UDOT Weather Operations
Road Weather Index / Performance Metric

Jeff Williams, UDOT Weather Operations Program Manager

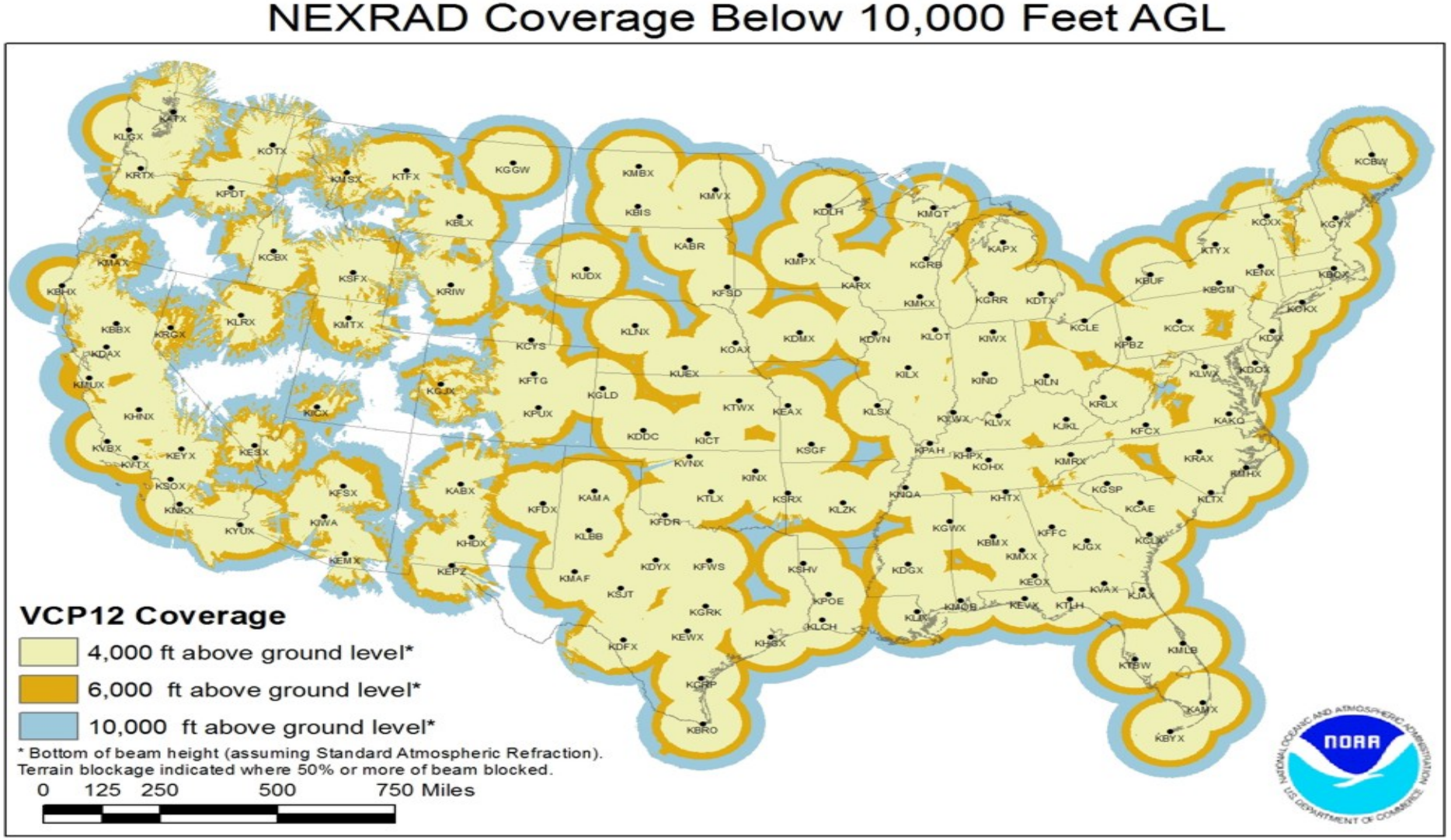
Elevate ITS

UDOT Keeping Utah Moving

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

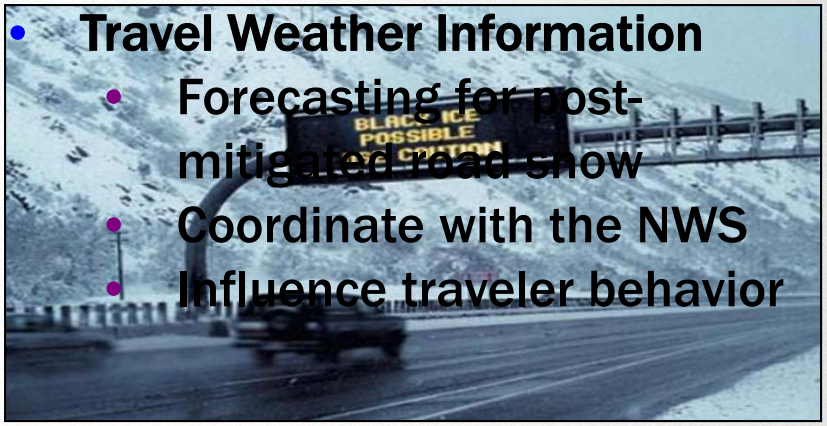
National Radar Coverage



UDOT Weather Group Overview

