Center for Transportation Research and Education

Winter Maintenance Operations & Maintenance Decision Support System

TRANS 691 Seminar

March 5, 2004

IOWA STATE UNIVERSITY

CTRE
Center for Transportation Research and Education

Why Winter Maintenance?

- Weather related traffic accidents cost USA $150 B annually in property damage, medical costs, lost productivity*

FHWA/JPO 2000

Why Winter Maintenance

- 6,600 deaths annually
- 470,000 injuries annually
- 544,000,000 hours lost annually
- Contributed to adverse weather conditions

Snow & Ice Control Facts

- State agencies spends $2 billion/annually on winter maintenance
- 20,000,000 Metric Tons of road salt are used annually
- 7 million gallons salt brine annually
- Demand for salt doubled in last 10 yrs
- Iowa DOT expenditures $35 Million/annually

Improved Strategies for Winter Maintenance

- Anti Icing
- RWIS Technology
- Improved Vehicle Technology
- Chemical Treatments
- Maintenance Decision Support System (MDSS)

Snow & Ice Control Strategies

- Anti-Icing and De-Icing
- De-Icing was traditional, ***reactive*** method used to break bond between snow and ice and pavement surface.

Anti-Icing

- ***Preventive*** strategy
- Chemicals, such as salt brine, applied to road surface prior to storm to PREVENT snow and ice from forming a bond to pavement surface.
- Timing of application is critical

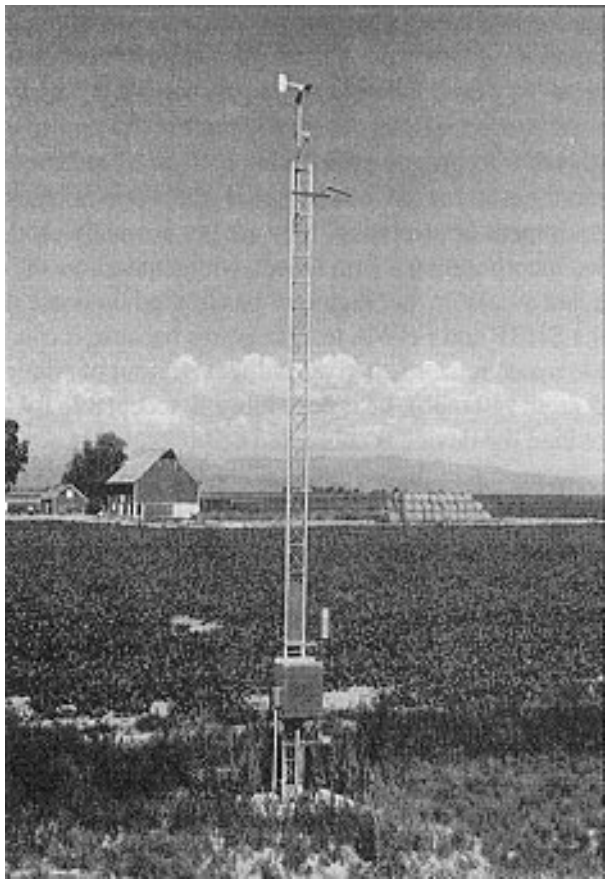
Pre-Wetting Chemicals

- The wetting of solid chemical prior to spreading can improve the effectiveness of the chemical in many situations.
- Spreads more uniformly
- Adheres better to road surface
- Longer lasting on road surface

Environmental Sensors

- Road Weather Information Systems (RWIS) are networks of data-gathering and road condition monitoring systems.
- Generally installed along roadside with RPU, Remote Processing Unit
- Provide air temperature, pavement temperature, wind speed direction, chemical concentration, relative humidity, pavement surface condition (e.g., wet, dry, chemical wet)
- Aurora Program

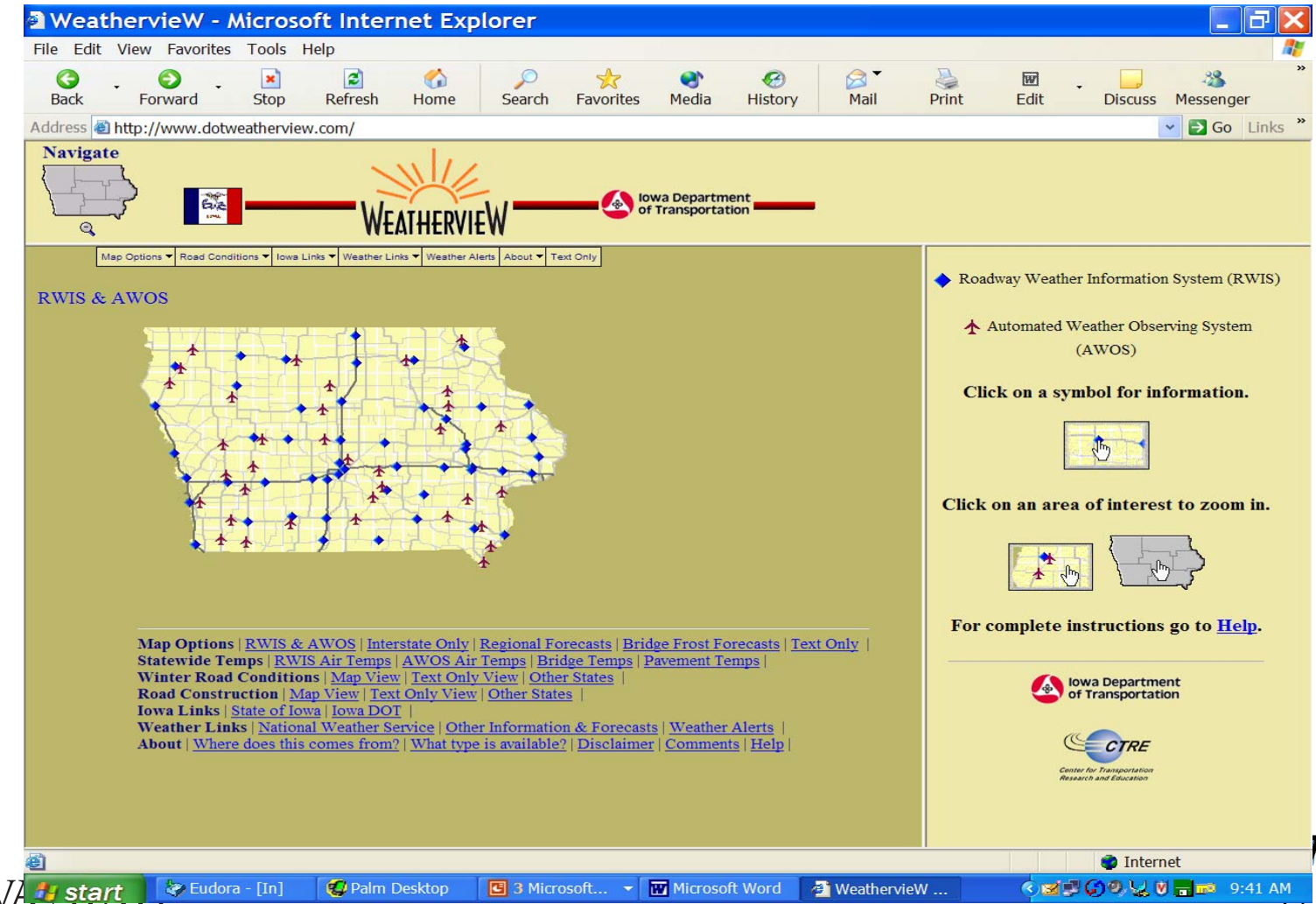
RWIS Station



Other Sensors

- Automated Weather Observing System (AWOS)- FAA
- Automated Surface Observing System (ASOS)- NWS
- Both provide automated weather information used in forecast models

WeathervieW

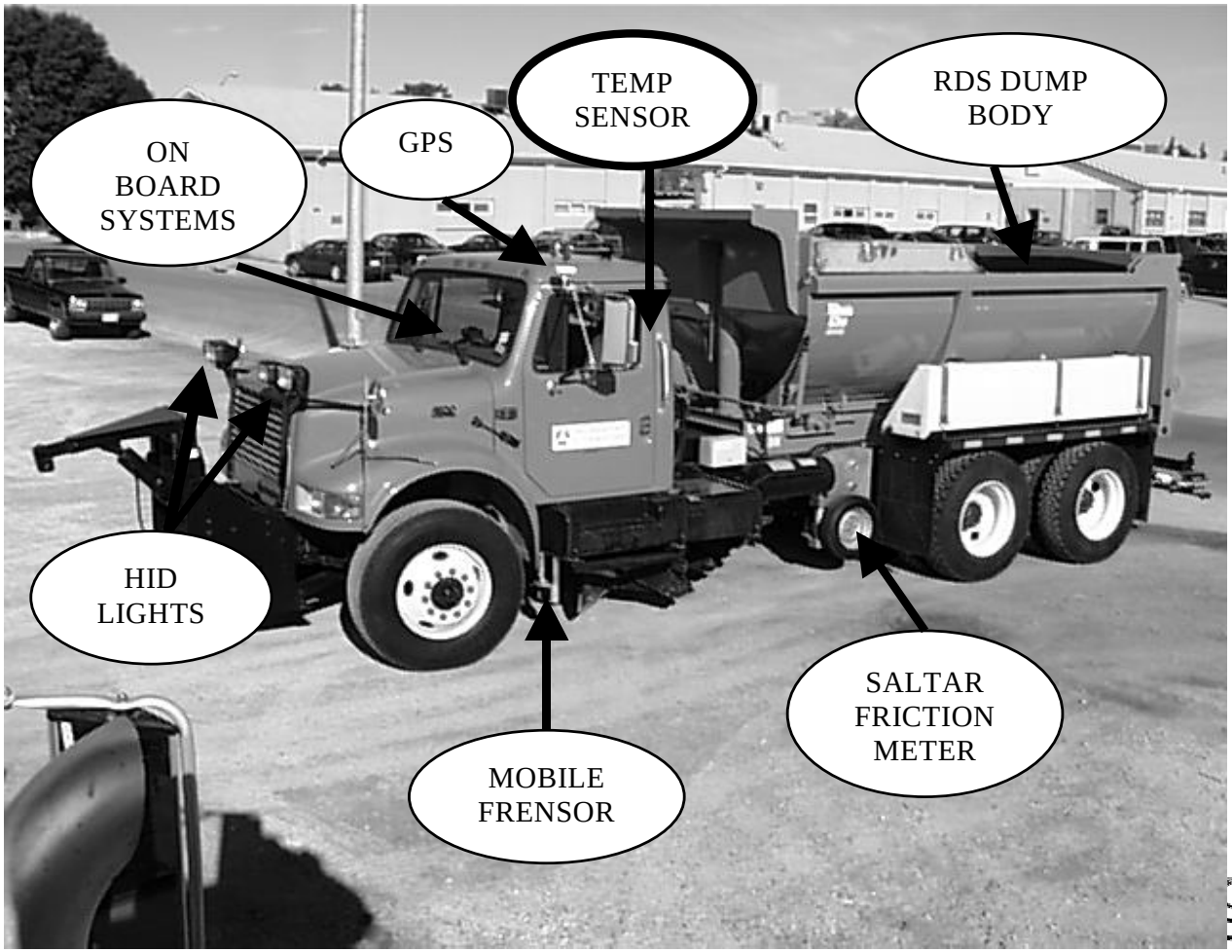


Improved Vehicle Technology

- “Concept” Vehicle Technology
- Improvements in vehicle components for more effectiveness in snow and ice control.

