ultimately be deployed by road operating agencies, including state departments of transportation (DOTs), and generally supplied by private vendors.

In 2003, The Iowa Department of Transportation was chosen a field test bed for the continuing development of this important research program. The FHWA also selected five national research centers to participate in the development of the prototype MDSS. They were selected because of the applicability of their expertise to the MDSS task. The participating national labs include the Cold Regions Research and Engineering Laboratory (CRREL), National Center for Atmospheric Research (NCAR), Massachusetts Institute of Technology - Lincoln Laboratory (MIT/LL), National Severe Storms Laboratory (NSSL), and the Forecast Systems Laboratory (FSL).

**Key words: decision support system—technology—winter maintenance**

## INTRODUCTION

The development of a prototype winter Maintenance Decision Support System (MDSS) is part of the Federal Highway Administration (FHWA) Road Weather Management Program. The objective of the MDSS effort is to produce a prototype tool for decision support to winter road maintenance managers. The MDSS is based on leading diagnostic and prognostic weather research capabilities and road condition algorithms, which are being developed at national research centers. It is anticipated that components of the prototype MDSS system developed by this project will ultimately be deployed by state departments of transportation (DOTs), and generally supplied by private vendors.

There are five national research centers that are participating in the development of the MDSS Functional Prototype (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 MDSS field demonstration evaluated the MDSS by operating the systems in a real time winter environment. This also allowed the users to work the system and verify the data. The following evaluations were performed in FY2003:

1. Weather prediction component
2. Treatment recommendations
3. Impact of supplemental mesoscale models
4. Potential benefit of operational system
5. Identify and evaluate current system limitations

The Iowa DOT provided a “test bed” for the MDSS prototype in the winter of 2003.

### ***Field Demonstration Period***

The MDSS field demonstration began on February 3, 2003 and continued through April 7, 2003, to capture all major snow events. The system operated 24-hours per day, 7-days per week during this period. Three DOT maintenance garages participated in the demonstration. They were:

- Ames Garage
- Des Moines - North

- Des Moines - West

***Selected Winter Maintenance Routes for Field Demonstration***

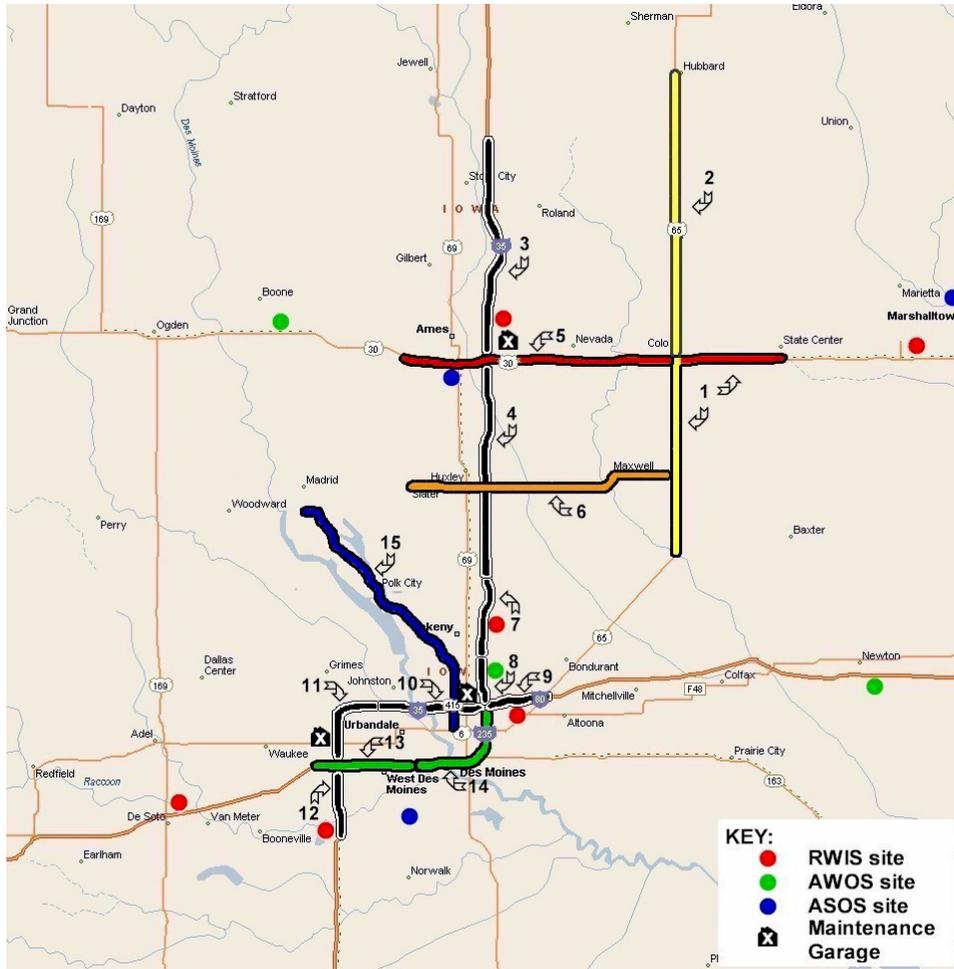
Iowa DOT representatives selected several winter road maintenance routes that were used in the MDSS field demonstration. A total of 15 routes, covering 400 miles were configured in the MDSS. The selected routes are described in Table 1 and a corresponding map of the routes is provided in Figure 1. Separate treatment plans were generated by the MDSS prototype for each of the routes shown in Figure 1.

