UDOT Weather Operations
Road Weather Index / Performance Metric
Jeff Williams, UDOT Weather Operations Program Manager
Utah Winter Weather Challenges

- **State of Utah**
  - Mix of Urban and Rural
    - 80% of population along Wasatch Front
  - Varied Terrain
    - 2,000 ft to 13,500 ft
  - Varied Snowfall
    - Alta – 508” per year, record is 910” (1983)
    - Wasatch Front - 40-120” per year
    - St George – 3” per year, Wendover 5” per year
  - Lake Effect Snowfall
    - Great Salt Lake never freezes
  - Downslope wind events
    - 102 mph along I-15 @ Centerville on 12/1/11
National Radar Coverage

NEXRAD Coverage Below 10,000 Feet AGL

VCP12 Coverage

- 4,000 ft above ground level*
- 6,000 ft above ground level*
- 10,000 ft above ground level*

* Bottom of beam height (assuming Standard Atmospheric Refraction). Terrain blockage indicated where 50% or more of beam blocked.

0 125 250 500 750 Miles
UDOT Weather Group Overview

- Road Weather Operations
- Forecasting for pre-mitigated road snow
- 5,000+ logged interactions per year

- Travel Weather Information
- Forecasting for post-mitigated road snow
- Coordinate with the NWS
- Influence traveler behavior

- Road Weather Information System (RWIS)
- 87 RWIS stations and growing
- Ongoing upgrade effort
- 5 portable RWIS trailers

- Research / Development
- Road Weather Index
- Blowing dust detection
- Automated alerts
- Devices and operation
- Etc.
Weather and Travel Time Reliability

Travel Time Index (systemwide)

- X-axis: Dates from 5/6/2013 to 7/30/2014
- Y-axis: Travel Time Index from 0.7 to 1.8

The graph shows the travel time index over time, with points scattered across the timeline indicating the reliability of travel times during different periods.
Weather and Travel Time Reliability

Travel Time Index (systemwide)

- Road snow (both commutes)
- Freezing rain event
- All day snow
- Road snow/ice (AM commute)
- Road snow (AM commute)
- Heavy valley rain/mountain snow
- Parleys Summit road snow

Date Range: 5/6/2013 to 7/30/2014
Economic Impact of Road Weather Events

Economic impact in Utah for a 24 hour statewide winter storm

Total Economic Impact
• $66.36 million
  - Wages & Salaries
    • $42.81 Million
  - Retail Sales
    • $18.26 million
  - Federal Taxes
    • $3.32 million
  - State and Local Taxes
    • $1.98 million

Source: American Highway Users Alliance performed by IHS Global Insight (2009)
The Problem Statement

How can we measure our snow mitigation performance?

What is measured can be managed - and the converse is also true
Indexes and Measures

- Several state by state winter severity indexes across the country
  - Climate Network (National Weather Service)
    - No road weather data used
    - Snowfall measured on grass
- Idaho Winter Performance Measure
  - Based on Road Weather Information System (RWIS) data
  - Post-storm assessment focused on recovery time
- Utah Road Weather Index
  - Real-time index to evaluate weather, road conditions and maintenance performance
  - Snowfall rates and road temperatures have the greatest impacts on roads
  - Account for blowing snow, freezing rain and wet/dry snowfall
  - Developed in-house
UDOT Winter Road Weather Index

- Quantifies atmospheric conditions and road conditions into one value
  - Accounts for snowfall rate, road temperature, blowing snow, freezing rain, and road grip/condition

- UDOT’s target for snow removal is to handle 1 inch of snow per hour. The index takes all the variables and creates a single baseline to judge a warm, wet snow vs. a cold dry snow by accounting for the various sources of difficulty in mitigation.

- The index will account for the difference in mitigation effort between 1 inch per hour at freezing and 1 inch per hour at 15 degrees.

- Established foundation for Winter Maintenance Performance Metric
Winter Road Weather Index - RWIS Variables

When road temperature < 35 °F and road is not dry...