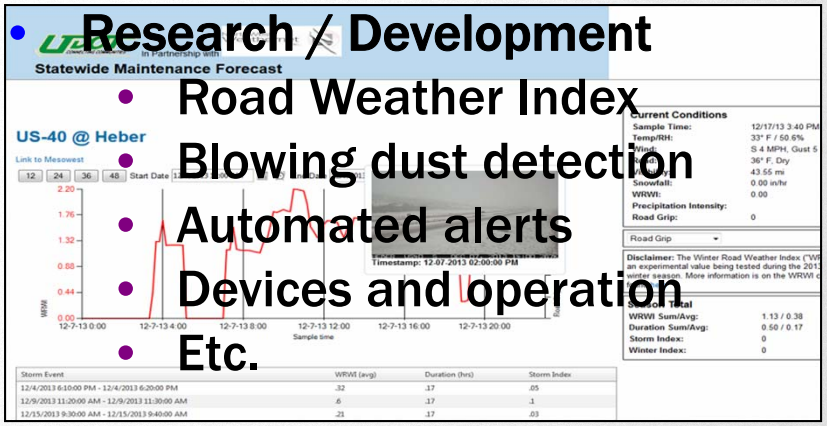
- **Road Weather Operations**
  - Forecasting for pre-mitigated road snow
  - 5,000+ logged interactions per year

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

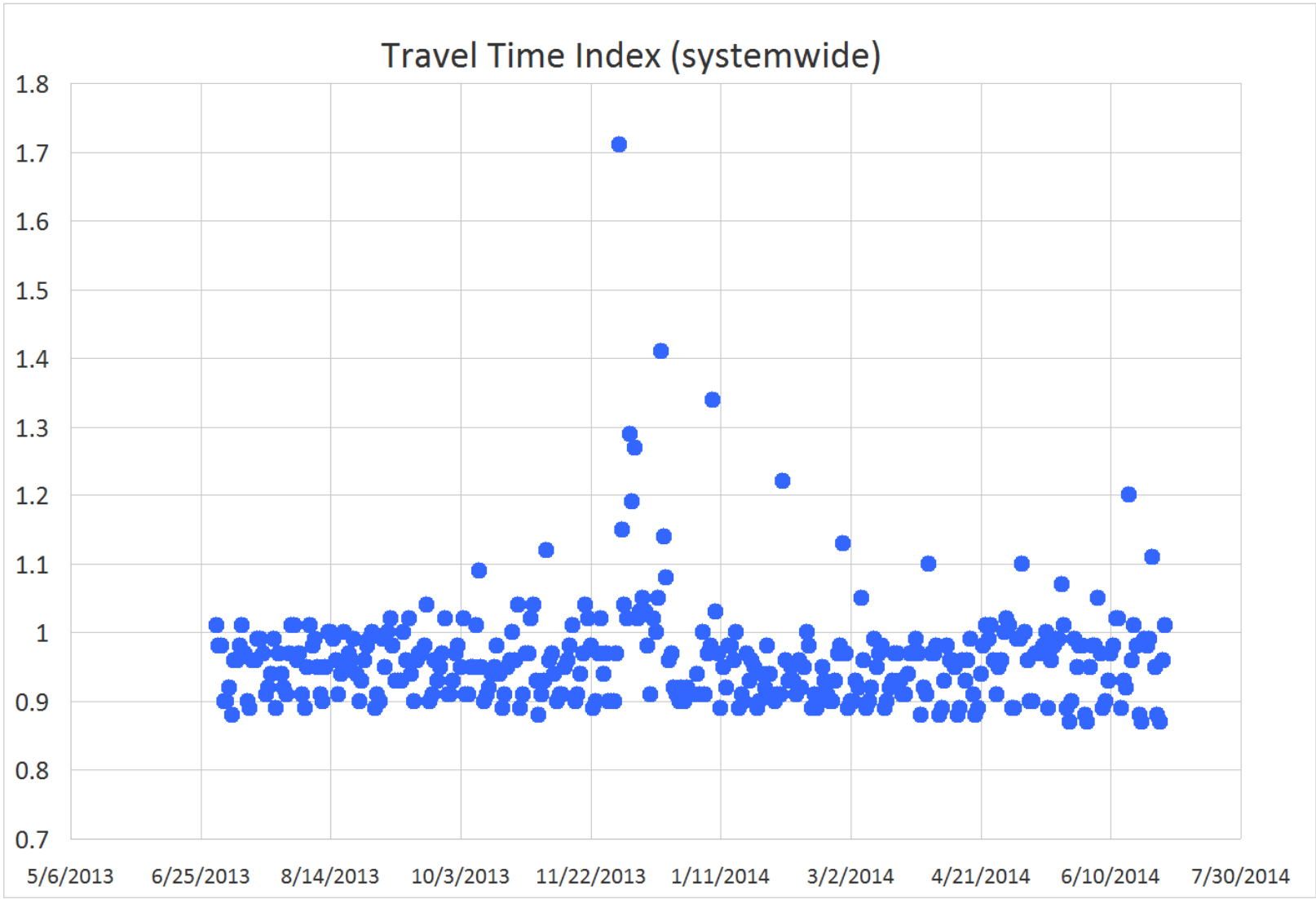


- **Road Weather Information System (RWIS)**
  - 87 RWIS stations and growing
  - Ongoing upgrade effort
  - 5 portable RWIS trailers