**TABLE 1. Iowa Maintenance Routes for the MDSS Field Demonstration**

Garage	Segment Number	Route	Start Mile Post	End Mile Post	ADT Range	Service Level
Ames	1A	US 65	98.38	112.09	1500-2000	C
Ames	1B	US 30	164.93	172.30	5000-6000	B
Ames	2	US 65	112.09	132.59	1000-2000	C
Ames	3	I-35	111.60	128.46	20000-23000	A
Ames	4	I-35	96.60	111.60	23000-26000	A
Ames	5	US 30	142.88	172.30	6000-27000	B
Ames	6	IA 210	13.79	34.43	1000-3000	D
Des Moines North	7	I-35	93.20	96.60	26000-53000	A
Des Moines North	8	I-35	86.94	93.20	53000-59000	A
Des Moines North	9	I-80	137.82	142.10	50000-61000	A
Des Moines North	10	I-35/I-80	131.50	137.82	59000-63000	A
Des Moines West	11	I-35/I-80	123.53	131.50	32000-72000	A
Des Moines West	12	I-35	67.89	72.70	22000-33000	A
Des Moines West	13	I-235	0.00	8.80	42000-125000	A
Des Moines North	14	I-235	8.80	14.26	46000-125000	A
Des Moines North	15	IA 415	0.00	21.93	1000-21000	B-D

Service Levels:

- |   |                         |   |                                  |
|---|-------------------------|---|----------------------------------|
| A | Interstates             | C | 2,500 – 5,000 vehicles per day   |
| B | 5,000+ vehicles per day | D | less than 2,500 vehicles per day |



**FIGURE 1. Map Of Routes to be Supported by the MDSS Prototype During the Winter of 2003 Iowa Field Demonstration**

*The MDSS Iowa Weather Display*

The MDSS Iowa Weather Display page was configured to provide weather alerts when the weather conditions deteriorated according to the criteria in the MDSS Technical Description. The alerts graphically referenced based on the Iowa weather forecast zones illustrated in Figure 2. These forecast zones are consistent with the weather forecast zones used by Meridian Environmental Technology, which is the operational road weather forecast provider for Iowa during the winter of 2002-2003.

