Why Winter Maintenance?

Weather related traffic accidents cost USA $150B 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
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

- GPS
- TEMP SENSOR
- RDS DUMP BODY
- ON BOARD SYSTEMS
- HID LIGHTS
- MOBILE FRENSEOR
- SALTAR FRICTION METER
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

NOAA/NWS
- Numerical Weather Prediction Models
- Surface Observations
- Model Statistics

NOAA/FSL (Boulder, CO)
- Supplemental Numerical Weather Prediction Models
- RWIS Data

NCAR (Boulder, CO)
- Road Weather Forecast System
- Road Condition & Treatment Module
- Data Server

Iowa DOT Data
- RWIS
- Road characteristics
- Route characteristics
- Thermal map data

Iowa DOT Ames Garage
- PC Java Application
- PC Java Application

Iowa DOT Des Moines West Garage
- PC Java Application
- PC Java Application

Iowa DOT Des Moines North Garage
- PC Java Application
- PC Java Application
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
Opening Screen
Weather Alert Screen
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 Alert Category to be satisfied is generated. All listed weather variables for a weather condition must be met. Empty variables may have any value.

<table>
<thead>
<tr>
<th>Weather Alert Category</th>
<th>Reason</th>
<th>Precip Type</th>
<th>Precip Rate</th>
<th>Wind Speed</th>
<th>Temperature</th>
<th>Rel. Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>Ice or Freezing Rain</td>
<td>Ice</td>
<td>&gt;= 1.5&quot;/hr</td>
<td>&lt; 5 mph</td>
<td>&lt; 35 deg. F</td>
<td></td>
</tr>
<tr>
<td>Extreme</td>
<td>Heavy Snow</td>
<td>Snow</td>
<td>&gt;= 0.5&quot;/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>Moderate Snow</td>
<td>Snow</td>
<td>&gt;= 0.25&quot;/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>Cold Rain</td>
<td>Rain</td>
<td>&gt;= 0.1&quot;/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>Light Snow</td>
<td>Snow</td>
<td>&lt; 0.25&quot;/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>Light Rain</td>
<td>Rain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td>No Conditions Met</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Road Alert Category</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>0.0 to 0.25</td>
</tr>
<tr>
<td>Poor</td>
<td>0.25 to 0.5</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.5 to 0.75</td>
</tr>
<tr>
<td>OK</td>
<td>0.75 to 1.0</td>
</tr>
</tbody>
</table>

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 (gustiest and expected gusts at time t)
3. 24 hour precipitation (rain or freezing rain in RWSS) occur anytime between the last time that snow occurred and time t
4. Maximum 24 hour temperature during the last 4 days of snowfall or less if the snow event lasted for 48 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

- Red tick shows selected time
- Place cursor over a forecast point
- Forecast weather categories at this site
- Forecast date/time, weather category & reason for the alert
Tabular Model Output for each Forecast Point
Introducing Probabilistic Forecast Information

