North/West Passage Winter Performance Measures – Project Summary

June 13, 2022 – FINAL

North/West Passage is a pooled fund program focused on developing effective methods for sharing, coordinating, and integrating traveler information, operational activities, and emerging technologies across state borders along I-90/I-94 from Washington (state) to Minnesota. ***This document is a summary of the North/West Passage Project 16.3 Winter Performance Measures that was conducted between October 2021 and May 2022.***

1.0 Project Goals

North/West Passage members were interested in continuing to share winter performance measure practices throughout the corridor and focused the goals of this project to:

- Establish a North/West Passage Winter Performance Measures Project Team
- Share findings of NCHRP 14-34: Performance Measures in Snow and Ice Control Operations
- Review North/West Passage Project 10.5: Winter Performance Management Practices
- Discuss current performance measures, gaps and desired changes, and challenges with consistent corridor performance measures
- Share current practices on the most common performance measures
- Identify action items or next steps for the North/West Passage to consider pursing

To accomplish the project goals, a series of webinars were conducted with the project team.

2.0 Project Team and Project Webinars

A North/West Passage Winter Performance Measures Project Team was established to participate in project webinars and provide input to the project. See Table 1.

Table 1: North/West Passage Winter Performance Measures Project Team

State	Project Team Members	
Minnesota	Cory Johnson Joe Huneke	Mitch Webster
Idaho	TJ McNeff	Saran Becker
Wyoming	Vince Garcia	
North Dakota	Brandon Beise	Brad Darr
South Dakota	Dave Huft Craig Smith	Thad Bauer
Montana	Doug McBroom	Mike Warren
Washington	David Baker Justin Belk	Jim Andersen James Morin

The Project Team participated in five webinars over seven months (October 2021 – April 2022). Recommendations from NCHRP 14-34: Performance Measures in Snow and Ice Control Operations were highlighted in Webinar #1 and Webinar #2 and a review of North/West Passage Project 10.5: Winter Performance Management Practices was provided. Webinar #1 also allowed for discussions on current

use and gaps of winter performance measures and challenges with consistent corridor performance measures. See Section 4.0. Based on the discussion, it was decided to focus the remaining webinars on two winter performance measures used by all members: Level of Service (LOS) and Recovery (i.e., return to normal speed or recovery time to bare pavement).

During Webinar #2, Webinar #3, and Webinar #4 North/West Passage member states (Wyoming DOT, Washington State DOT, Minnesota DOT, Montana DOT, South Dakota DOT, and North Dakota DOT) presented on their state's approaches for measuring and reporting recovery time and LOS. In addition, Utah DOT presented on tools used for winter performance management. See Section 5.0.

After the state presentations, next steps for North/West Passage to consider regarding winter performance measures were identified during Webinar # 4 and Webinar #5. See Section 6.0.

3.0 Resources and Related Efforts

There were a few key resources and related efforts referenced throughout the project that are described in this section as well as a comparison of performance measures from the related resources and efforts.

3.1 Summary of Resources and Efforts Related to this Project

This section highlights information from key winter performance measures related documents and related efforts that were shared during the project team webinars.

Resource 1: NCHRP 14-34: Performance Measures in Snow and Ice Control Operations (2019)

One resource referenced multiple times during this project was the final report that results from the NCHRP project titled Performance Measures in Snow and Ice Control Operations, completed in 2019 as NCHRP 14-34. This resource is briefly summarized as:

- This document provides recommendations for performance measures for snow and ice control. The recommendations in the report include examples, such as:
    - Define and use a Weather Event as the Starting Point for Performance Measurement
    - Develop both a Storm Severity Index and a Seasonal Severity Index
    - Pick consistent Level of Service and Recovery criteria and how they are measured across the agency
    - Report Performance Information
- There are three parts to this report: Part 1 Research Overview, Part II Guide for Performance Measures in Snow and Ice Control Operations and Part III User Guide for Spreadsheet Tool. Key highlights from Part II were emphasized during the overview in this project.
- The research looked at various input-output-outcome-impacts categories and measures.
    - Input and output measures are important for information day-day tactics and decision making about event response
    - However, the guidance in the report focuses on the outcome and impacts end of the spectrum.
- The guidance is "geared toward enabling a greater consistency in collecting, analyzing, and reporting outcomes and impacts associated with snow and ice control operations."
- Defining performance measures is a collaborative activity that requires a careful look at the agency's mission, goals, and operational objectives. **It is likely that no two agencies will have**

the same set of performance measures to assess the success or effectiveness of their programs. As agencies seek to create a core set of performance measures in these areas, it is important to note a number of items. See Figure 1. (Source: National Academies of Sciences, Engineering, and Medicine 2019. *Performance Measures in Snow and Ice Control Operations*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25410)