- Road Condition
  - Snow, ice and road grip (coefficient of friction)
- Road Temperature
  - The colder the road, the more difficult to mitigate
- Visibility
  - Used to estimate snowfall rate
  - Precipitation occurrence (yes or no)
    - Define start and end time of storm event
    - Precipitation occurrence used to differentiate fog from snow
- Wet-bulb Temperature
  - Lower the wet-bulb temperature equates to drier snow thus more transportable
  - Used to distinguish rain from snow
- Wind Gust (>= 20 mph)
  - More impact with lowering wet-bulb temperatures
Winter Maintenance Performance Metric

• Cause vs. effect approach
  – Atmospheric conditions and road temperature (cause) vs. resulting road grip or condition (effect)
• 1” per hour snowfall rate is the benchmark
• Road grip/conditions categorized into snow-covered, partially snow-covered/slushy, or wet/dry

• Benefits
  – Assess winter plow performance per given winter weather conditions
  – Resource assessment tool
  – Budget/Planning
  – Public response for poor road conditions under intense storm conditions
  – Improve mobility during weather events
### Winter Maintenance Performance Metric Basis

<table>
<thead>
<tr>
<th>Winter Weather Index</th>
<th>Snowfall Rate</th>
<th>Expected Mitigated Road Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>💫💫💫 Heavy</td>
<td>&gt; 1&quot; per hour</td>
<td>Snow Covered</td>
</tr>
<tr>
<td>💫💫 Light to Moderate</td>
<td>.25 to 1&quot; per hour</td>
<td>Slushy/ Partially Snow Covered</td>
</tr>
<tr>
<td>✱ Flurries or no snow</td>
<td>&lt; .25&quot; per hour</td>
<td>Wet or dry</td>
</tr>
</tbody>
</table>

**Contributing factors also considered with Winter Weather Index**

| Road Temperature             | Blowing snow      | Wet or dry snow                                   |
Performance Metric “Rubik’s Cube”

Definitions:

Green – Road condition exceeds acceptable road conditions per given weather conditions

Yellow – Acceptable road conditions per given weather conditions

Red – Recovery time. Potential for improved road conditions per given weather conditions

Snowfall Rate = 1”/hr
Road Temp = 32°
Wet-Bulb Temp = 32°
Light winds

Snowfall Rate = 1/4”/hr
Road Temp = 32°
Wet-Bulb Temp = 32°
Light winds

Winter Wx

Flurries to No Winter Wx

Heavy Winter Wx

Snow Covered (.30) (GRIP)/Condition -> Slush (.50) Wet/Dry
Boulder Summit - Winter Weather Index (cause)
### Storm Performance

<table>
<thead>
<tr>
<th>Storm Severity</th>
<th>Red %</th>
<th>Yellow %</th>
<th>Green %</th>
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</thead>
<tbody>
<tr>
<td>Sum</td>
<td>19</td>
<td>79</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>169</td>
<td>169</td>
<td>169</td>
</tr>
<tr>
<td>Percent</td>
<td>11.24%</td>
<td>46.75%</td>
<td>42.01%</td>
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</table>

**Winter Maintenance Performance Metric - Boulder Summit - 4/16-17**

![Road conditions at Boulder Summit](udot.utah.gov)
Big Cottonwood Canyon – Cardiff RWIS
Winter Maintenance Performance Metric

Storm Performance

<table>
<thead>
<tr>
<th></th>
<th>Red %</th>
<th>Yellow %</th>
<th>Green %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum</td>
<td>37</td>
<td>79</td>
<td>171</td>
</tr>
<tr>
<td>Total</td>
<td>287</td>
<td>287</td>
<td>287</td>
</tr>
</tbody>
</table>

12.89% 27.53% 59.58%
UDOT’s RWIS Network

- 92 RWIS Sites
  - 5 portable RWIS trailers
  - 64 RWIS sites are upgraded and now compatible with Road Weather Index

- RWIS upgrade
  - Visibility sensor
  - Non-invasive road sensor
Analysis / Report Generation

- Temporal
  - Monthly
  - Whole Season
- Spatial
  - Statewide
  - Region
  - Shed
  - Individual RWIS site

- Reportable Variables
  - Winter Maintenance Performance
  - Winter Weather Index (storm intensity)
  - Number of storms
  - Storm duration
  - Climate normal comparison
  - Budget comparisons
Limitations

- Based on a 12” sample area of a road, typically in middle of far right lane.
  - AVL, mobile weather observations and modeling could fill in the gaps
  - RWIS sites becomes a quality control location
  - Plow camera interpretation software (determine road condition)

- Flurries in fog confuses the algorithm
  - Investigating particle counts to fine tune algorithm

- Instrumentation
  - Newer technology
  - Tough environment
  - Not all road surfaces are alike
  - Calibration can drift, frequent calibration is needed
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