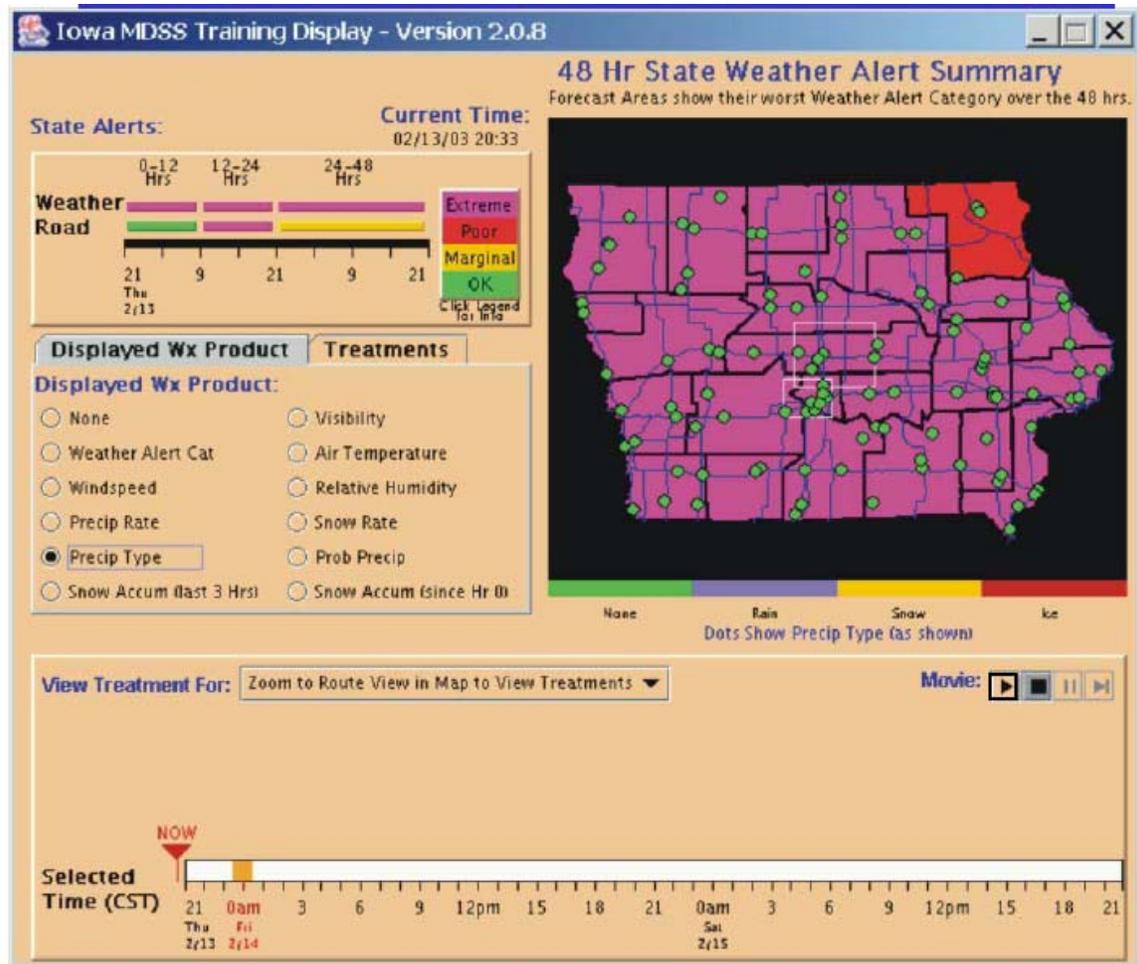
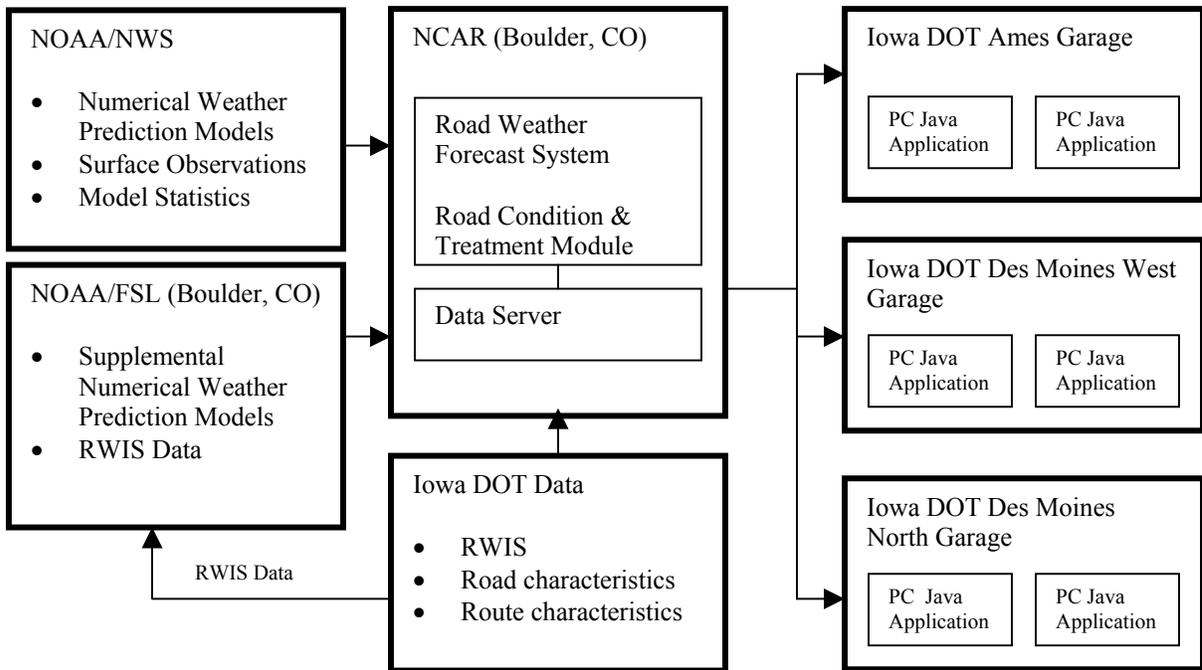