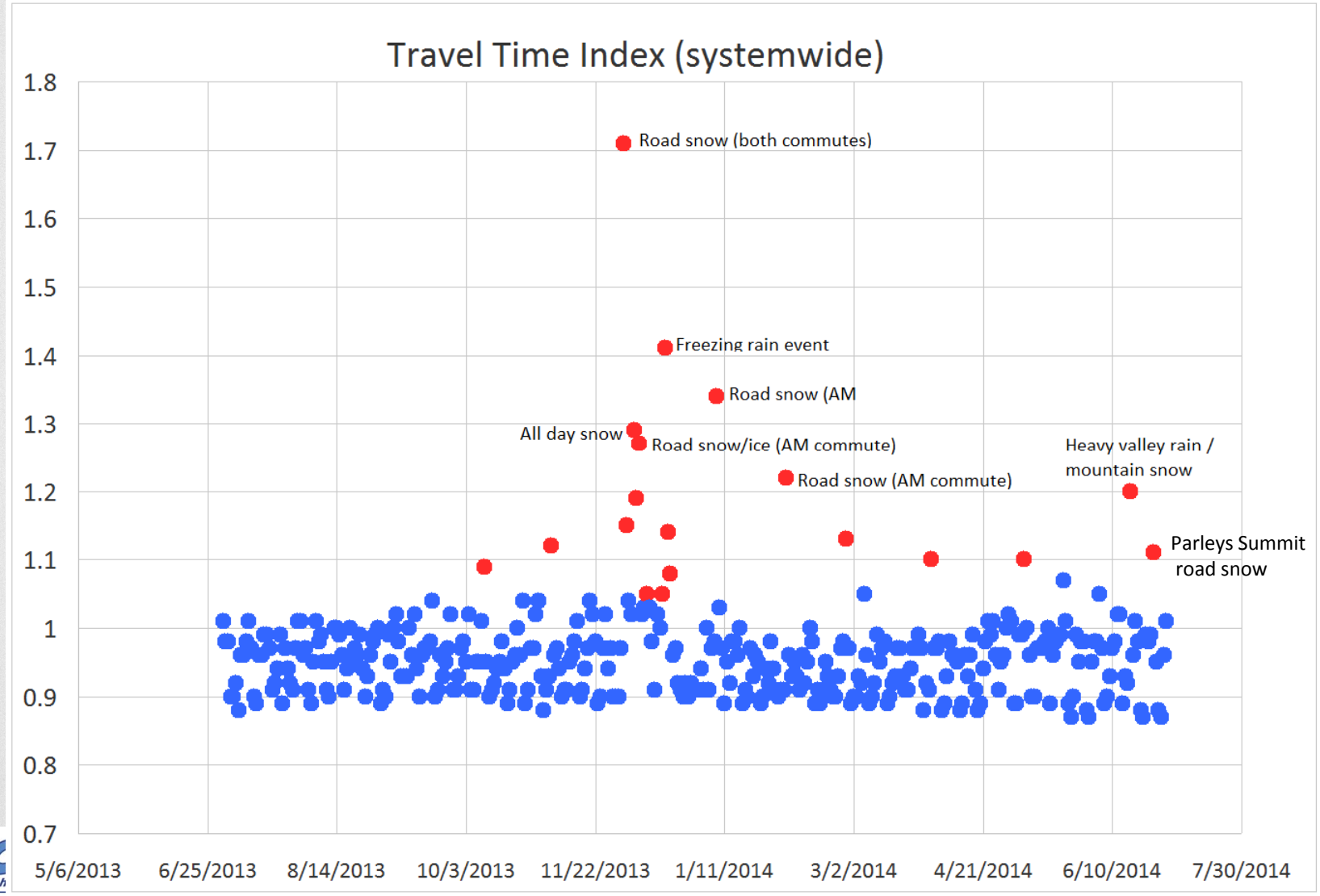
- **Research / Development**
  - Road Weather Index
  - Blowing dust detection
  - Automated alerts
  - Devices and operation
  - Etc.



