Road Weather Information Systems (RWIS) and Winter Operations Performance Measures
2018 Purdue Road School
Today’s Topics

• Weather impacts
• What is RWIS? How old is this tool?
• Key RWIS Technology/Innovation
• Key RWIS sensing parameters
• New Data/CBI Improvements for Winter Operations & Maintenance
• Winter Operations Performance Measurement (PM)
• New PM Methods/Case examples
Weather Impact on Transportation

- **Safety**
  - 1.57± million weather-related crashes/year
    - 7,400 fatalities; 690,000 injuries
    - 24% of all crashes occurred on slick pavement or under adverse weather

- **Mobility**
  - Cost of congestion is $9.45 billion/year for the 85 major urban areas (weather causes ~25% of non-recurrent delay on highways)
  - 554 million vehicle-hours of delay per year from snow, ice, and fog

- **Productivity (economic)**
  - Weather related delay adds $3.4 billion to freight costs annually

- **Environment**
  - Chemicals affect watersheds
  - Air quality
  - Infrastructure
To Do Your Job Well You Must Know About...

• Staffing levels
• Equipment and material availability
• Staff and equipment effectiveness
• Outside influences (traffic/congestion)
• Weather and road conditions
RWIS System Overview
Typical RWIS Site

- 33 feet Wind Sensor
- Height based on required field of view Camera
- 10 feet Radiation Sensor
- 6.5-10 feet Visibility Sensor
- 6.5-10 feet Precipitation Sensor
- 10 feet Snow Depth Sensor
- Road Surface, Subsurface, Flooding, Water Level, and Precipitation Accumulation Sensors Located Away from the Tower, Pressure Sensor in RPU
Typical RWIS Site Components

- Wind Speed/Wind Direction
- Non-invasive condition and temperature sensor
- Relative Humidity/Dew point and Precipitation Sensor
- RPU with cell modem communications
- Sub-Surface Temperature Sensor
NON INTRUSIVE PAVEMENT TEMPERATURE SENSOR – FIXED MOUNT (NIRS)
NIRS31 (non-invasive sensor)

Measured parameters:

- Surface conditions: Dry, Damp, Wet, Snow, Ice
- Waterfilm height, Snow height
- Ice percentage in water
- Freezing point, Surface temperature
- Friction coefficient

6 – 15 m
5 – 45°
Salinity and Chemical vs. Friction

- Traditional roadway tools focus and rely on Salinity and Chemical detection

- Traditional tools are chemical dependent.

- Traditional tools are intrusive based technology and have a high life cycle cost structure.

- New Technology offers lower life cycle cost structures, enhanced data sets with an innovative and simplistic maintenance philosophy shift.
Freeze Point – Decision Point

• When using Freeze Point, the decision point is many times not as simple as it could be.

Surface Temp 29°F (-1.6° C)
Fp 28°F (-2.2° C)
Chemically wet / wet & treated

Surface Temp 29°F (-1.6° C)
Fp 30°F (-1.1° C)
Chemically wet / wet & treated

Surface Temp 29°F (-1.6° C)
Fp 32°F (0° C)
Ice Warning

When this change will occur is not easy to tell.
Multiple chemical options with varied Freeze points

How much Chemical do you need?

300 lb. per lane mile?

300 lb. per lane mile with 0.05 inch water on the surface = 7.17% saturated solution

300 lb. per lane mile with 0.10 inch water on the surface = 3.62% saturated solution

Remember though 0.05 and 0.10 inches of water are only 0.5 and 1.0 inches of snow respectively.
**Friction and Chemical concentration**

- Ice layer showing small amount of ICE – Friction 0.6
- As ice increases in density...Friction will fall – Friction<0.6
- Note this is independent of chemical
- Real measure of what is important to the driver

- There are multiple tools!

**INDOT examples:**

- INDOT has FP2000 and IRS31 (intrusive) roadway sensors to measure chemical concentrations
- IRS31 and NIRS31 roadway sensors also measure Friction
- INDOT has Mobile MARWIS Systems that report Roadway Friction
What do the grip/friction numbers mean?