FIGURE 2. MDSS Iowa Weather Display Page

### *MDSS System Configuration for Iowa*

The MDSS core components (e.g., Road Weather Forecast System, Road Condition and Treatment Module and data server) operated centrally at NCAR in Boulder, Colorado. A server at NCAR communicates (via the Internet) with local PCs running the display application at the Iowa DOT maintenance garages. Supplemental weather forecast models run at FSL in Boulder and the data are forwarded to NCAR for inclusion in the Road Weather Forecast System (RWFS). Iowa DOT RWIS data were also provided to NCAR via FSL as part of the MADIS project (1).

The MDSS displays are located in the three maintenance garages. Each garage had the MDSS display running at the supervisor's desk and an additional display application at the shift supervisor's desk. Data were obtained over the Internet (client-server approach). A simplified illustration of the system configuration is provided in Figure 3.



**FIGURE 3. Depiction of the MDSS Prototype Configuration for the Iowa Field Demonstration. All Network MDSS Connections to the Sites will be Via the Internet (Figure Courtesy of NCAR).**

### FIELD-TEST PERIOD

The national labs were responsible for preparing a technical performance assessment by performing data analyses that seek to answer questions related to the technical performance of the MDSS system. Iowa DOT worked with the labs to identify critical ground truth data sets.

From the period of February 3-April 7, 2003 the MDSS was field-tested. There were a total of eight weather events that tested the system, in various stages of intensity.

#### System Tests

Total Weather incidents:	8
Light Snow Events	5
Heavy Snow Events	3
Mix: Snow/Rain/Ice	1

### ***Data Sources***

Iowa DOT also provided field weather and operational data from the garages to verify the model. Data were obtained from several sources. Where available, data were obtained and archived in real time. Archived data were used if not available in real time. The following data were collected for verification:

- a) Iowa RWIS (weather and road condition data)
- b) NWS METAR (aviation observations)
- c) Local observer surface data (where available)
- d) Weather satellite
- e) Weather radar
- f) NWS storm summaries
- g) Iowa DOT observations (where available)
- h) Iowa DOT Maintenance Concept Vehicle data
  - i. Air temperature
  - ii. Pavement temperature
  - iii. Material distribution setting
  - iv. Freezing point detection
  - v. Treatment type
  - vi. Treatment rate
  - vii. Plow position

### ***Data Collection Forms***

In order to fully estimate the road conditions and determine the actual treatments performed during each event, it was necessary for Iowa DOT personnel to fill out data forms following each shift that required winter road treatments.

Numerous iterations of the format and content for these forms were determined through discussions between Iowa DOT, the Labs and the FHWA.

The winter maintenance data collection forms captured the following information:

- Date
- Shift time
- Route ID
- Equipment type
- Treatment performed
  - Treatment start and stop times
  - Chemicals used (NaCl, CaCl<sub>2</sub>, etc.)
  - Chemical amount (tonnage)
  - Plowing performed
- Estimated road condition per route
  - Wet, dry, icy, snow packed, blowing snow, snow depth, slush, rain, freezing rain, frost, etc.
  - Road temperature (where available from equipment)
- Any other pertinent observations such as chemical dispersion rate, condition of road before and after treatment, precipitation start and stop times.