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.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
<th>Wx Alert</th>
<th>Air T (F)</th>
<th>Tot Snow (in)</th>
<th>Dewpt (F)</th>
<th>RH (%)</th>
<th>Precip Type</th>
<th>Prob Precip (%)</th>
<th>Prob Rain (%)</th>
<th>Prob Snow (%)</th>
<th>Prob Ice (%)</th>
<th>Prob Precip (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00</td>
<td>Sat</td>
<td>None</td>
<td>21.7</td>
<td>0.0</td>
<td>11.0</td>
<td>63</td>
<td>None</td>
<td>45</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>13:00</td>
<td>Sat</td>
<td>None</td>
<td>23.0</td>
<td>0.0</td>
<td>11.2</td>
<td>60</td>
<td>None</td>
<td>31</td>
<td>11</td>
<td>99</td>
<td>9</td>
<td>0.0</td>
</tr>
<tr>
<td>14:00</td>
<td>Sat</td>
<td>None</td>
<td>24.3</td>
<td>0.0</td>
<td>12.3</td>
<td>60</td>
<td>None</td>
<td>42</td>
<td>0</td>
<td>96</td>
<td>15</td>
<td>0.0</td>
</tr>
<tr>
<td>15:00</td>
<td>Sat</td>
<td>None</td>
<td>24.6</td>
<td>0.0</td>
<td>14.0</td>
<td>63</td>
<td>None</td>
<td>36</td>
<td>2</td>
<td>98</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>16:00</td>
<td>Sat</td>
<td>Marginal</td>
<td>24.7</td>
<td>0.1</td>
<td>14.3</td>
<td>64</td>
<td>Snow</td>
<td>38</td>
<td>0</td>
<td>100</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>17:00</td>
<td>Sat</td>
<td>Marginal</td>
<td>23.4</td>
<td>0.3</td>
<td>16.4</td>
<td>74</td>
<td>Snow</td>
<td>55</td>
<td>0</td>
<td>100</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>18:00</td>
<td>Sat</td>
<td>Marginal</td>
<td>23.3</td>
<td>0.4</td>
<td>17.8</td>
<td>79</td>
<td>Snow</td>
<td>68</td>
<td>29</td>
<td>99</td>
<td>7</td>
<td>0.02</td>
</tr>
<tr>
<td>19:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>51</td>
<td>11</td>
<td>100</td>
<td>4</td>
<td>0.01</td>
</tr>
<tr>
<td>20:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>64</td>
<td>11</td>
<td>100</td>
<td>3</td>
<td>0.0</td>
</tr>
<tr>
<td>21:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>49</td>
<td>11</td>
<td>97</td>
<td>6</td>
<td>0.0</td>
</tr>
<tr>
<td>22:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>27</td>
<td>16</td>
<td>94</td>
<td>3</td>
<td>0.0</td>
</tr>
<tr>
<td>23:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>24</td>
<td>16</td>
<td>93</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>00:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>18</td>
<td>4</td>
<td>95</td>
<td>7</td>
<td>0.0</td>
</tr>
<tr>
<td>01:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>51</td>
<td>9</td>
<td>90</td>
<td>9</td>
<td>0.01</td>
</tr>
<tr>
<td>02:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>43</td>
<td>11</td>
<td>92</td>
<td>9</td>
<td>0.01</td>
</tr>
<tr>
<td>03:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>47</td>
<td>12</td>
<td>94</td>
<td>8</td>
<td>0.02</td>
</tr>
<tr>
<td>04:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>55</td>
<td>10</td>
<td>93</td>
<td>7</td>
<td>0.03</td>
</tr>
<tr>
<td>05:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>63</td>
<td>7</td>
<td>92</td>
<td>6</td>
<td>0.04</td>
</tr>
<tr>
<td>06:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>72</td>
<td>4</td>
<td>91</td>
<td>5</td>
<td>0.06</td>
</tr>
<tr>
<td>07:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snow</td>
<td>73</td>
<td>4</td>
<td>91</td>
<td>5</td>
<td>0.04</td>
</tr>
<tr>
<td>08:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>18.1</td>
<td>2.8</td>
<td>16.1</td>
<td>92</td>
<td>Snow</td>
<td>76</td>
<td>5</td>
<td>92</td>
<td>4</td>
<td>0.03</td>
</tr>
<tr>
<td>09:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>18.2</td>
<td>3.0</td>
<td>16.0</td>
<td>91</td>
<td>Snow</td>
<td>76</td>
<td>5</td>
<td>92</td>
<td>4</td>
<td>0.01</td>
</tr>
<tr>
<td>10:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>18.2</td>
<td>3.2</td>
<td>15.6</td>
<td>89</td>
<td>Snow</td>
<td>77</td>
<td>5</td>
<td>93</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>11:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>18.2</td>
<td>3.3</td>
<td>15.1</td>
<td>87</td>
<td>Snow</td>
<td>78</td>
<td>4</td>
<td>95</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>12:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>18.3</td>
<td>3.5</td>
<td>14.6</td>
<td>85</td>
<td>Snow</td>
<td>80</td>
<td>4</td>
<td>96</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>13:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>16.0</td>
<td>3.7</td>
<td>14.6</td>
<td>84</td>
<td>Snow</td>
<td>70</td>
<td>3</td>
<td>98</td>
<td>4</td>
<td>0.01</td>
</tr>
<tr>
<td>14:00</td>
<td>Sun</td>
<td>Marginal</td>
<td>19.3</td>
<td>3.8</td>
<td>14.6</td>
<td>82</td>
<td>Snow</td>
<td>51</td>
<td>3</td>
<td>99</td>
<td>4</td>
<td>0.01</td>
</tr>
</tbody>
</table>
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

To try an alternative treatment scenario, click this button.
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
Concept Vehicle Data

Daily Work Sheet - Snow Removal, Ice Control & Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Equipment usage time</th>
<th>Equipment usage distance (miles)</th>
<th>Date: 2/18/2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plow</td>
<td>0:00:00</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Left Wing</td>
<td>0:00:00</td>
<td>0</td>
<td>Truck ID: 30144</td>
</tr>
<tr>
<td>Right Wing</td>
<td>0:00:00</td>
<td>0</td>
<td>Console ID: DCS710C</td>
</tr>
<tr>
<td>Scraper</td>
<td>0:00:00</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

No equipment data collected in this pass

<table>
<thead>
<tr>
<th>Start Time</th>
<th>Stop Time</th>
<th>Master On</th>
<th>Average Speed (mph)</th>
<th>Spreading Distance (mi)</th>
<th>Sand (tons)</th>
<th>Salt (tons)</th>
<th>Prod1 (tons)</th>
<th>Prod2 (tons)</th>
<th>Prewet (gal)</th>
<th>Anti ice (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:32:13</td>
<td>12:03:32</td>
<td>1:31:19</td>
<td>31.21</td>
<td>47.50</td>
<td>0.00</td>
<td>8.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>19182.00</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
<td>31.21</td>
<td>47.50</td>
<td>0.00</td>
<td>8.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>19182.00</td>
</tr>
</tbody>
</table>
Additional Data Sets

- Crew reports
- Winter Supplements
- Roadway Chemical Samples
- Autoscope
- Snow Pyromonometer
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 National Center for Atmospheric Research (NCAR) web site at: http://www.rap.ucar.edu/projects/rdwx_mdss/index.html