Integrating Weather into Transportation Operations - Decision Support Beyond Snow & Ice Control

Ray Murphy, ITS Specialist
Federal Highway Administration

Overview

- The Problem... Weather Impacts
- The Challenge... Road Weather Management
- MDSS... Snow & Ice Decision Support
- Integrating Weather into Transportation Operations - MODSS & Clarus
The Problem - Weather & Safety

> The annual toll under adverse weather conditions:
  - 7,400 fatalities
  - 690,000 injuries
> 24% of all crashes occurred on slick pavement or under adverse weather

The Problem - Weather & The Economy

> Direct Costs for snow removal (> $2 billion/year) and infrastructure repair (> $5 billion/year)
> Road closures that cause lost retail trade, wages, and tax revenue can exceed $10 billion/day in eastern U.S.
> Weather-related delay adds $3.4 billion/year to freight costs; $9.45 billion/year for all in 85 major urban areas
> About 25% of non-recurrent congestion on freeways is due to weather; system delay is 1 billion hours/year
> Travel delay can increase by 11% to 50% depending on weather severity

Source: Economic Statistics for NOAA, fifth edition, April 2006; USDOT
The Problem - Weather & The Environment

> Anti-icing and deicing materials effect watersheds, air quality and the infrastructure

The Past - the Great Divide

Transportation Community

Weather Community

The Challenge - develop solutions that will:

- reduce the impacts,
- be cost-effective, and
- foster further development and innovation in a fiscally constrained environment
Framing the Challenge

- Transportation Resources & System Status
- Weather Forecast Models
- Observing Systems

Societal Benefits... ultimately saving lives, time and money

Decision Support Systems & Assessments
- Management Decisions
- Policy Decisions

On-going feedback to optimize value and reduce gaps

Road Weather Management Development Approach

> Multi-disciplinary:

<table>
<thead>
<tr>
<th></th>
<th>Transportation</th>
<th>Weather (Wx)</th>
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<tbody>
<tr>
<td>Public</td>
<td>State &amp; Local DOTs</td>
<td>NWS</td>
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<tr>
<td>Private</td>
<td>Suppliers, etc.</td>
<td>Wx Services</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td>Research Community</td>
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> Federal investments in high-risk research
> Develop prototypes, not individual solutions
> Don’t stop at software - it also requires training, outreach, marketing
> Measure performance
APWA World Congress New Orleans, Louisiana

Road Weather Management Program

Federal Highway Administration (FHWA) Road Weather Management Program objective:

• Develop an understanding of how weather and road conditions impact the nation’s roadways
• Determine how best to mitigate road weather impacts

FHWA initiated a project to:

• Construct a MDSS functional prototype (MDSS FP) that can provide objective guidance to winter road maintenance decision makers concerning the appropriate treatment strategies to use to control roadway snow and ice during adverse winter weather events
• Provide a system that will serve as a catalyst for additional research and development by the private sector
• Raise overall awareness of the impact of weather on the roadway system by involving: AMS, APWA, ITSA, TRB, AASHTO, State & Local DOTs, private sector, universities, national labs, etc.
• Investigate new weather technologies and methods that may have applicability for road weather use
Road Weather Management Program

**Applied Research:**
- Maintenance Decision Support System (MDSS)
- Maintenance & Operations Decision Support System (MODSS)
- The *Clarus* Initiative

**FHWA initiated a project to:**
- Stakeholder Coordination
- Technology Transfer, Training & Education
- Performance Management & Evaluation

Improve safety & mobility by alleviating the effects of adverse weather on the transportation system.

**MDSS Strategic Capabilities**

- **Weather Information**
  - Air temperature
  - Relative humidity
  - Wind speed/direction
  - Precipitation type, rate, accumulation

- **Pavement Information**
  - Road temperature
  - Bridge temperature
  - Bridge frost potential
  - Blowing snow potential
  - Road contamination & chemical concentration

- **Treatment Guidance**
  - Treatment type (plow, chemical, pre-treat)
  - Treatment amount
  - Treatment location
**MDSS Tactical Capabilities**

- Observed (e.g., RWIS)
  - Air temperature
  - Relative humidity
  - Wind speed
  - Road temperature
  - Bridge temperature
  - Subsurface temp.