**MDSS Supplemental Daily Log: AMES GARAGE**

Driver Name:	Truck ID:
Shift Start Date:	Shift Start Time: (AM/PM)
Shift End Date:	Shift End Time: (AM/PM)
Comments:	

Segment ID	Route	Start MP	End MP
1A	U.S. 65	98.38	112.09
1B	U.S. 30	164.93	172.30
2	U.S. 65	112.09	132.59
3	I-35	111.60	128.46
4	I-35	96.60	111.60
5	U.S. 30	142.88	164.93
6	IA 210	13.79	34.43

**Directions: Use 1 Column per Treatment. Use a New Column if one of the following applies:**

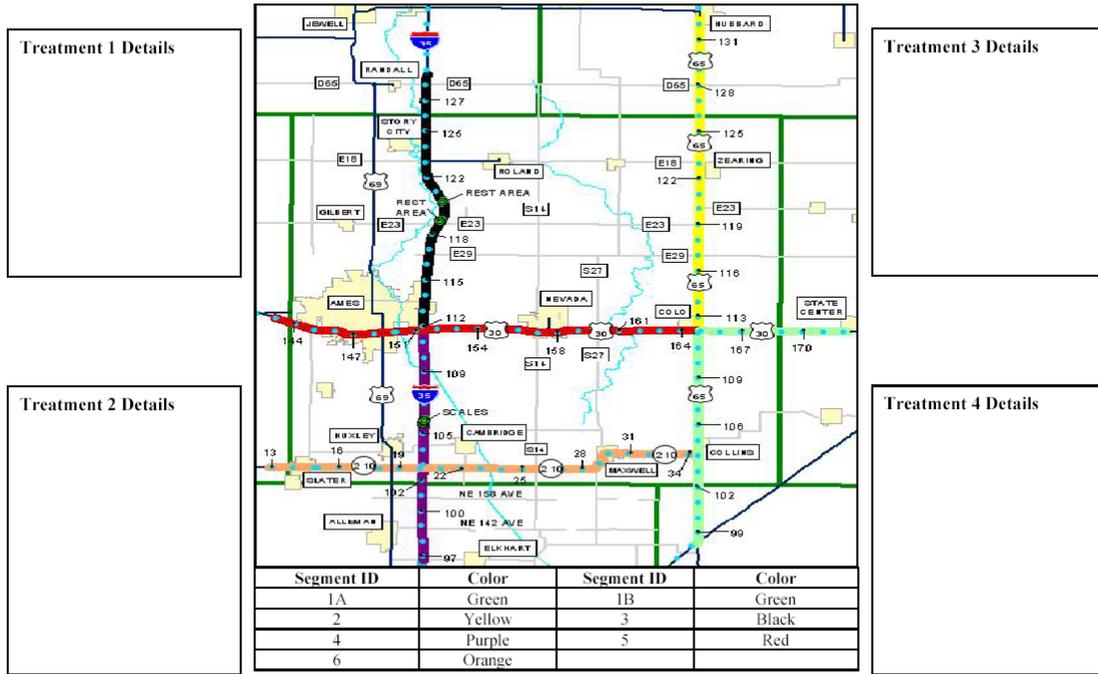
- 1). you are starting a new segment
- 2). you make a significant change on the same segment (such as a change of application rate)
- 3). you begin a second treatment on the same segment

Mark up the map on the reverse side with any additional details that makes the report of your treatment more complete.