Weather and Travel Time Reliability



Weather and Travel Time Reliability



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

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

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

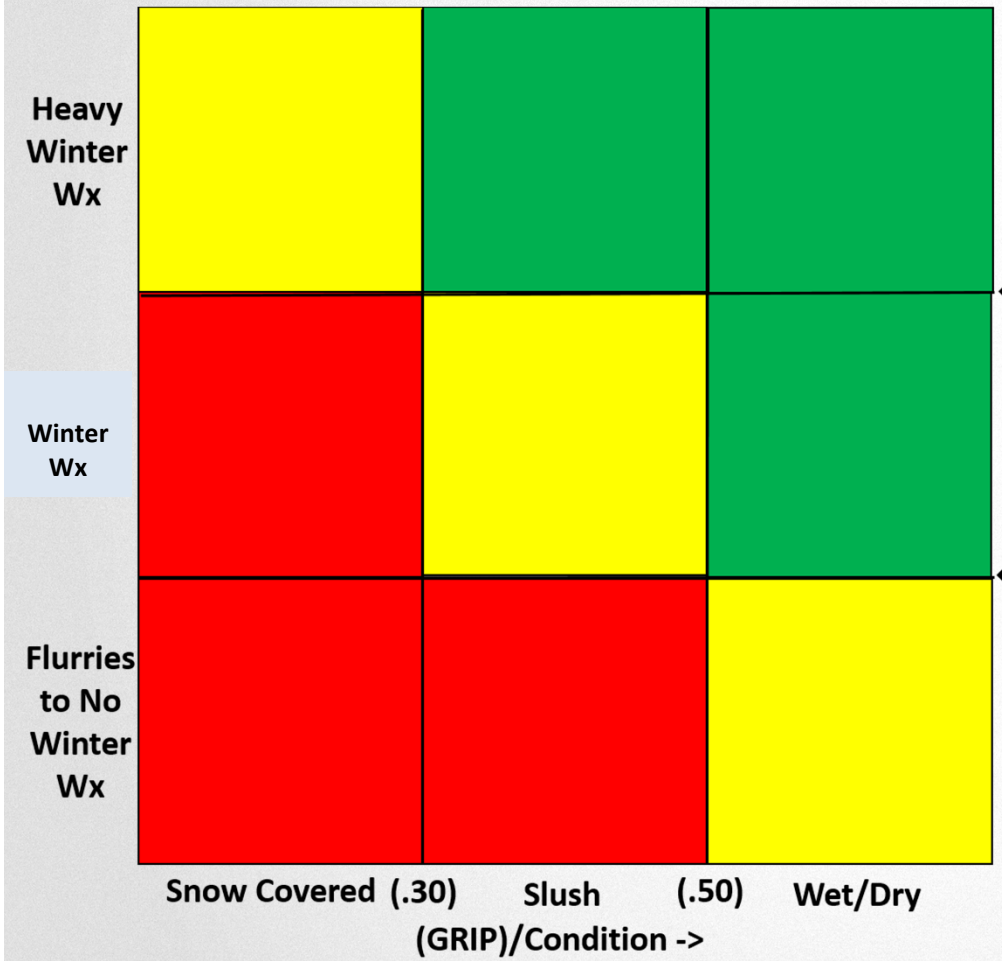
- Benefits
  - Assess winter plow performance per given winter weather conditions
  - Resource assessment tool
  - Budget/Planning
  - Public response for poor road conditions under intense storm conditions
  - Improve mobility during weather events

Winter Maintenance Performance Metric

- **Winter Maintenance Performance Metric Basis**

Winter Weather Index	Snowfall Rate	Expected Mitigated Road Condition
❄❄❄ Heavy	> 1" per hour	Snow Covered
❄❄ Light to Moderate	.25 to 1" per hour	Slushy/ Partially Snow Covered
❄ Flurries or no snow	< .25" per hour	Wet or dry
Contributing factors also considered with Winter Weather Index		
Road Temperature	Blowing snow	Wet or dry snow

Performance Metric "Rubik's Cube"



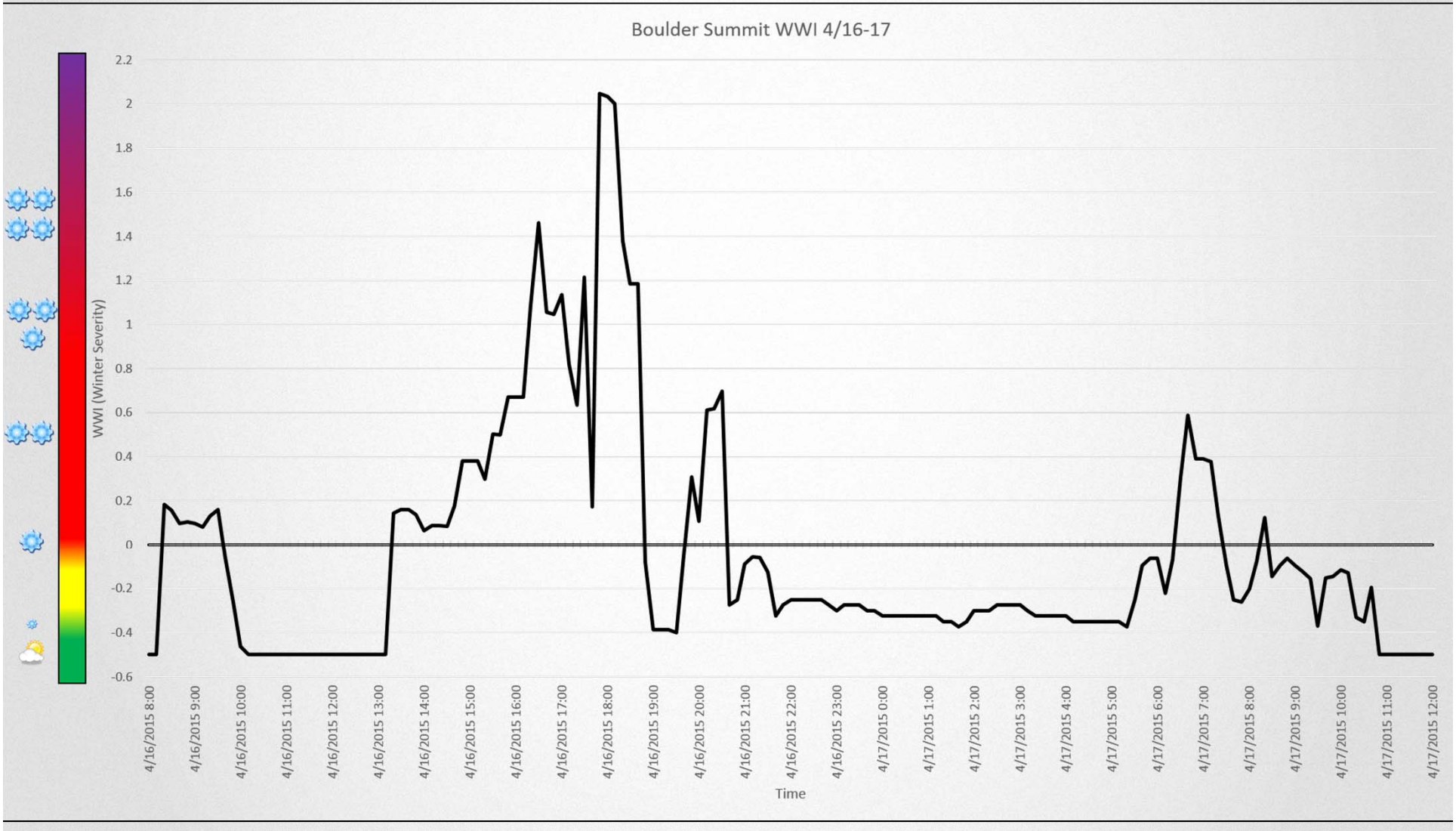
Definitions:

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

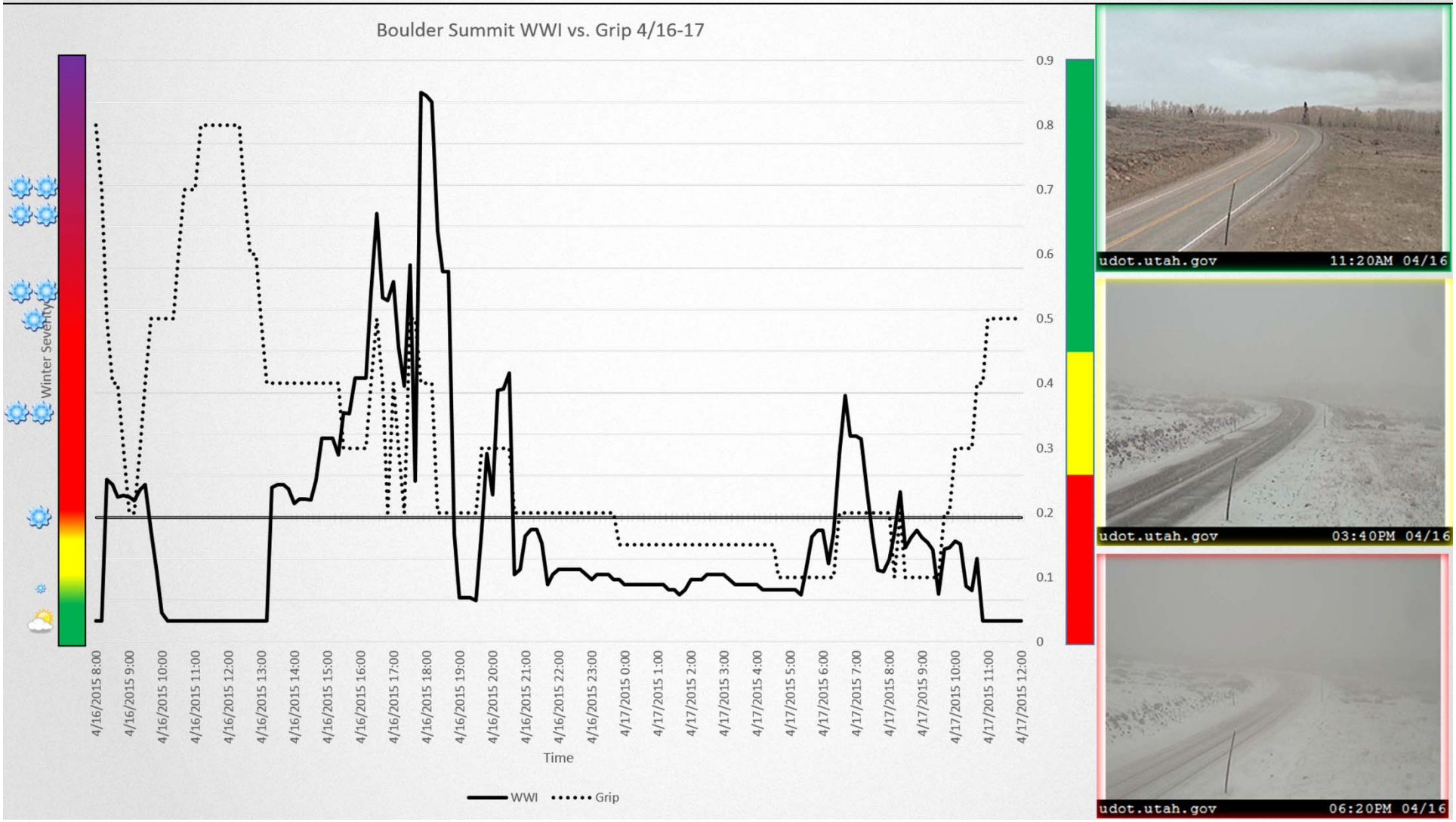
Yellow – Acceptable road conditions per given weather conditions

