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
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)

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/6/2013</td>
</tr>
<tr>
<td>6/25/2013</td>
</tr>
<tr>
<td>8/14/2013</td>
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<td>10/3/2013</td>
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<td>4/21/2014</td>
</tr>
<tr>
<td>6/10/2014</td>
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<tr>
<td>7/30/2014</td>
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</table>
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
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
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

#### 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**

<table>
<thead>
<tr>
<th>Road Temperature</th>
<th>Blowing snow</th>
<th>Wet or dry snow</th>
</tr>
</thead>
</table>
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
Boulder Summit - Winter Weather Index (cause)
Boulder Summit – SR-12 (Level 2)
Winter Maintenance Performance Metric – 1”/hr

Storm Performance

<table>
<thead>
<tr>
<th>Red %</th>
<th>Yellow %</th>
<th>Green %</th>
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</thead>
<tbody>
<tr>
<td>78</td>
<td>20</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>169</td>
<td>169</td>
</tr>
<tr>
<td>Percent</td>
<td>46.15%</td>
<td>11.83%</td>
</tr>
</tbody>
</table>
Storm Performance

<table>
<thead>
<tr>
<th></th>
<th>Red %</th>
<th>Yellow %</th>
<th>Green %</th>
</tr>
</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>
</tr>
</tbody>
</table>

Winter Maintenance Performance Metric - Boulder Summit - 4/16-17
Big Cottonwood Canyon – Cardiff RWIS
Winter Maintenance Performance Metric

Winter Maintenance Performance Metric – Cardiff, 12/25-26

Storm Performance

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<th>Red %</th>
<th>Yellow %</th>
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<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>
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</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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