Segment ID Covered (circle one)	Treatment 1						Treatment 2						Treatment 3						Treatment 4											
	1A	1B	2	3	4	5	6	1A	1B	2	3	4	5	6	1A	1B	2	3	4	5	6	1A	1B	2	3	4	5	6		
Treatment Start Time	AM/PM						AM/PM						AM/PM						AM/PM											
Treatment End Time	AM/PM						AM/PM						AM/PM						AM/PM											
Did You Plow?	YES		NO		YES		NO		YES		NO		YES		NO		YES		NO		YES		NO		YES		NO			
Lane Materials Applied On	Driving Center Passing						Driving Center Passing						Driving Center Passing						Driving Center Passing											
Pre-Storm Chemical Application	YES		NO		YES		NO		YES		NO		YES		NO		YES		NO		YES		NO		YES		NO			
Note amount	Brine gal/lane-mile						Brine gal/lane-mile						Brine gal/lane-mile						Brine gal/lane-mile											
During Storm Chemicals applied? (Circle type)	NONE						NONE						NONE						NONE											
Note amount	Salt Calcium Iceban		Iceslicer brine		gal or lb/lane-mile		Salt Calcium Iceban		Iceslicer brine		gal or lb/lane-mile		Salt Calcium Iceban		Iceslicer brine		gal or lb/lane-mile		Salt Calcium Iceban		Iceslicer brine		gal or lb/lane-mile		Salt Calcium Iceban		Iceslicer brine		gal or lb/lane-mile	
Abrasives applied? (amount)	lb/lane-mile						lb/lane-mile						lb/lane-mile						lb/lane-mile											
Road condition before treatment (Circle all that apply)	dry		wet		slushy		icy		snow-packed		road frost		drifting snow		dry		wet		slushy		icy		snow-packed		road frost		drifting snow			
Road condition after treatment (Circle all that apply)	dry		wet		slushy		icy		snow-packed		drifted snow		unknown		dry		wet		slushy		icy		snow-packed		drifted snow		unknown			
Estimate Traffic Volume (circle one)	low		normal		high		low		normal		high		low		normal		high		low		normal		high		low		normal		high	
Traffic speed (circle one)	stopped		slow		normal		stopped		slow		normal		stopped		slow		normal		stopped		slow		normal		stopped		slow		normal	
Treatment Specific Comments																														

**FIGURE 3. Data Collection Form for Ames Garage**

Mark up this map with any information that adds detail to the treatment information from the front of this form (examples: show the treatment route, highlight areas of drifts, and indicate accident locations). Use the boxes provided to organize the details. Draw a line from the box to the highlighted region.



Ames\_100A

**FIGURE 4: Second Page of Data Collection Form**

The data collected from the field will be incorporated into the MDSS improve the model.

## CONCLUSIONS AND RECOMMENDATIONS

Following the field demonstration, a MDSS Stakeholders' meeting was held in Des Moines on June 17 – 18, 2003 to discuss the outcome of the project. Interested parties from across the USA, and other countries including Great Britain, Canada, were on hand to provide input to the MDSS project.

The following recommendations were put forth following this past winters' field demonstration:

The MDSS weather predictions need improvement. The MDSS failed to pick up light snow events. While these events do not produce a lot in precipitation, operationally, the garages still need to deploy personnel and equipment to clear the roadways. The garages also reported that the start time for events were not as accurate as they would have liked. To effectively deploy the pre-treatments, it is critical for the field supervisors to know the start time of precipitation events.

During the field-tests, the garage users also requested refinements in the display portion of the MDSS interface. The display on the screen uses dots to indicate weather conditions. The users of the systems asked that the weather data be shown, along with wind direction and velocity to more readily obtain the weather conditions.

An important aspect of the field test was to collect weather data from the garages and equipment operators. To collect the data we used paper data collection forms that the equipment operators and supervisors completed. This proved to be a cumbersome and time-consuming process. The field staff strongly recommends that further data collection be automated to allow the equipment operators to focus on the task at hand. Data, such as plow position, location, spreader rates, pavement temperature, etc. can be collected with the existing GPS and AVL units that Iowa DOT has. Other data, such as weather and traffic conditions will still have to be collected manually.

A further recommendation is to tie the MDSS into the chemical inventory system to track chemical usage and assist in the chemical inventory at optimal levels.

The MDSS shows real promise in assisting winter maintenance managers in fighting winter storms. If fully deployed, the MDSS could assist winter maintenance managers statewide with prompt, accurate, tactical information to alleviate the effects of winter weather on the roadways. By providing as much probabilistic weather forecasts and treatment recommendations as possible to the field-level supervisors, they can use those data to make better-informed decisions on clearing the roadways in a cost effective manner.

For more complete information on the Maintenance Decision Support System (MDSS) program, please refer to the following website:

[http://www.rap.ucar.edu/projects/rdwx\\_mdss/index.html](http://www.rap.ucar.edu/projects/rdwx_mdss/index.html)

## REFERENCES

1. Tutorial on the Maintenance Decision Support System Field Demonstration Software. February 4, 2003. [http://www.rap.ucar.edu/projects/rdwx\\_mdss/iowa.html](http://www.rap.ucar.edu/projects/rdwx_mdss/iowa.html)