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

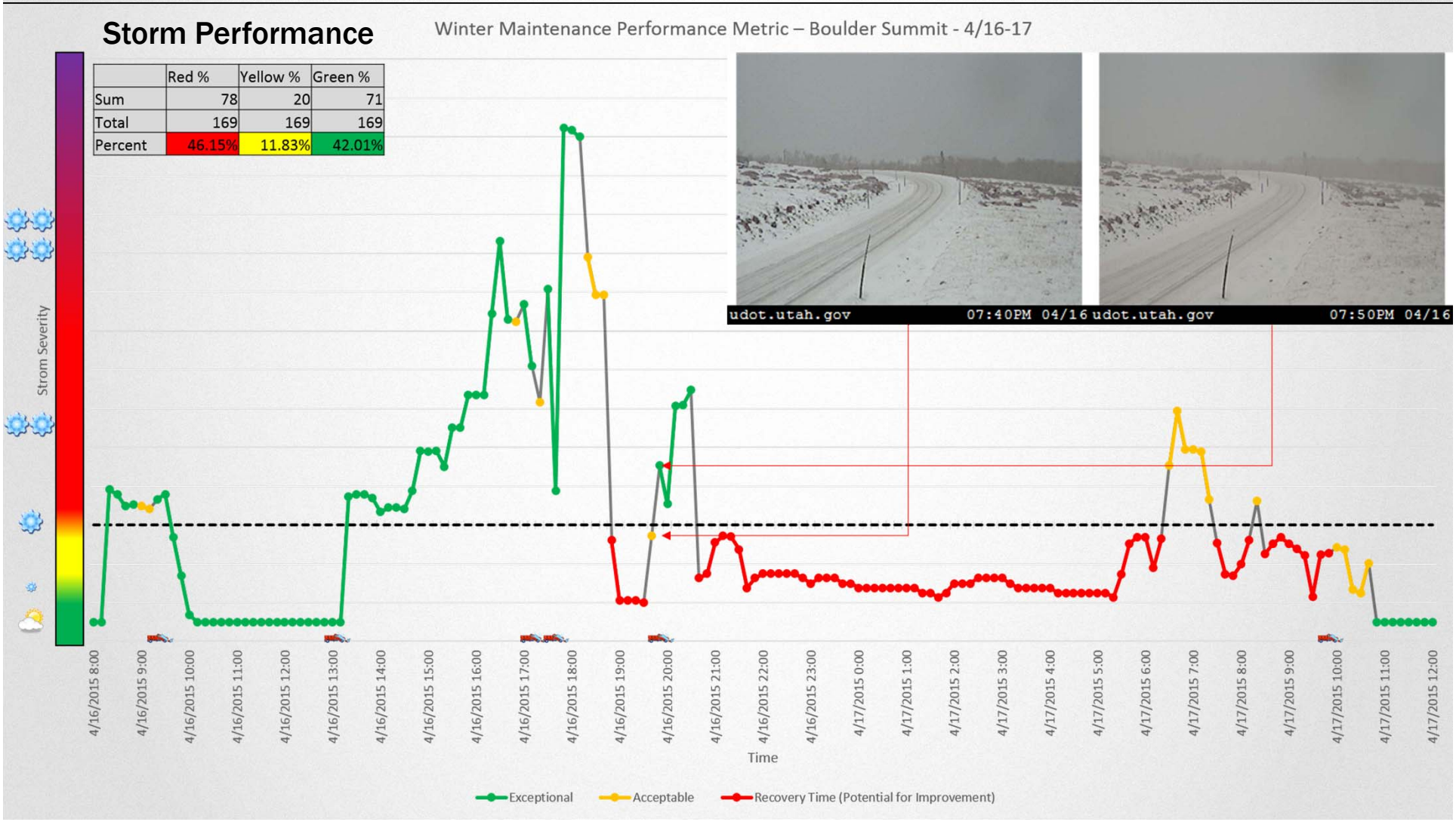
Boulder Summit - Winter Weather Index (cause)