- Remotely Sensed
  - Radar reflectivity
  - Satellite imagery

- Other
  - Automated Vehicle Location (AVL)
  - Camera (fixed and mobile)
  - Tactical alerts
    - Frozen precipitation
    - Pavement temp. < 0°C

**MDSS Structure**

- Data Ingest Module
- Road Weather Information System (RWIS) data
- Miscellaneous observations (e.g., airport)

- Road Wx Forecast and Data Fusion Module
- Consensus forecast generation

- Road Condition and Treatment Module
- Road temperature and condition forecasts
- Rules of practice for anti-icing and deicing operations
- Treatment recommendations

- Java-based Display
- Delivery of information and data from upstream modules to end users via an interactive Graphical User Interface
MDSS Modules: Data Input

National Weather Service Data
- Surface Observations (METAR)
- National Weather Models
- Regional Weather Models
- Model Statistics

State DOT Data
- RWIS/ESS Observations
- Road Characteristics
- Route Metadata

Road Weather Forecast System
- Forecast Module 1
- Forecast Module 2
- Forecast Module 3
- Forecast Module 4
- Forecast Module 5
- Forecast Product

Road Cond & Treatment Module
- Road Temperature Prediction Model
- Chemical Concentration Algorithm
- Rules of Practice for Anti- and Deicing
- Blowing Snow Algorithm
- Bridge/Road Frost Algorithm

MDSS Modules: Data Fusion

National Weather Service Data
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Road Weather Forecast System
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Road Cond & Treatment Module
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- Chemical Concentration Algorithm
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MDSS Modules: Customization

National Weather Service Data
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- RWIS/ESS Observations
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Road Weather Forecast System
- Forecast Module 1
- Forecast Module 2
- Forecast Module 3
- Forecast Module 4
- Post Processor
- Forecast Product

Road Cond & Treatment Module
- Road Temperature Prediction Model
- Chemical Concentration Algorithm
- Rules of Practice for Anti- and Deicing
- Blowing Snow Algorithm
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MDSS Modules: GUI

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MDSS Graphical User Interface

Road Weather Forecast System

Road Cond & Treatment Module
The MDSS Main Screen Display is composed of 4 main parts:

- **State Alerts and Local Routes**
- **Road & Weather Alerts**
- **Weather & Road Parameters**
- **Time Selection and Animation**

The State is plotted into county forecast zones. Routes views are selected from the pull down menu.

Main Display with radar & air temperatures

Selected Maintenance Area

Area Observations submenu

Point Observations submenu
Display GPS/AVL Plow information

Shows Snow Depth, Wind Speed & Plow info
Maintenance Decision Support System

- Version 5.0
  - incorporates radar and satellite images,
  - updates the road temperature model and
  - generates alerts to predicted problems

- Moved from a research project to a market ready technology

- Innovations:
  - 1st program to convert weather forecasts into a transportation decision tool
  - Integrated AVL data into MDSS for tactical tool & strategic use

MDSS Version 5.0 Refinements and Improvements

Java-based Display

- Integrating support for various fixed and mobile cameras
MDSS Version 5.0 Refinements and Improvements

Java-based Display

- Enhancements to real-time and near-term road weather hazards

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MDSS Version 5.0 Refinements and Improvements

Java-based Display

- Examine archived events, including weather and road condition forecasts, observations, treatment recommendations, and selected treatment actions
MDSS Version 5.0 Refinements and Improvements

Java-based Display

• Incorporating support for animating AVL data and playback

Invest in MDSS

State & local agencies spend billions...