Minnesota IVI

Iowa Highway Maintenance Concept Vehicle



Chemical Treatments

- Road Salt is most common chemical used for anti-icing
- Problems with corrosion
- Environmental Canada is looking closely at use of road salt
- Ice-Ban, LCS are use sparingly but expensive

Maintenance Decision Support System (MDSS)

- Maintenance Decision Support System is a FHWA supported effort to produce a prototype tool for decision support for winter road maintenance managers to help make highways safer.

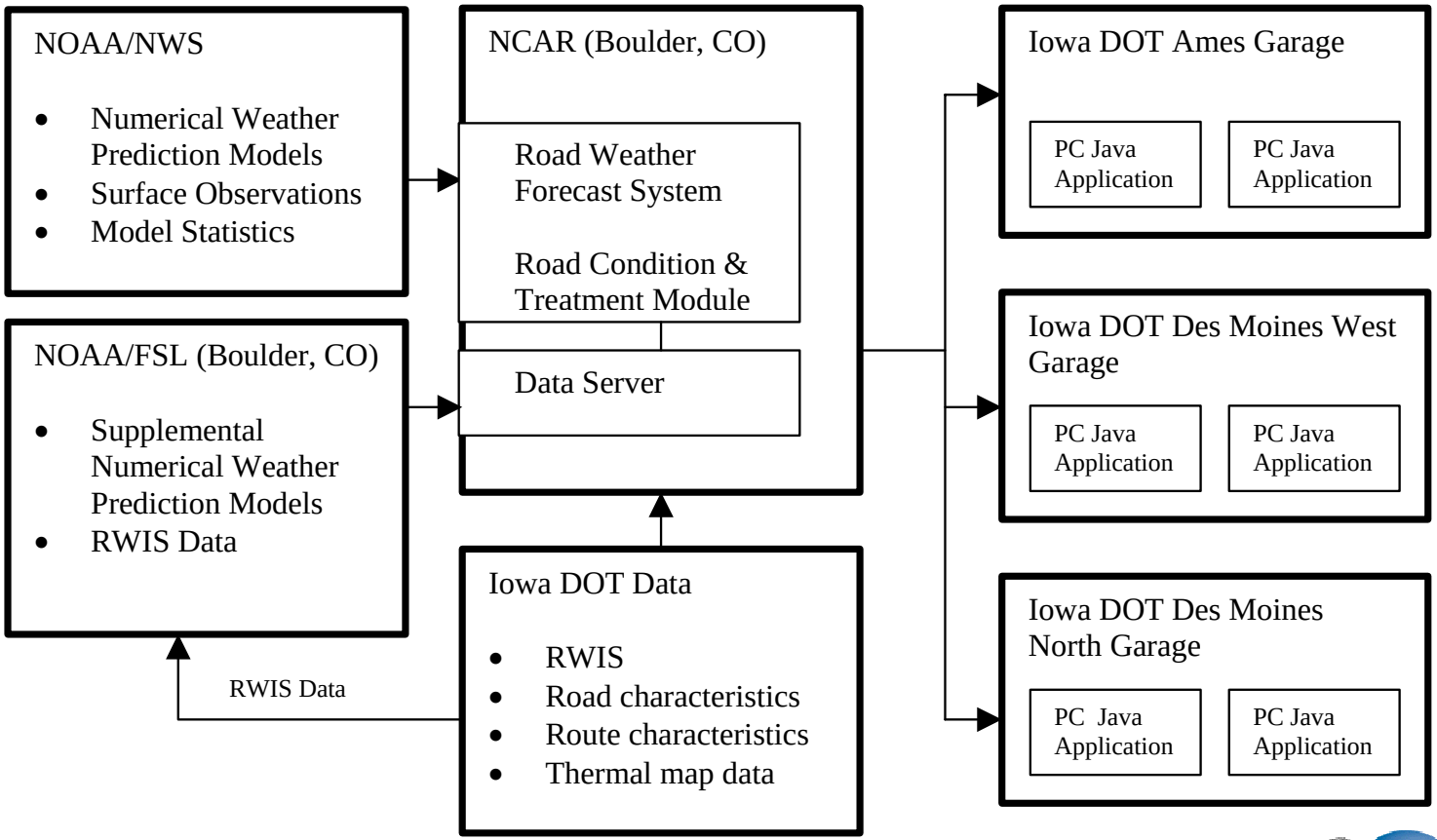
MDSS

- Federal project, funded through the Intelligent Transportation System (ITS) Joint Project Office (JPO) of the FHWA.
- Develop prototype system to be further developed by, and integrated with other entities.
- Provide platform for private vendors (often called Value Added Meteorological Services or VAMS).

National Research Effort

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

MDSS Configuration



Evaluations Performed

- Weather Prediction
- Treatment recommendations
- Impact of supplemental mesoscale (regional) models
- Potential benefit of operational systems
- Identify and evaluate current systems limitations

Weather Prediction Component

- Weather Models Used
  - AVN – National Weather Service model
  - Eta – National Weather Service Model
  - METAR – Meteorological Surface Observation
  - MM5 – Mesoscale Model – Version 5 (NCAR & Penn State)
  - RAMS – Regional Atmospheric Modeling System (Colorado State University)
  - WRF – Weather Research & Forecasting Model
  - Make up ensemble forecast

Weather Prediction Component

- Issues
  - Accuracy
  - Importance of “light” snow events
  - Wind and blowing snow alerts
  - Frost Prediction- complex

Operational Components

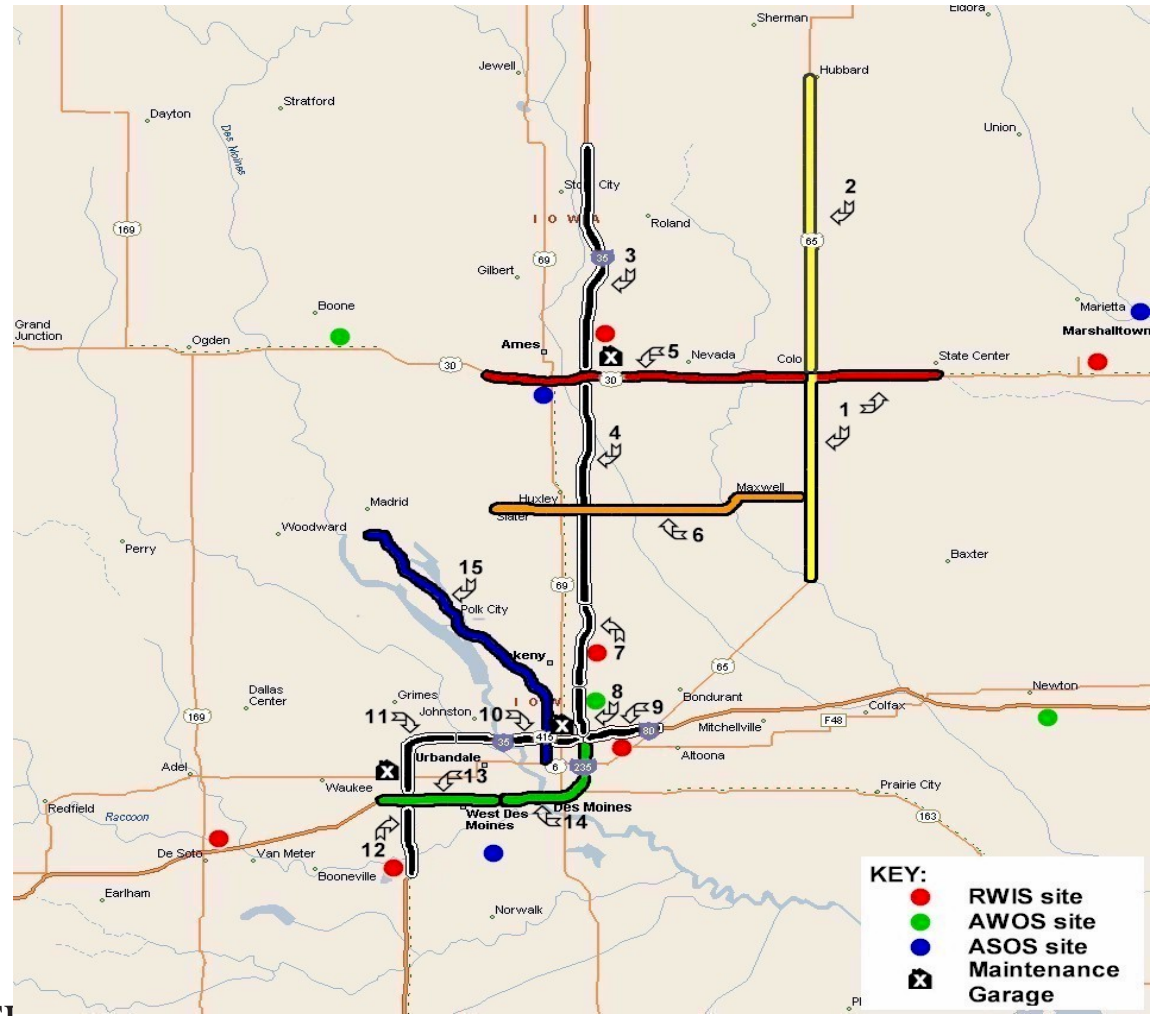
- Rules of Practice
  - Generally followed
  - Decisions made in field as conditions warrant
  - Operators given autonomy
- Underestimate effect of blowing snow
  - Blowing snow hazardous- “ground blizzards”
  - Algorithm changed for 2004 to capture effects
- Effect of traffic on treatments
  - Complex, hard to calculate
- Effectiveness of road chemical treatment