- This is the point that traffic mobility is affected
- Above 0.6 usually wet (or dry) surface
- General ranges of grip
  - .60-.82 wet
  - .50-.60 slush or ice forming
  - .40-.50 snow pack or icy
  - Below .40 cars may start sliding off
  - .30 and lower multiple slide offs possible; mobility greatly affected

Goal: Monitor progress and quality of treatment through friction observations as events unfold
How friction information can be used to maintain roads

- **Level of Service** - Operators receive real time friction data and use this to adjust their treatment of the road

- **Storm Management** - Friction data are collated to a central location and used to deploy assets to locations where friction levels are unacceptable

- **Application of materials** - Real time friction values are used to adjust the application of materials directly from the truck

- **Operator Safety** - Real time friction values provide in-cab warnings to alert operators to presence of black ice

- **Early warning for Ice formation** - Patrol vehicles use friction to locate ice formation and call out trucks for de-icing

- **Litigation** - Archived friction values provide significant benefit when agencies are sued for accidents

- **Quality control** - Friction is used as an independent quality check of roadway conditions. Especially helpful when maintenance services are contracted services.

- **ITS Applications** - Friction values used to inform and advise the traveling public of road conditions with VMS signs or traffic signal control

- **Friction on chemically treated roadways** - In some circumstances liquid chemicals can give rise to slick surface conditions. Using friction devices would allow for improved guidelines for liquid chemical usage
Mobile Road Weather Station (MARWIS)

- Installed on Supervisor/Patrol vehicles
- Measurements
  - Grip (Slipperiness)
  - Road state (Dry, Moist, Wet, Snow, Ice)
  - Layer thicknesses
  - Surface Temperature
  - Dew Point Temperature
  - Air temperature
  - Humidity
- In-vehicle system operation/calibration via smartphone or iPad
- Verification and Route based measurement inputs for operational decision making
Fixed and Mobile Temperature/Friction sensors
INDOT MARWIS Program

- Tool for public safety as well as DOT winter maintenance decision support/MDSS program
- Can be a great Social media tool to reach large segments of the population.
Freezing rain forecasted tonight. Crews are treating, but temps will be above freezing so minimal impact is expected indot.carsprogram.org
Data

- Grip (Pavement Friction)
- Pavement Temperature
- Relative Humidity
- Dew Point
- Air Temperature
- Roadway Imagery (Photos)

- Real-time-Data Accessibility for all users with alerting functionality (Cloud based GUI, iPad Tablet App and/or AVL display).
Benefits of Mobile Weather Observations

- Complements traditional fixed RWIS weather data
  - Fills in the gaps between the fixed stations
  - Identification of problematic sites
  - Data whenever and wherever you need it

- Tool for forecast verification

- Integrates into existing AVL systems, hydraulic control systems or telematics

- Indicates real-time condition of the road

- Tool for Key Performance Indicator monitoring
  - More consistent evaluation of the road state
  - No need to stop for collecting samples
  - No need to do braking for getting the results
  - Measurements can be done when driving in normal traffic flow

- Improves decision making through better information
Mobile and Fixed Data Complement each other

• A single parameter called GRIP can enable the entire winter maintenance policy
• Simplifies the complexity of meteorology
• Single system offers consistent information to all users
• Treatment recommendations both manual or auto-proposed speed the decision making process but also offers a consistent approach across all decision makers
• A fully integrated system allows reporting and continuous improvement to be at the heart of the system
Performance monitoring and reporting throughout the entire weather event

• Forecast accuracy
  – Complete “like for like” verification based upon difference between forecast grip and observed grip
  – Feedback will help to continuously improve forecast accuracy

• Contractor performance
  – Archive will show whether contractor operated as planned
  – Performance can be monitored by observed Grip levels
  – Targets can be based upon minimum expected level of Grip on any route
  – Performance based contracts can be easily measured
  – Data collected by weather stations and from data input into system

• Resource reporting
  – As all aspects of the winter program are recorded in one application resource management reports can be easily created
  – Winter index reports can be generated to assess spending levels
Varieties of Winter Operations
Performance Measures

- Storm Performance Index
- Traditional Performance measurement tools
Idaho Storm Performance Index

- What is it?
  - A numerical value – estimates performance
    - Data comes from RWIS sites
      - Algorithm uses Grip, Wind Speed, Surface Temperature, Water/Ice/Snow thickness
    - Lower numbers indicate better performance
  - A storm severity index is also calculated using empirical data
    - Severity = Wind + Snow + (300/Temperature)
    - Larger values indicate worse storms
  - ITD’s Value assessment
    - Quantifying storm event
    - Measuring performance
    - Identifies cost of accomplishments
    - Critiquing operations
    - Provides comprehensive training
    - Establishes accountability
    - Enhances customer service
    - Future automation for transparency
Storm Performance Index

• Why develop it?
  – To increase road safety and reduce accidents
  – To increase mobility and reduce traffic snarl-ups
  – To improve de-icing chemical effectiveness and reduce costs
    • The natural by product of this is to lessen the environmental impact
Storm Performance Index inputs

- **Ice up time**: Duration of time below a roadway grip of 0.6.
- **Lowest surface temperature**: recorded during the ice-up time
- **Maximum Wind Speed**: recorded during the ice-up time
- **Maximum Precipitation Layer**: recorded during the ice-up time-in any form
- **Maximum Precipitation Layer**: recorded outside the ice-up time
  - Wet pavement, 0.6 or greater roadway grip with roadway temperatures below freezing indicates a perfect PI score of 0.0.
Storm Performance Index

- The input parameters are inserted into an algorithm that produces an index.