Activities include all necessary labor, equipment, & materials used for applying salt, other chemicals, or sand to the roadway during or after weather events; for plowing snow, ice, and slush from roadways and bridges.
MDSS...
A Smart Investment in Winter Maintenance

Benefit Areas:

- Safety
- Mobility
- Productivity
- Efficiency
- Energy & Environment
- Customer Satisfaction

MDSS = Smart Return On Investment (ROI)
Executive Summary

- Overview
- Why Use MDSS?
- Deploying MDSS
- Lessons Learned
- Getting Help

MDSS DEPLOYMENT GUIDE

Deploying MDSS

- Deployment Phases & Tasks
  - Planning & Justification
  - Acquisition
  - Implementation
  - Use & Evaluation

MDSS DEPLOYMENT GUIDE
MODSS premise...

MODSS: Maintenance & Operations Decision Support System

- Leverage lessons learned & software developed for MDSS
- Integrate Weather into Transportation Operations - Decision Support Beyond Snow & Ice maintenance to areas such as traffic management & construction

2007 Stakeholder Meeting

State DOT Participants - MODSS Traffic Management

- Todd Kramascz
- Ed Cox
- Dave Kinnecom
- Ralph Patterson
- Dave Bowlby
- Dave Rossback
- Jeff Galas
- Brian Burk
- Larry Haas
Basic MODSS Requirements

> **Rapid updates** should be provided (minutes not hours)
> Extreme **quality control** should be employed
> **Historical data** should be available (event review)
> **Data export** should support common formats (xml, shape files, etc.)
> **Automated alerts** should be provided (user defined thresholds)
> Design should support tactical (0-3 hrs) and planning horizons (1 to 5 days)
> An **event planner** feature should be provided

Traffic Management Activities
Outcomes from the MODSS stakeholder meeting:

> Traveler information - alert drivers to road weather conditions (e.g., flooded roads) for improved route choice and trip timing

> Incident Management - resource allocation based on local weather events

> Signal control -
  – modify signal timing due to traffic flow changes under adverse weather
  – Provide tactical information to assist repair crews (e.g., radar, lightning detection)
Transition to MODSS

MODSS = Maintenance & Operations Decision Support System

- National Weather Service Data
  - Surface Observations (METAR)
  - National Weather Models
  - Regional Weather Models
  - Model Statistics

- State DOT Data
  - RWIS/ESS Observations
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- Road Weather Forecast System

- New Customized Modules
  - Maintenance beyond Snow & Ice
  - Traffic Management
  - Construction

- Graphical User Interface

MODSS: High-level View

- Meteorology
  - Environmental Sensor Stations (ESS)
  - Vehicle-based Observations (VII)
  - Supplemental Wx Obs (ASOS, Radar, Satellite)
  - Numerical Weather Forecast Data

- Surface Transportation Weather Management System (Clarus)

- Operations
  - Traffic Monitoring Systems
    - Cameras, Loops
  - Traffic Analysis Tools
  - Standard Operating Procedures (e.g., Rules of Practice)

- Maintenance & Operations Decision Support System (MODSS)

- Winter Maintenance Decision Support System (MDSS)
- Maintenance Beyond Snow & Ice Control Decision Support System
- Traffic Management Decision Support System
- Construction Management Decision Support System
- Other Surface Transportation Decision Support Systems

- Strategies & Guidance to aid Surface Transportation Decision-Makers
Weather-Responsive Traffic Management

Goals/Objectives:

✓ Build awareness and create a culture in which incident management integrates the potential affects of weather on roadway safety and capacity.

✓ Encourage the development of new concepts and tools to facilitate the integration of weather into your incident management programs.

✓ Understand the importance for developing inter-agency coordination and cooperation between the weather and incident management communities.

✓ Help develop effective performance measures which include weather parameters for incident management programs.

Nonrecurring Congestion

The three main causes of nonrecurring congestion are:

✓ incidents ranging from a flat tire to an overturned hazardous material truck (25 percent of congestion),

✓ work zones (10 percent of congestion), and

✓ weather (15 percent of congestion).