Effects of Blowing Snow

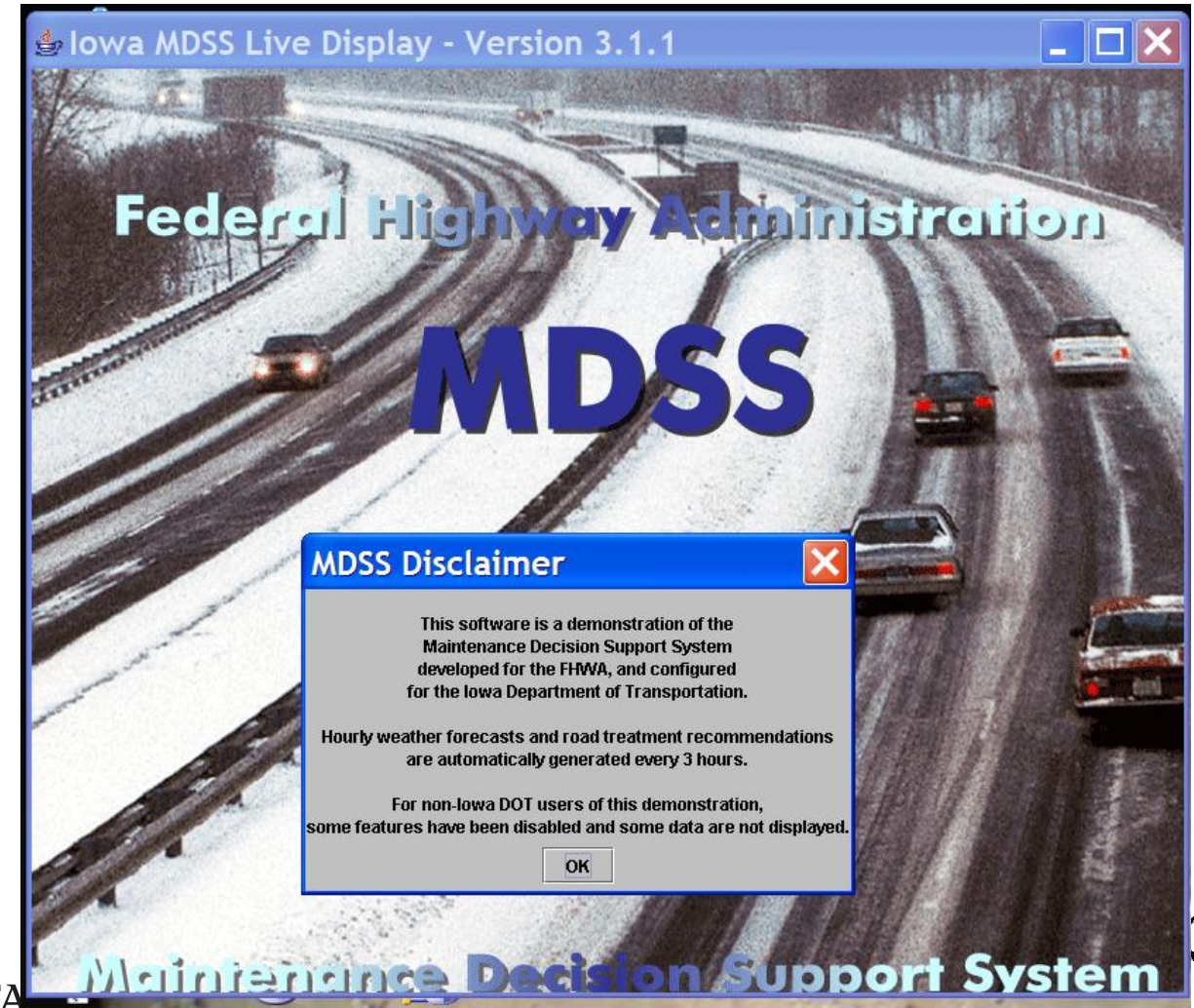
Field Demonstration

- First Demo Feb 3, 2003 to April 7, 2003
- 2nd Demonstration Period, Dec. 29, 2003 to March 19, 2004
- Ames garage
- Des Moines North
- Des Moines West