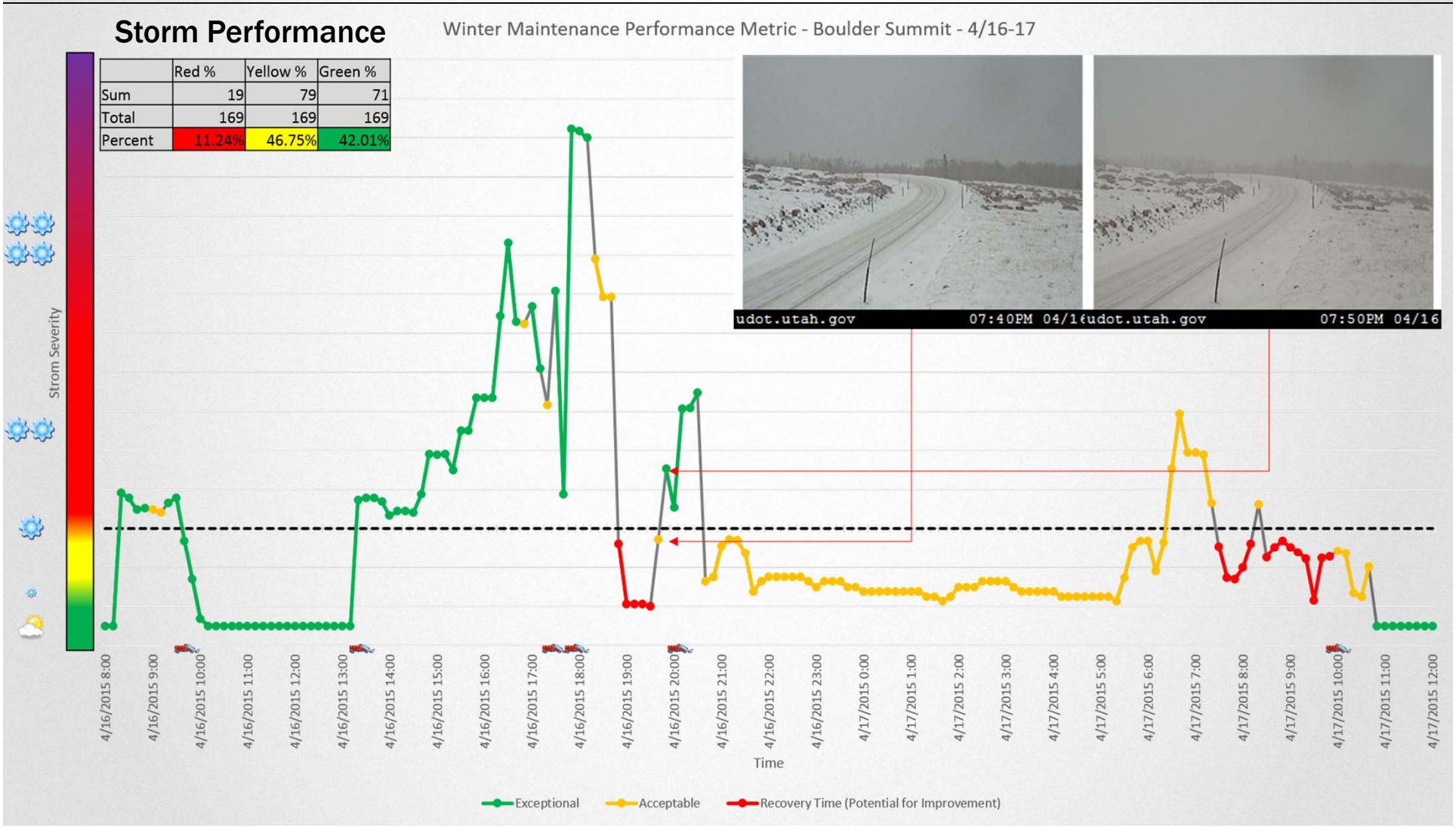
Boulder Summit
Winter Weather Index/Road Grip



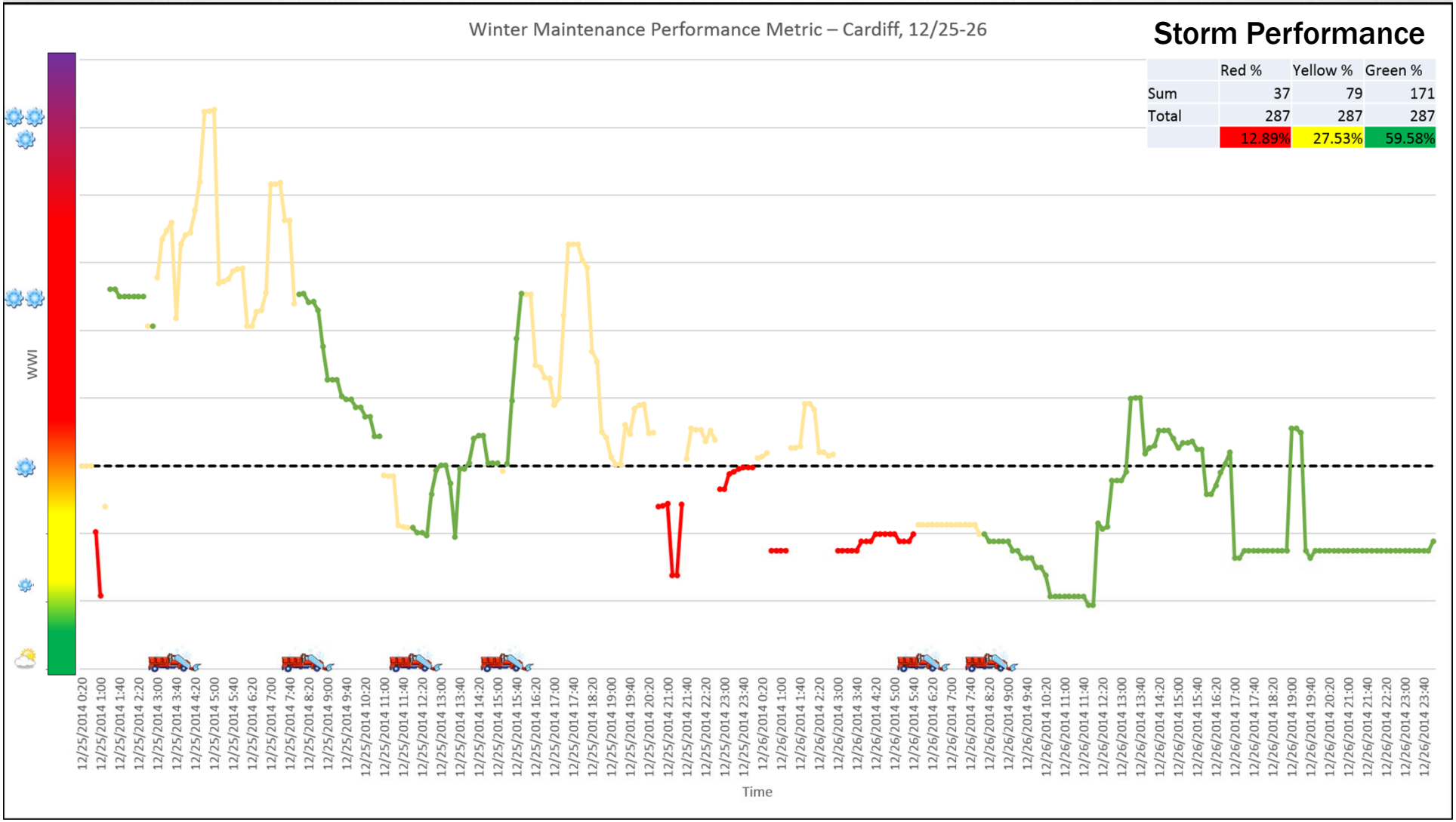
Boulder Summit– SR-12 (Level 2)
Winter Maintenance Performance Metric – 1”/hr