Source: “Traffic Congestion and Reliability,” FHWA (September, 2005)
Reducing Non-Recurring Congestion

- About half of congestion is caused by temporary disruptions that take away part of the roadway from use - or "nonrecurring" congestion.
- Nonrecurring events dramatically reduce the available capacity and reliability of the entire transportation system. This is the type of congestion that surprises us.
- Travelers and shippers are especially sensitive to the unanticipated disruptions to tightly scheduled personal activities and manufacturing distribution procedures.

Aggressive management of temporary disruptions, such as incidents, work zones, weather, and special events can reduce the impacts of these disruptions and return the system to "full capacity."

Weather Integration in TMC/TOC’s

- **Team:** Battelle, Iteris, URS, Meridian, McFarland Mgmt.
- **Objectives:**
  - Document needs/opportunities for TMC integration
  - Explore concept, methods, potential & challenges for integration

**GOALS**

- Review and synthesize existing practices around the country
- Identify needs and opportunities for weather integration
- Provide guidance and tools to transportation agencies
- Describe benefits of weather integration
Weather Integration in TMC’s

- Five levels of integration were analyzed
  - Operational,
  - Physical,
  - Technical,
  - Procedural,
  - Institutional

- Summary of Practices
  - Most centers respond to traffic, not weather
  - Use info from Weather Channel and ESS
  - 16 TMC’s out of 38 receive daily weather info, only 4 integrate weather in daily operations (mostly for advisory purposes)
TMC Weather Integration

Definition: How people, organizations and systems interact to share information, make better decisions, and improve TMC/TOC transportation operations, safety and security during weather events.

Dimensions of Integration

Physical Integration
Technical Integration
Procedural Integration
Institutional Integration

Operational Integration

Opportunities for Integration

> Suggestions towards integration & weather responsive traffic management

– Tailor weather products to needs of decision makers
– Emphasize weather information quality and forecast accuracy
– Encourage research on how weather affects traffic operations and how integration can help
– Address both traffic and transit operations as affected by weather
### Best Practices in Weather Integration

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<th>Integration Concept</th>
<th>Integration Strategy (representing increasing levels of integration)</th>
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<td>• Dedicated weather operations supervisor</td>
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<td></td>
<td>• Identified TMC or maintenance staff member tasked with coordinating weather information at TMC</td>
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<td>• Intra-TMC committee tasked with weather information coordination</td>
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### Benefits of integrating weather data for traffic management:

- More effective advisory, treatment and control strategies
- Smoother TMC activity flow and ability to handle severe weather effects
- Enhanced information exchange to support operations
- Better prepared (informed) TMC operators making better decisions
- Integrated operations lead to satisfied customers
- Reduced weather surprises, better operational response, and a safer transportation system

**TMC Integration Study - Final Report will be available in October**
The Clarus Initiative

> A major initiative to assimilate, quality check and disseminate real-time atmospheric and pavement observations from the States’ investments in environmental sensor stations, and

> Demonstrate the value of “Anytime, Anywhere Road Weather Information” provided by both public agencies and the private weather enterprise to transportation users and operators
The way to get this data into MDSS/MODSS is by the data collection and management system, Clarus.

RWIS/ESS Data
A healthy and reliable ESS network is the basis for a more effective MDSS

Clarus Web Portal
http://www.clarus-system.com
APWA World Congress New Orleans, Louisiana

**Clarus in Minnesota**

MnDOT operates 96 ESS across the state

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**Participation Status for Clarus as of 31 Jul 2008**

Local DOT Participation
- City of Indianapolis
- McHenry County, IL
- NY State Thruway

Color Key
- Connected to Clarus (light green)
- Pending Connection
- Considering Connection

Canadian RWIN Participation
Value of Clarus

> Performs a standard QC and data validation process on all States’ sensor stations
> Allows States to view each other’s data
> Provides health monitoring capability for the sensor network
> Enables States to see full benefit of their investments

Thank you!

Ray Murphy, ITS Specialist
ray.murphy@dot.gov  708-283-3517

Road Weather Management Program
http://www.ops.fhwa.dot.gov/weather/

US DOT- FHWA... moving the American Economy