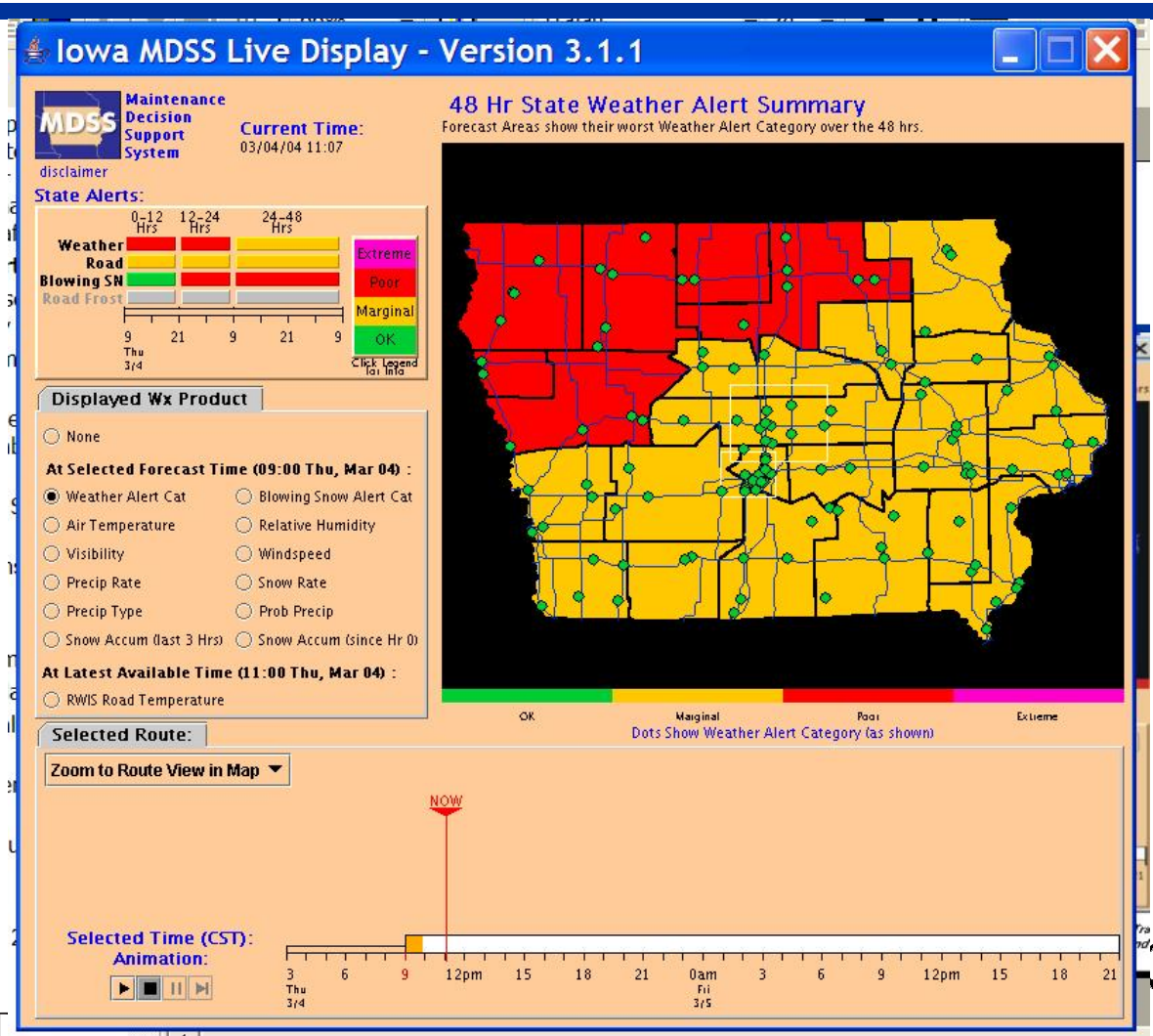
Demonstration Area



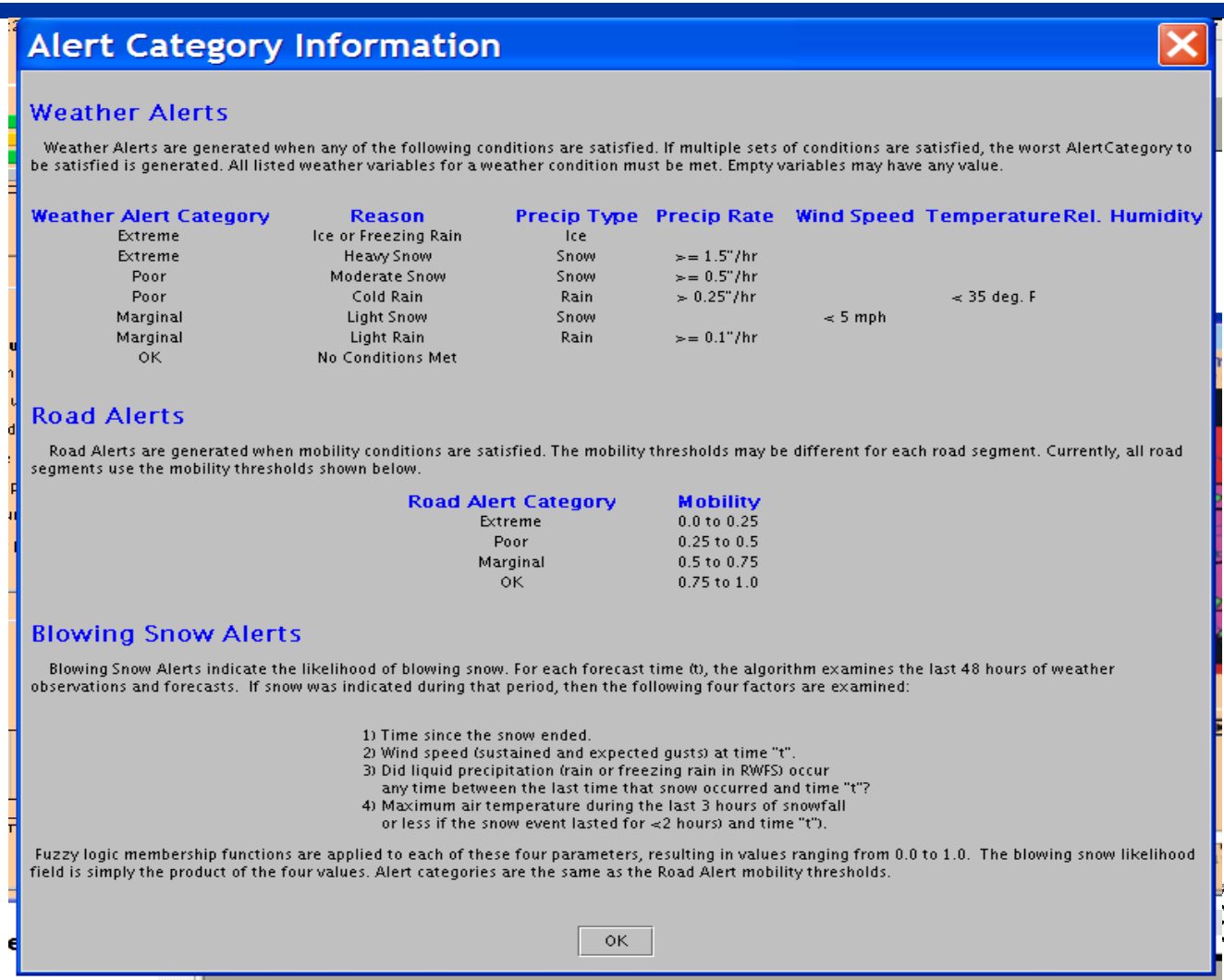
Opening Screen



Weather Alert Screen



Alert Category Information



Alert Category Information

Weather Alerts

Weather Alerts are generated when any of the following conditions are satisfied. If multiple sets of conditions are satisfied, the worst AlertCategory to be satisfied is generated. All listed weather variables for a weather condition must be met. Empty variables may have any value.

Weather Alert Category	Reason	Precip Type	Precip Rate	Wind Speed	Temperature	Rel. Humidity
Extreme	Ice or Freezing Rain	Ice				
Extreme	Heavy Snow	Snow	>= 1.5"/hr			
Poor	Moderate Snow	Snow	>= 0.5"/hr			
Poor	Cold Rain	Rain	> 0.25"/hr		< 35 deg. F	
Marginal	Light Snow	Snow		< 5 mph		
Marginal	Light Rain	Rain	>= 0.1"/hr			
OK	No Conditions Met					

Road Alerts

Road Alerts are generated when mobility conditions are satisfied. The mobility thresholds may be different for each road segment. Currently, all road segments use the mobility thresholds shown below.

Road Alert Category	Mobility
Extreme	0.0 to 0.25
Poor	0.25 to 0.5
Marginal	0.5 to 0.75
OK	0.75 to 1.0

Blowing Snow Alerts

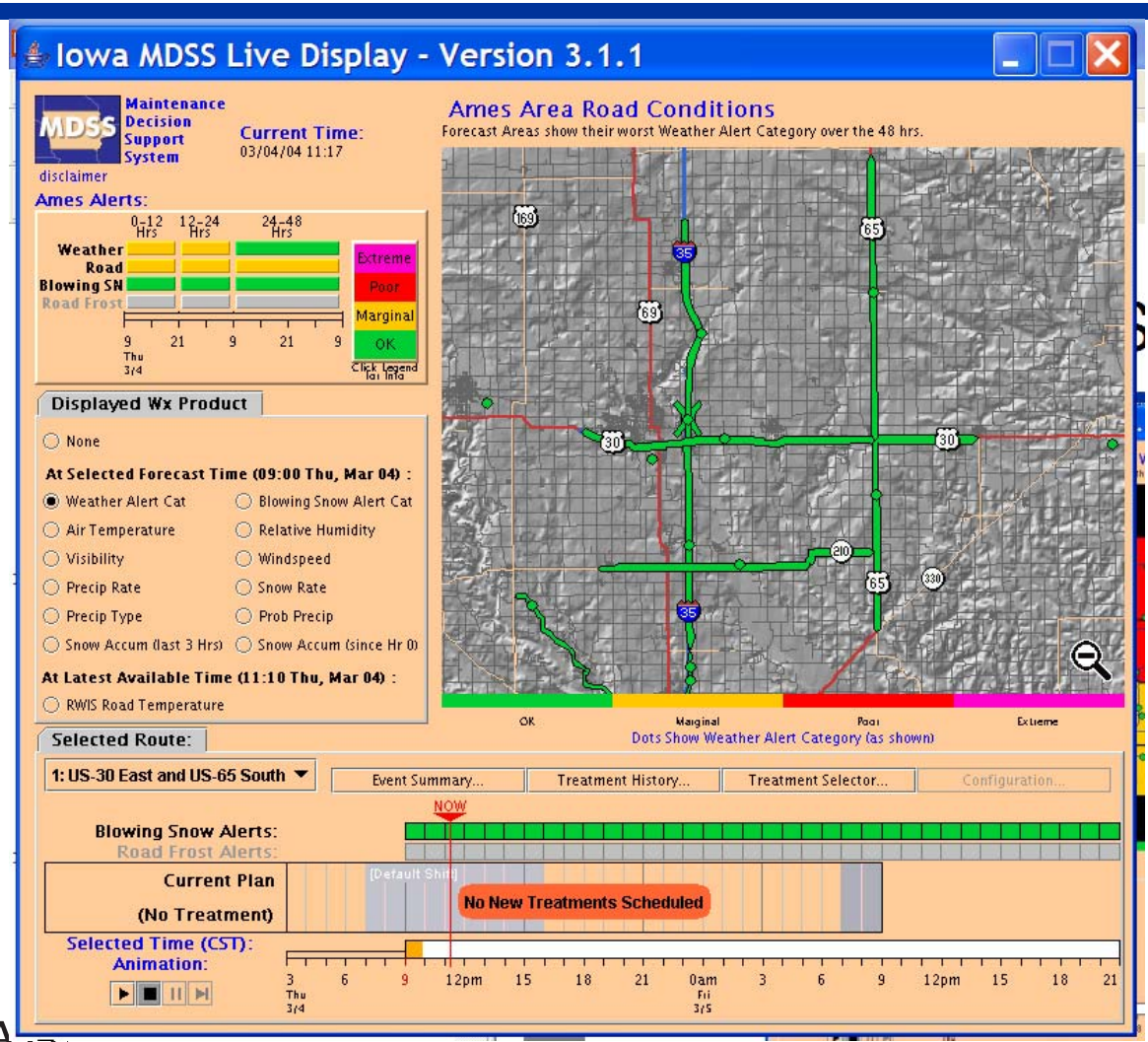
Blowing Snow Alerts indicate the likelihood of blowing snow. For each forecast time (t), the algorithm examines the last 48 hours of weather observations and forecasts. If snow was indicated during that period, then the following four factors are examined:

1) Time since the snow ended.
2) Wind speed (sustained and expected gusts) at time "t".
3) Did liquid precipitation (rain or freezing rain in RWFS) occur any time between the last time that snow occurred and time "t"?
4) Maximum air temperature during the last 3 hours of snowfall or less if the snow event lasted for <2 hours) and time "t").

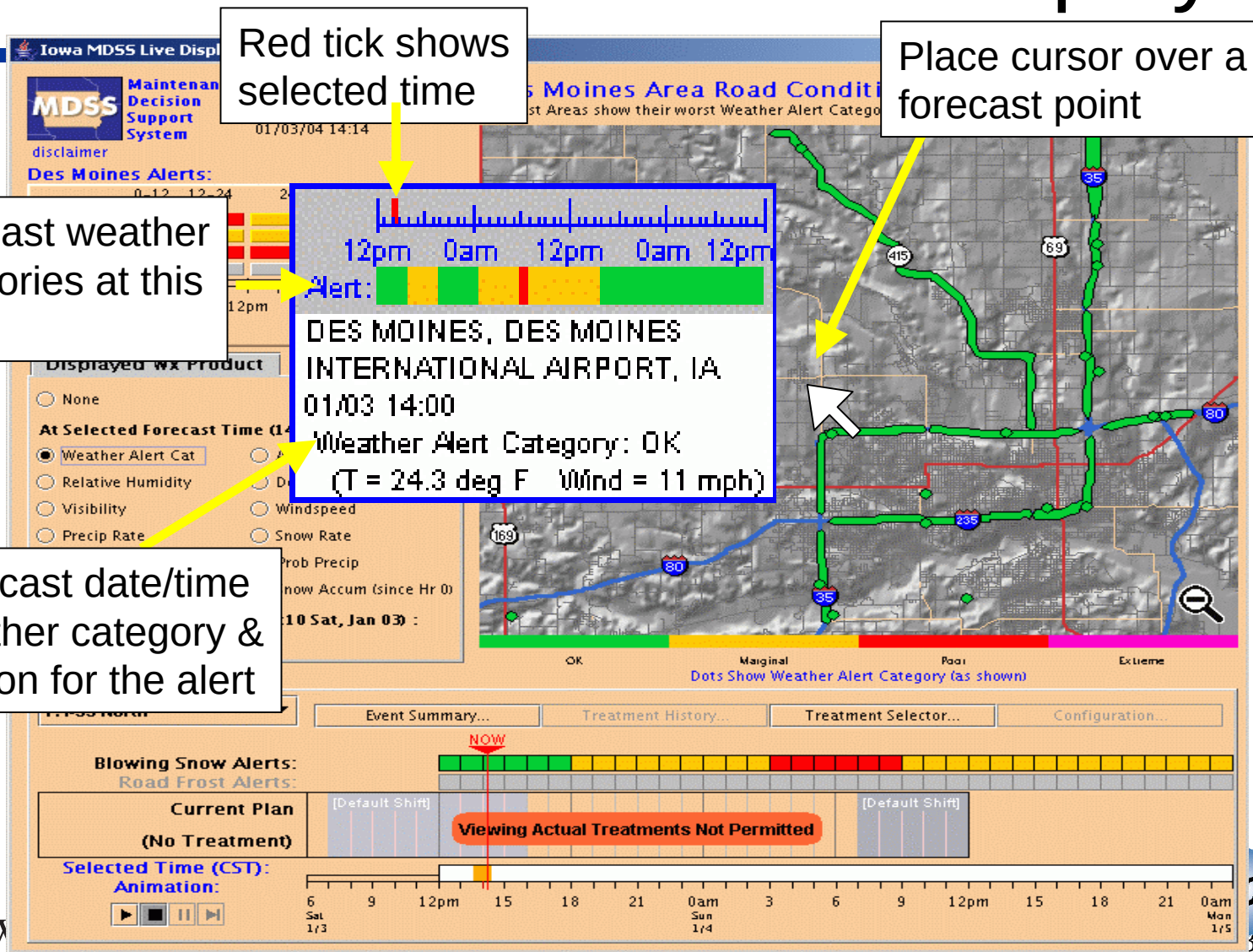
Fuzzy logic membership functions are applied to each of these four parameters, resulting in values ranging from 0.0 to 1.0. The blowing snow likelihood field is simply the product of the four values. Alert categories are the same as the Road Alert mobility thresholds.