Boulder Summit– SR-12 (Level 2)
No Overnight Plowing Adjustment

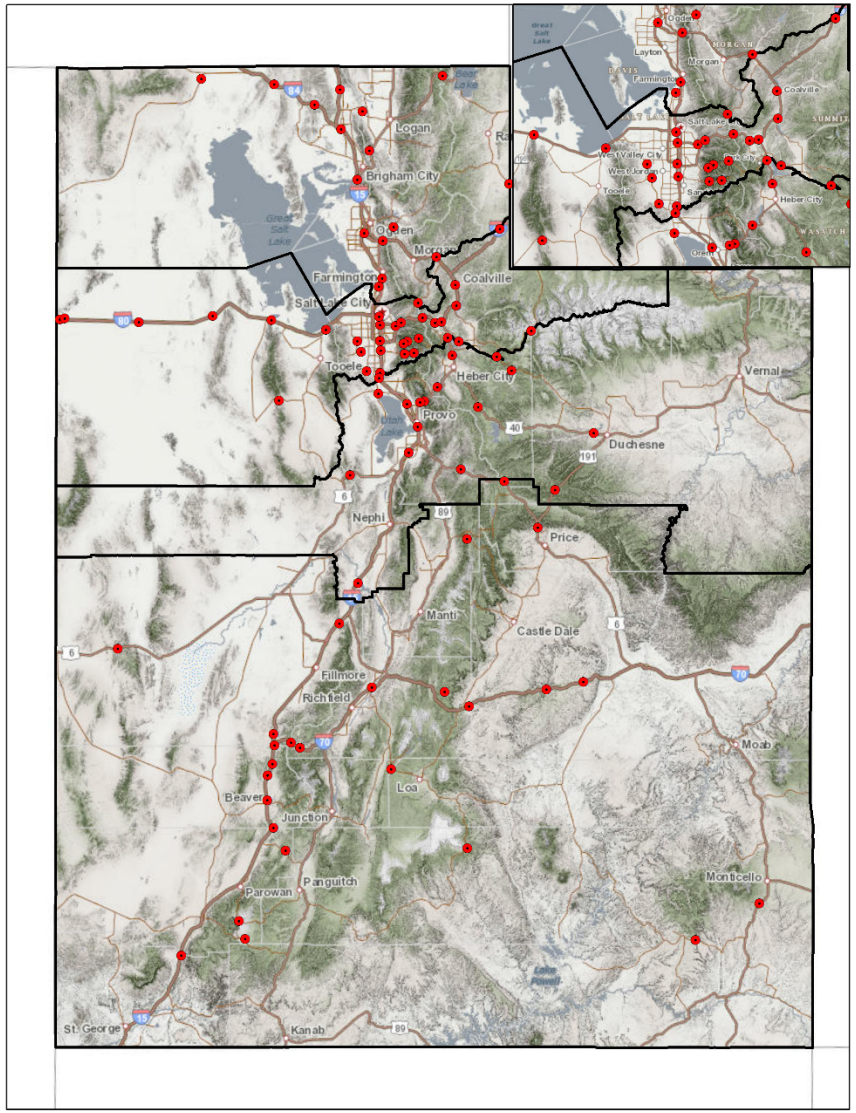


Big Cottonwood Canyon – Cardiff RWIS
Winter Maintenance Performance Metric



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

Contact Info

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