### Storm Performance Index Report

<table>
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<tr>
<th>Station</th>
<th>Date</th>
<th>Time Range</th>
<th>Event</th>
<th>Duration (hours)</th>
<th>Max Wind Speed (mph)</th>
<th>Max Ice Layer (mm)</th>
<th>Max Snow Layer (mm)</th>
<th>Max Water Layer (mm)</th>
<th>Min Surface Temp (°F)</th>
<th>Severity Index</th>
<th>Performance Index</th>
<th>Mobility Index</th>
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<td>D5 - Malad Summit</td>
<td>25-Oct-2012</td>
<td>04:30 - 10:00</td>
<td>FROST treated</td>
<td>5.50</td>
<td>5.59</td>
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<td>0.00</td>
<td>0.02</td>
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<td>0.31</td>
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<td>28.04</td>
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Why was a grip of 0.6 identified......

– This is the point that traffic mobility is affected
– Above 0.6 usually wet (or dry) surface
– General ranges of grip
  • .60-.82 wet
  • .50-.60 slush or ice forming
  • .40-.50 snow pack or icy
  • Below .40 cars may start sliding off
  • .30 and lower multiple slide offs possible; mobility greatly affected
Varieties of Winter Operations
Performance Measures

• Storm Performance Index

• Traditional Performance Measurement tools
RWIS roadway and traffic data
“traditional”

Per weather event basis: Post storm analysis

1. User reviews an archive view, table or report of the RWIS display containing the surface condition to verify an effective treatment: i.e. chemically wet, treated roadway while a below freezing surface temperature exists.

2. During this same time period, the average traffic speeds along coordinated traffic and winter maint. routes are recorded.

3. Analysis: How quickly do the average traffic speeds resume to normal (average levels) after the start of the specific weather event is a measure of roadway maint. performance.
RWIS roadway and traffic data
“traditional + grip”

Per weather event basis: Post storm analysis

1. User reviews an archive view, table or report of the RWIS display containing the surface condition to verify an effective treatment: i.e. chemically wet, treated roadway while a below freezing surface temperature exists.

2. During this same time period, the average traffic speeds along coordinated traffic and winter maint. routes are recorded.

3. During this same time period, the average grip values from RWIS stations along coordinated traffic and winter maint. routes are recorded.

4. Analysis: How quickly do the average traffic speeds resume to normal (average levels) and grip values rise to at least 0.6 after the start of the specific weather event is a measure of roadway maint. performance.
Winter Operational Value of a Storm Performance Index and/or Performance Measures

According to field experience:

- Quantifying storm event
- Measuring performance
- Identifies cost of accomplishments
- Critiquing operations
- Provides comprehensive training
- Establishes accountability
- Enhances customer service
- Automation for transparency
Complete Weather Decision Support Solution

Building Blocks of Effective RWIS/ITS Solution

Include

• Strategically Located RWIS/ITS infrastructure in the Field

• Flexible, Accessible, Graphical User Interface that has aligned Maintenance and Specific ITS functionality and goals

❖ Performance Measurement Policy or Plan in place

• Knowledge to the Users through consultation and a routine and consistent training regiment.
On-going, Routine Education Program

• Annual RWIS User Training promotes and supports utilization of RWIS as an Weather Responsive Traffic management tool.
  • How do I use all these tools together?

• Adoption of a regular training program ensures the RWIS, (Weather Data) is being used in harmony with processes to make effective and efficient decisions.

• Routine, Regional Training Workshops are a good catalyst for sustainable educational programs for any agency.

• Promotion of cross functional “best practices” and “performance measures” between agency and departments
Kurt Kinion | Director of ITS Development
Josh Coulter | Territory Sales Manager

Intelligent Weather Solutions

The Hoosier Company, Inc.
Mobile/Text: 314-705-0791-Kurt
Mobile/Text: 317-726-6682-Josh
Sales Office: 317-876-6675 or 1-800-521-4184
Email: kkinion@hoosierco.com
Visit our website: www.hoosierco.com