OK

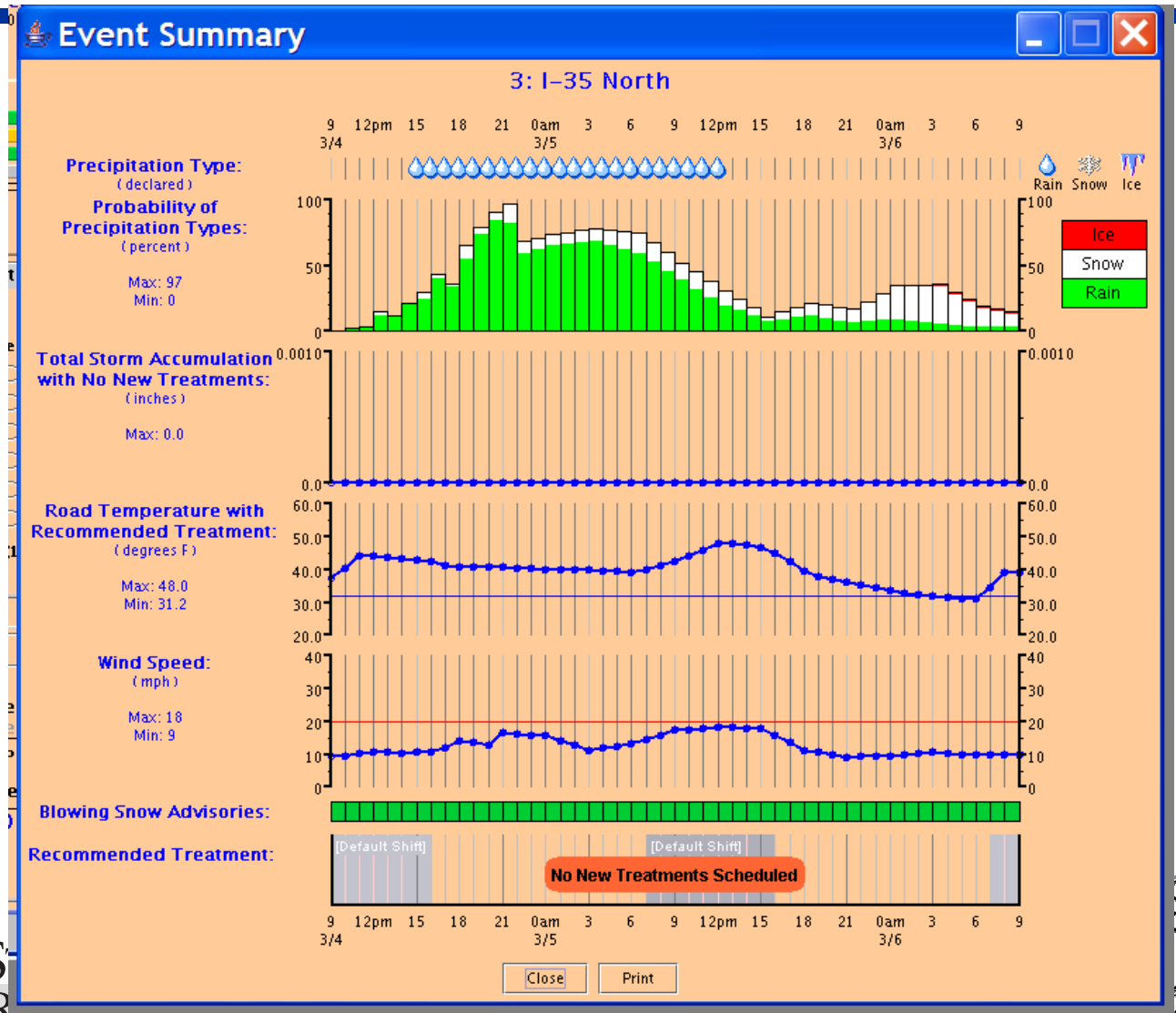
Weather Alerts–Point Forecasts



Forecast Point Status Display



Event Summary Page



Tabular Model Output for each Forecast Point Introducing Probabilistic Forecast Information

Graph

DES MOINES, DES MOINES INTERNATIONAL AIRPORT, IA

Date Name	Wx Alert	Air T (F)	Tot Snow (in)	Dewpt (F)	RH (%)	Precip Type	Prob Precip...	Prob Rain (...	Prob Snow ...	Prob Ice (%)	Precip
12:00 Sat	None	21.7	0.0	11.0	63	None	45	0	100	0	0.0
13:00 Sat	None	23.0	0.0	11.2	60	None	31	11	89	9	0.0
14:00 Sat	None	24.3	0.0	12.3	60	None	42	0	96	15	0.0
15:00 Sat	None	24.6	0.0	14.0	63	None	36	2	98	5	0.0
16:00 Sat	Marginal	24.7	0.1	14.3	64	Snow	38	0	100	1	0.01
17:00 Sat	Marginal	23.4	0.3	16.4	74	Snow	55	0	100	1	0.02
18:00 Sat	Marginal	23.3	0.4	17.8	79	Snow	68	29	99	7	0.02
19						Snow	51	11	100	4	0.01
20						None	64	11	100	3	0.0
21						None	49	11	97	6	0.0
22						None	27	16	94	3	0.0
23						None	24	16	93	5	0.0
00						None	16	4	95	7	0.0
01						Snow	39	9	90	9	0.01
02						Snow	43	11	92	9	0.01
03						Snow	47	12	94	8	0.02
04						Snow	55	10	93	7	0.03
05						Snow	63	7	92	6	0.04
06						Snow	72	4	91	5	0.05
07						Snow	73	4	91	5	0.04
08:00 Sun	Marginal	18.1	2.8	16.1	92	Snow	75	5	92	4	0.03
09:00 Sun	Marginal	18.2	3.0	16.0	91	Snow	76	5	92	4	0.01
10:00 Sun	Marginal	18.2	3.2	15.6	89	Snow	77	5	93	4	0.02
11:00 Sun	Marginal	18.2	3.3	15.1	87	Snow	78	4	95	4	0.02
12:00 Sun	Marginal	18.3	3.5	14.6	85	Snow	80	4	96	4	0.02
13:00 Sun	Marginal	18.8	3.7	14.6	84	Snow	70	3	98	4	0.01
14:00 Sun	Marginal	19.3	3.8	14.6	82	Snow	61	3	99	4	0.01

Probabilities of Rain, Snow, Ice, overall chance of precipitation & declared precipitation type are presented in tabular form. This allows operators to assess the probabilities of each precipitation type.

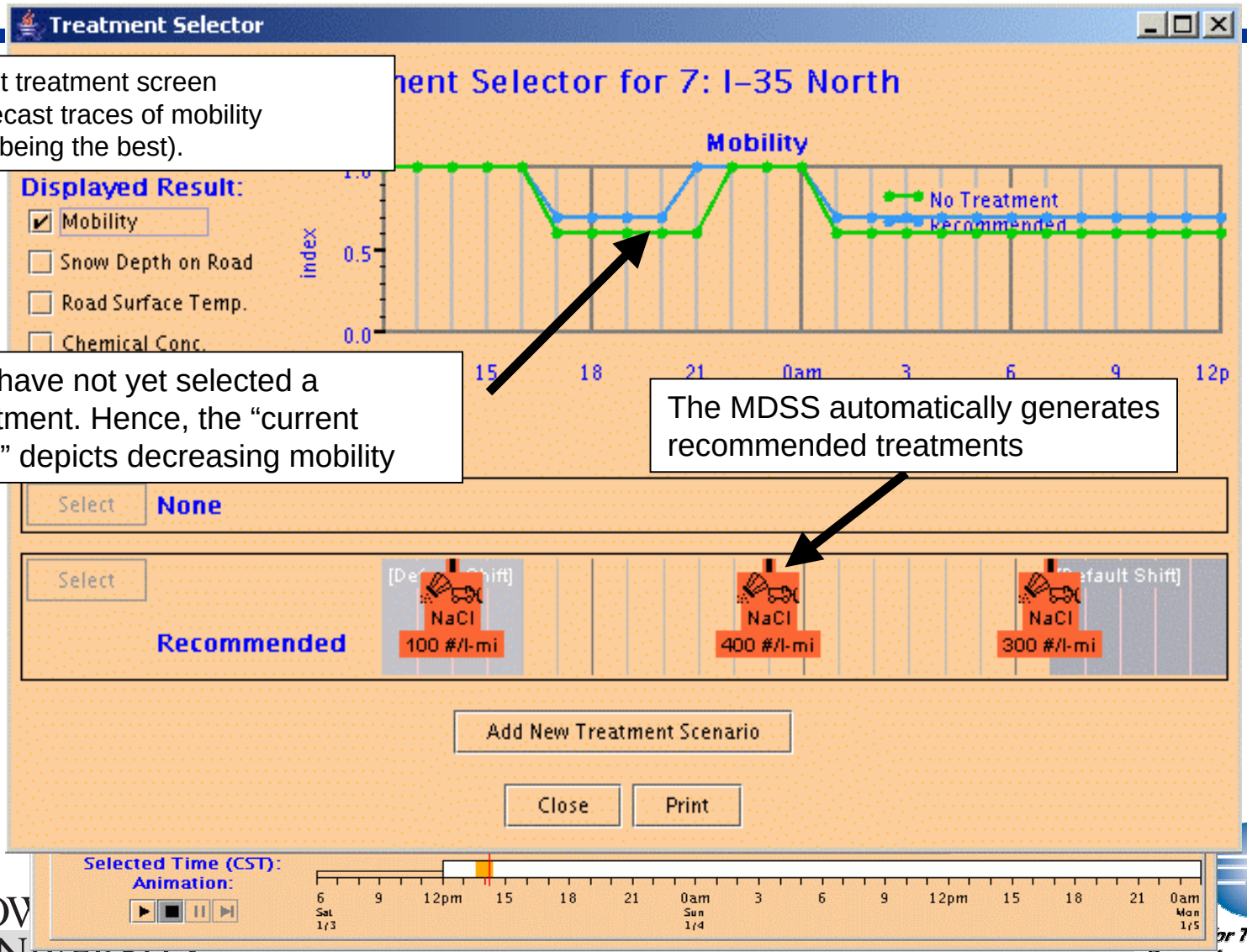
Close | Print | Graph View | Table View

MDSS Treatment Recommendations

The default treatment screen shows forecast traces of mobility index (1.0 being the best).

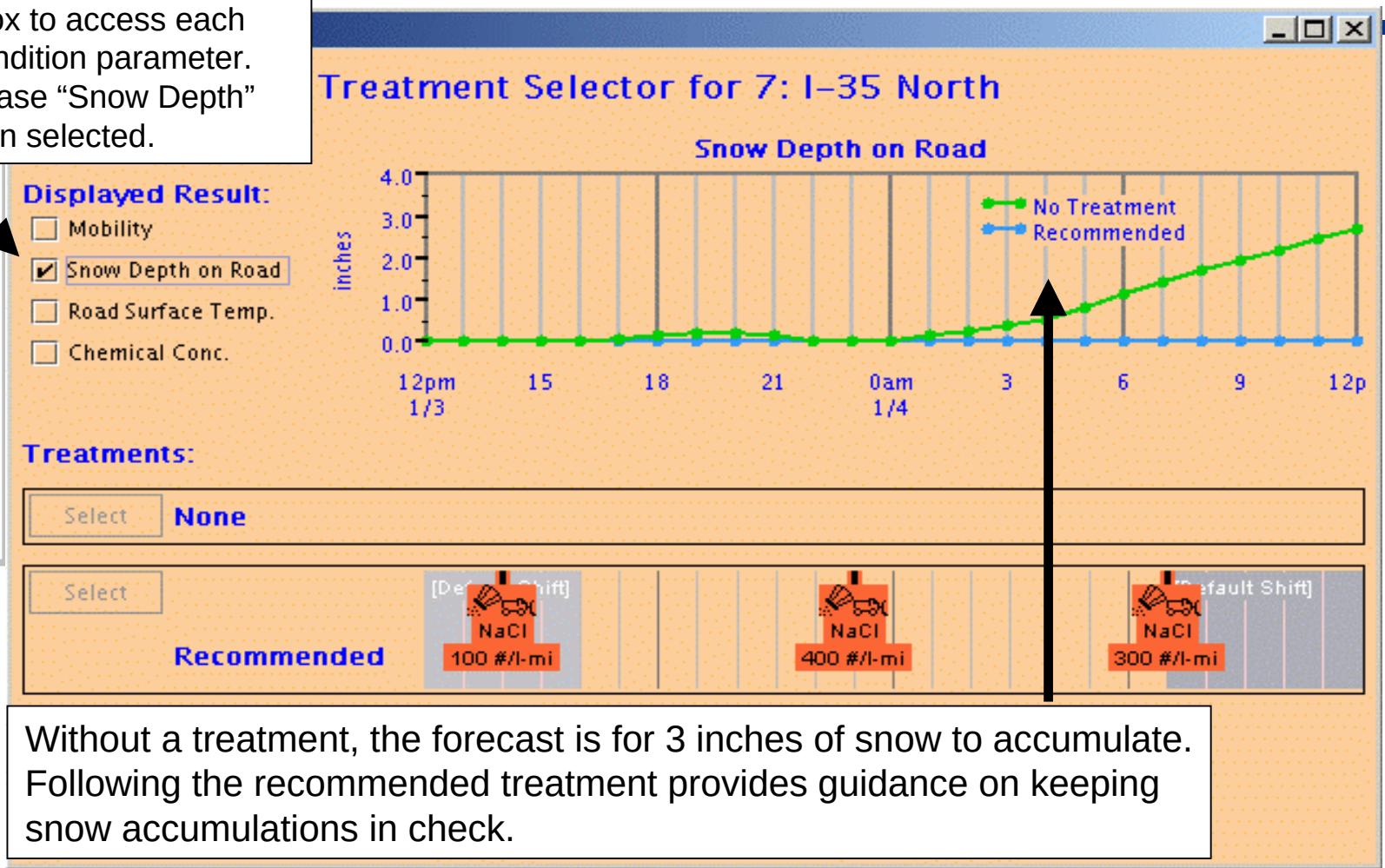
We have not yet selected a treatment. Hence, the “current plan” depicts decreasing mobility

The MDSS automatically generates recommended treatments



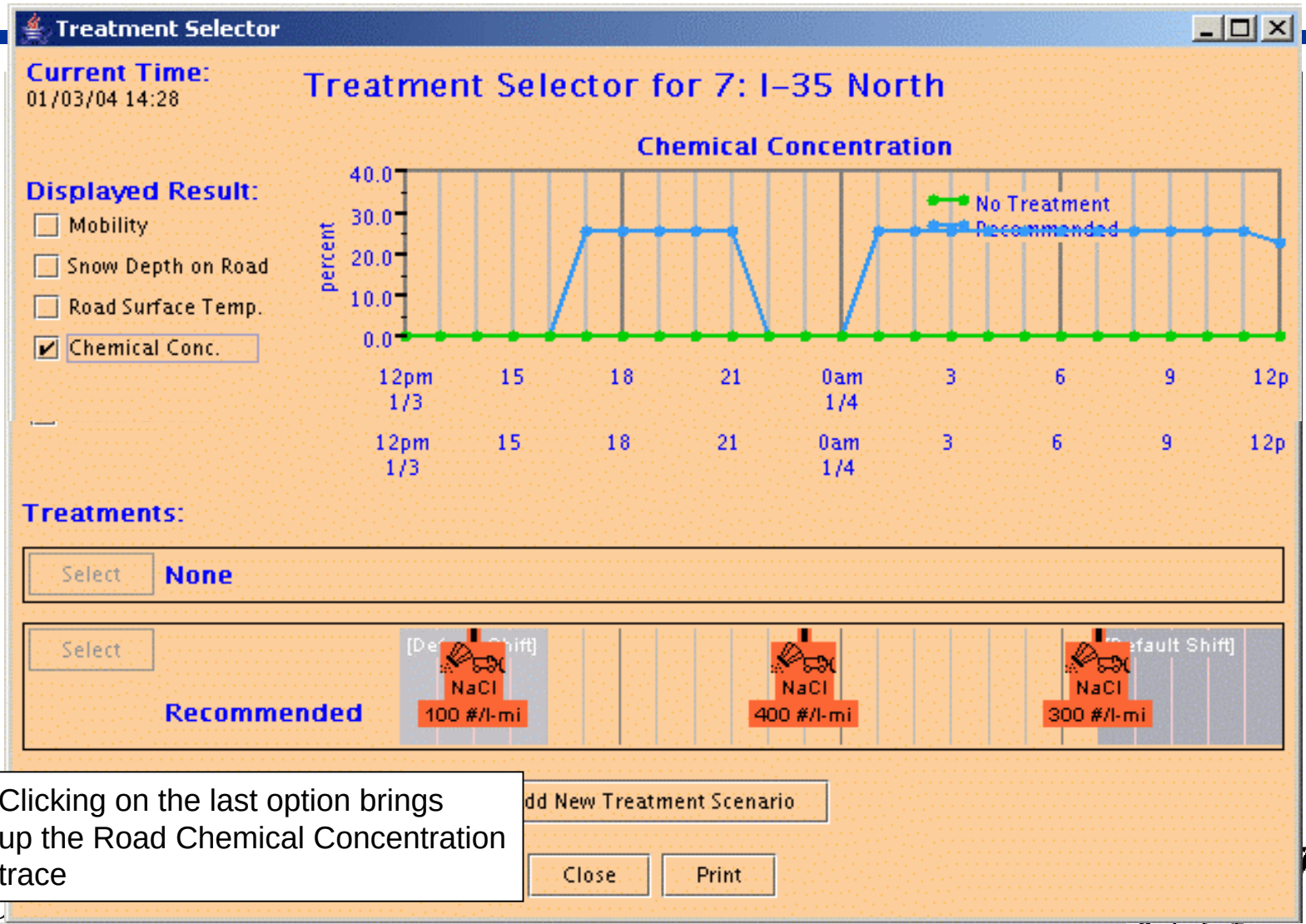
MDSS Treatment Recommendations

You can click on each checkbox to access each road condition parameter. In this case “Snow Depth” has been selected.



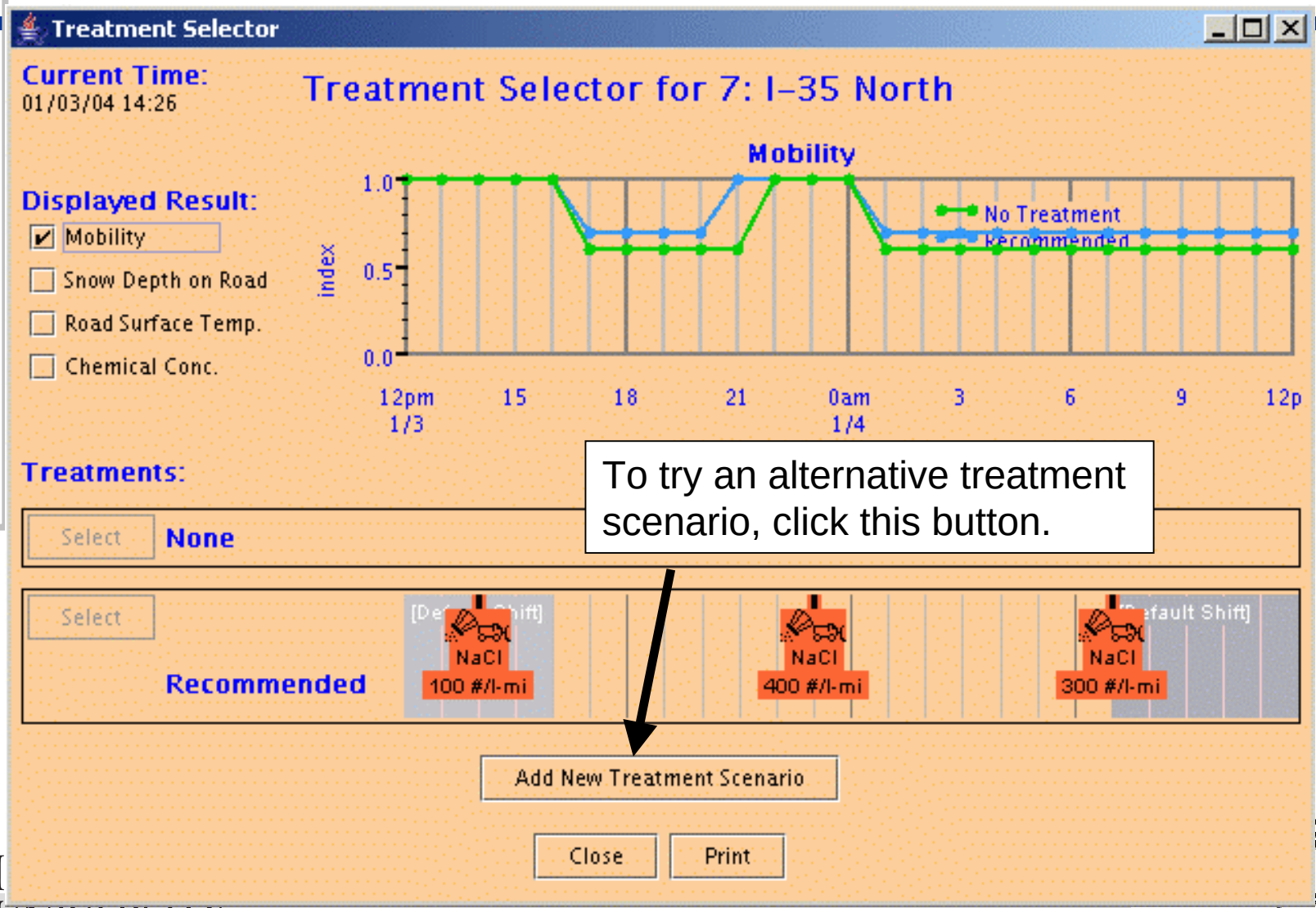
Without a treatment, the forecast is for 3 inches of snow to accumulate. Following the recommended treatment provides guidance on keeping snow accumulations in check.

MDSS Treatment Recommendations

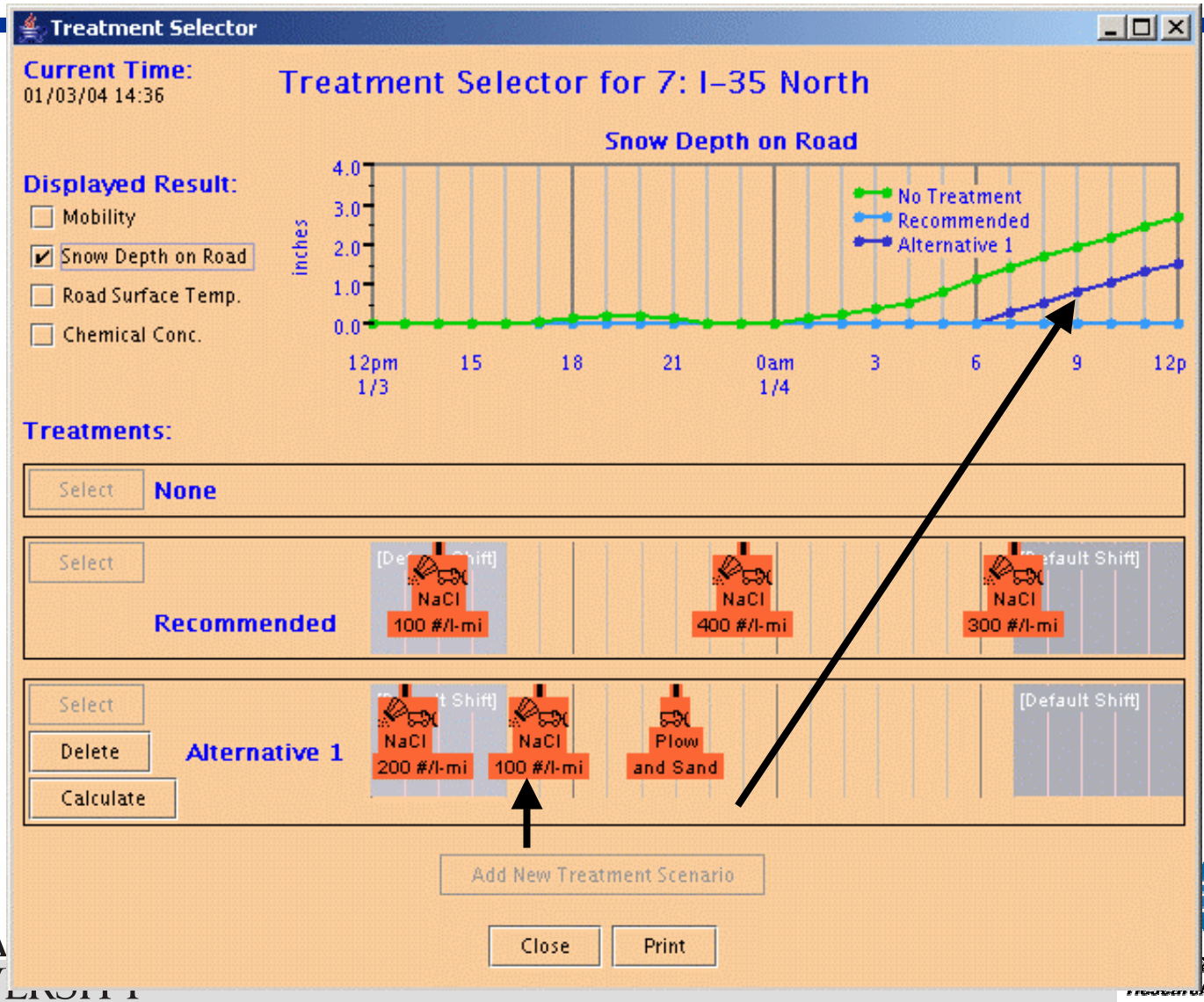


Clicking on the last option brings up the Road Chemical Concentration trace

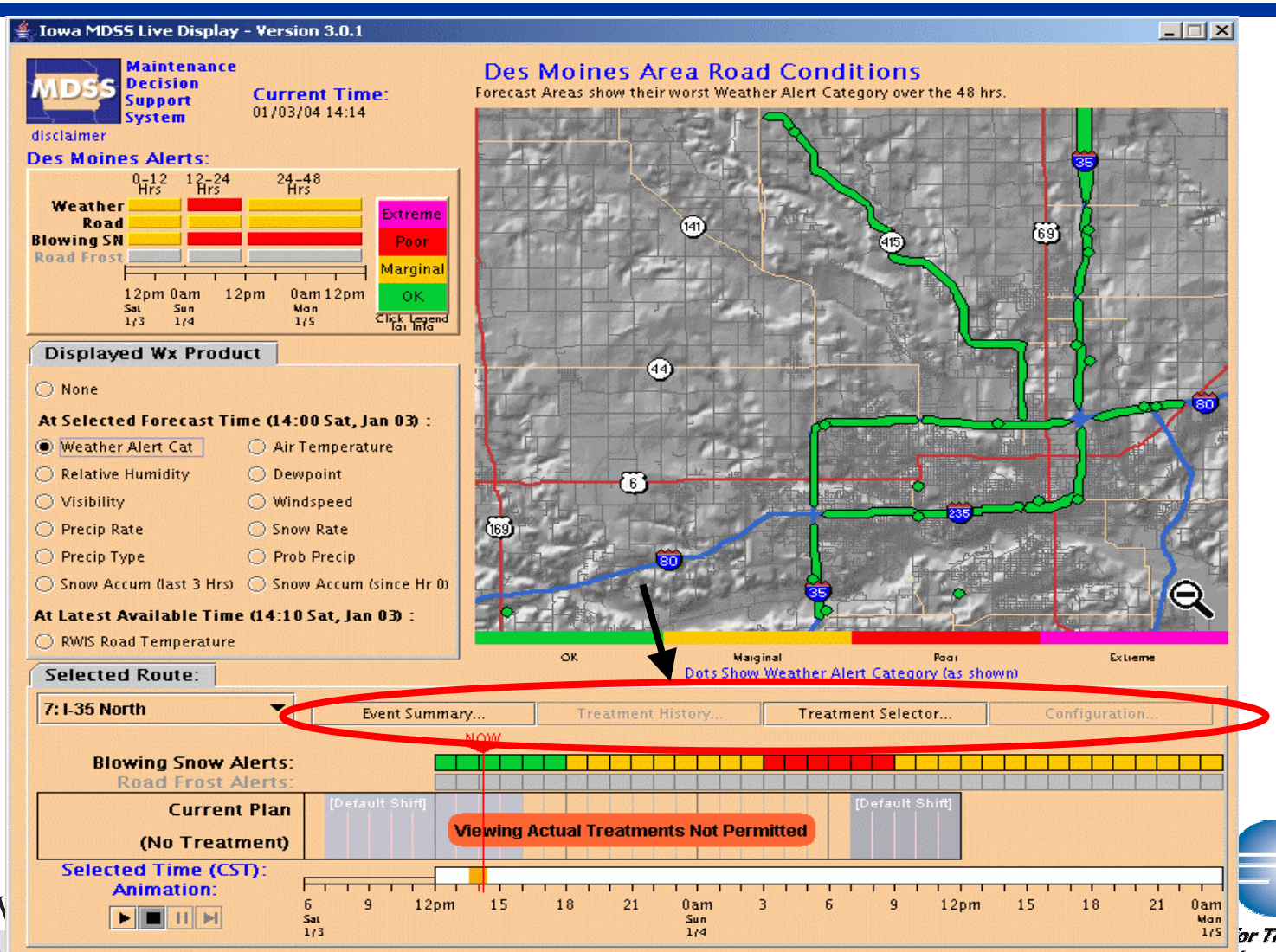
“What-If” Scenarios



Treatment “What-If” Scenarios



Functionality Wrap-Up

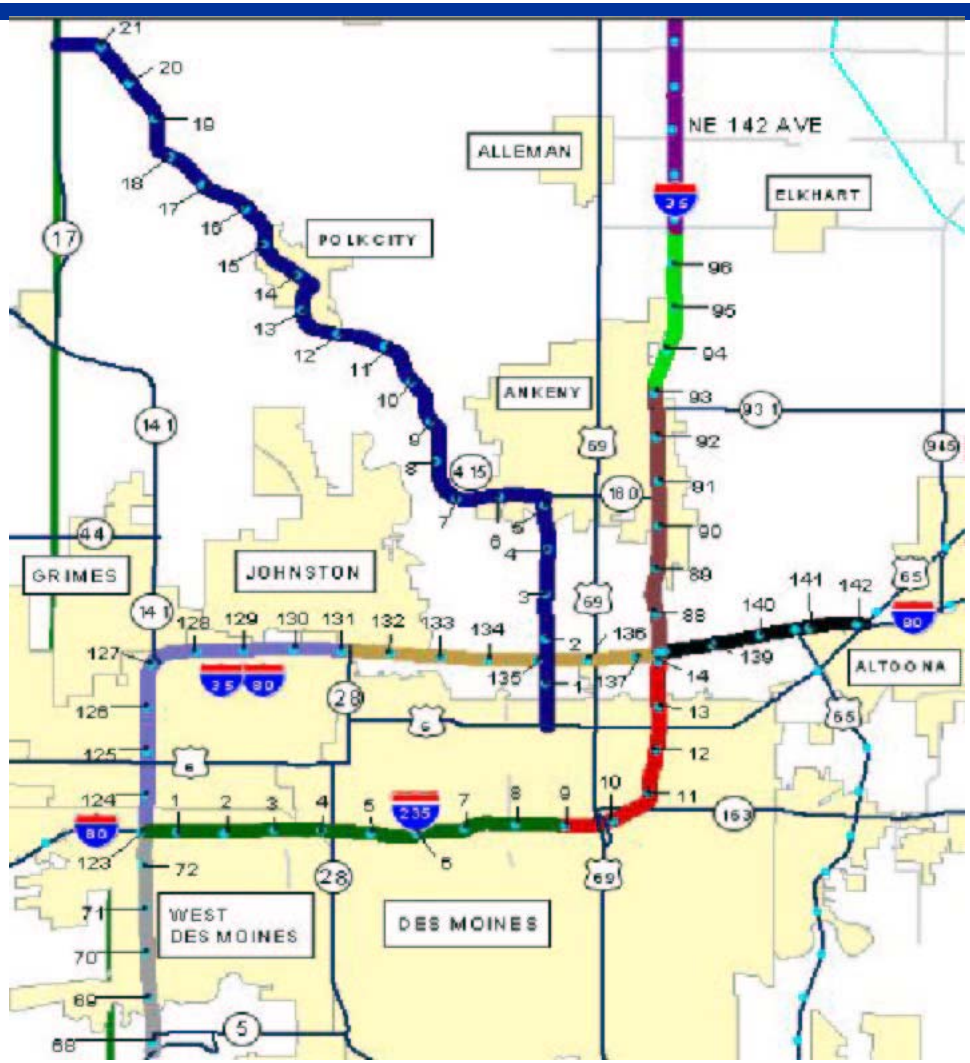


Verification Data

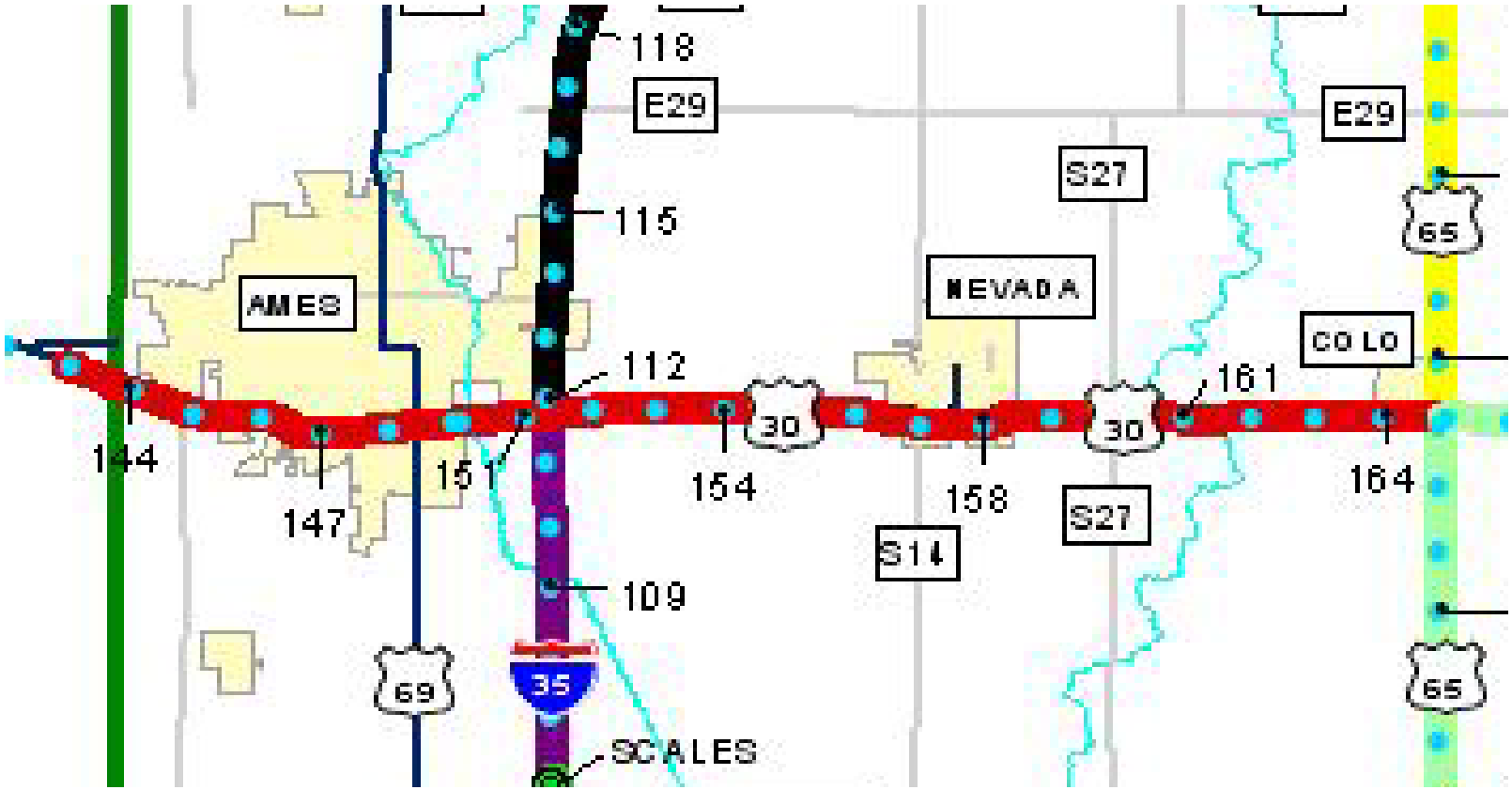
- Iowa DOT provided field weather and operational data from the garages to verify the model.
- Iowa RWIS
- NWS METAR
- Local observer surface data
- Weather Satellite
- Weather Radar
- Others

Observed Conditions

Des Moines Area Map



Ames Area Map



Concept Vehicle Data

Daily Work Sheet - Snow Removal, Ice Control & Equipment

Equipment	Equipment usage time	Equipment usage distance (miles)
Plow	0:00:00	0
Left Wing	0:00:00	0
Right Wing	0:00:00	0
Scraper	0:00:00	0

Date: 2/18/2004

Truck ID: 30144

Console ID: DCS710C

Operator ID:

No equipment data collected in this pass

Start Time	Stop Time	Hours Master On	Average Speed (mph)	Spreading Distance (mi)	Sand (tons)	Salt (tons)	Prod1 (tons)	Prod2 (tons)	Prewet (gal)	Anti ice (gal)
10:32:13	12:03:32	1:31:19	31.21	47.50	0.00	8.00	0.00	0.00	0.00	19182.00
TOTALS		**1:31:19**	**31.21**	**47.50**	**0.00**	**8.00**	**0.00**	**0.00**	**0.00**	**19182.00**

*UW FastTrack2000

Additional Data Sets

- Crew reports
- Winter Supplements
- Roadway Chemical Samples
- Autoscope
- Snow Pyronometer

Autoscope Info

Snow Depth Gauge

Conclusions

- Demonstration to finish this year
- MDSS will be able to provide maintenance managers with additional information
- Complement other information sources

Field Data

Field Data

Thank You

On behalf of the Federal Highway Administration, the Iowa Department of Transportation, and the national laboratories involved in the MDSS project, thank you for your interest.

An MDSS Stakeholder Meeting will take place in Boulder, CO during the July 21-22, 2004 to discuss the results of this demonstration and to share experiences. All are welcome to attend. Contact Andy Stern at astern@mitretek.org for further information.

For additional information on the MDSS project, please visit the following web sites:

The Federal Highway Administration, Road Weather Management Program site at: http://www.ops.fhwa.dot.gov/weather/index.htm

The National Center for Atmospheric Research (NCAR) web site at:

http://www.rap.ucar.edu/projects/rdwx_mdss/index.html