No individual performance measure is a perfect representation of the complexity of snow and ice response.	• Multiple measures provide a balanced report.
Not all performance measures that are important to an agency can be fully controlled by the agency's response activity.	•The linkage from the activity to the measure may be indistinct, but overall trends may still be valuable
Starting the process of performance measurement is the first and often the most important step	•Don't try to be perfect, focus on what can be done now
Performance measurement will likely be based on a subset of agency roadways	•Unlikely to have the ability to collect data on every mile of roadway •Performance measurement will likely be based on a sampling
Performance measures identified by an agency need to be simple and easily understood not only by the agency's stakeholders but also its own staff	•The more stringent the requirements, the more sophisticated the data needs, or the less automated the analysis approach, the more challenging the performance measure becomes

Figure 1: Items to note when creating a core set of performance measures
(Source: National Academies of Sciences, Engineering, and Medicine 2019. *Performance Measures in Snow and Ice Control Operations*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25410)

- There are 10 key steps identified to develop and assess performance measures. Steps 1, 2, 3, 6, 7, and 8 were reviewed by the North/West Passage members during the project team webinars for this project.
    - Defining Performance Measures
        - **Step 1 – Review mission and goals**
        - **Step 2 – Refine operational objectives**
        - **Step 3 – Identify performance measures**
        - Step 4 – Develop analytic approaches
    - Implementing Performance Measures
        - Step 5 – Inventory current practices and gaps
        - **Step 6 – Identify data sources and needs**
    - Using Performance Information
        - **Step 7 – Set targets and establish baseline**

        - **Step 8 – Report performance**
    - Reinforcing Performance-Based Management
        - Step 9 – integrate into decision making
        - Step 10 – Evaluate process and identify improvements
- In Step 3 the relationship between operational objectives and performance measures is identified. See Figure 2.

Objective	Identified Performance Measures
Maintain level of service during event	Percent of time road segments meet agency-defined level-of-service thresholds during winter storms
Meet recovery criteria set by agency	Percent of segments meeting time to regain or recover to acceptable criteria for agency-defined segments after the end of event
Meet reliability targets for specific routes	Percent of trips within accepted difference between measured travel time index and additional expected travel time index for snow and ice events for selected routes
Support safe operations of the roadway	Five-year rolling average of fatalities and injuries (number, rate) during a winter season
Meet customer satisfaction ratings	Customer satisfaction ratings for snow and ice response
Support efficient use of resources to meet operational objectives	Cost of snow and ice control to meet established performance criteria for a given winter severity
Support environmental stewardship goals by optimizing material use	Agency within acceptable difference between expected and actual use of salt and other materials in a season

Figure 2: Relationship between operational objectives and performance measures
(Source: National Academies of Sciences, Engineering, and Medicine 2019. *Performance Measures in Snow and Ice Control Operations*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25410)

Resource 2: North/West Passage Winter Performance Management Practices (2016)

An additional resource referenced during this project was the North/West Passage project completed during 2016 titled "Winter Performance Management Practices".

This project documented North/West Passage states' winter performance management practices and then identified commonalities and similarities. Table 2 summarizes the winter performance measures by North/West Passage members gathered. See Figure 3 for an example of the winter performance practices documented.

Table 2: Winter performance measures used by North/West Passage members from 2016

State	LOS	Winter Performance Index	Winter Mobility Index	Winter Maintenance Service Level Guidelines	Customer Satisfaction Assessment / Public Satisfaction	Return to Bare Pavement	Normal Condition Regain Time	Snow and Ice Costs	Material Usage	Speed Recovery
Washington	■									
Idaho		■	■							
Montana				■						
Wyoming	■									
South Dakota	■				■					
Minnesota					■	■	■			
North Dakota					■			■	■	■

Washington State Department of Transportation

General Information	Measure	Description	Targets	Data	Data Sources
General information about the agency maintenance program	**Brief title of the measure**	**More detailed description of what the measure consists of**	**Various targets identified by the agency for a certain desired level of performance in relation to the measure**	**Element or unit of data used for the measure**	**Sources used to gather data associated with the measure**
- Budget approximately $75-80M annually - Maintains 18,600 lane miles - Fleet of 500 plow trucks - 1,110 full-time employees and 166 seasonal/part-time employees - Geography ranges from temperate rain forests near the coast, high mountain passes in the Cascades, desert like Central Washington plateaus, and the rolling wheat fields of the Eastern Washington Palouse	Level of Service	Treatment level goals 1-5 are established for all routes within a region. Level 1 is the highest with instructions for treatment pre-event, during event and post-event. The Snow and Ice Plan contains maps illustrating treatment level goals for each route within a region. Following treatment, level of service is measured in terms of the resulting impact on road surface conditions and in terms of the impact on travelers.	Level of service targets: - LOS A to B: Snow or ice buildup encountered rarely. Bare pavement attained as soon as possible. Travel delays rarely experienced. - LOS B to C: Snow or ice buildup encountered at times but infrequent. Travel at times may experience some isolated delays with roads having patches of black ice, slush, or packed snow. - LOS C to D: Snow or ice buildup encountered regularly. Travel likely to experience some delays with roads having black ice or packed snow with only the wheel track bare. - LOS D to F: Compact snow buildup encountered regularly. Traveler will experience delays and slow travel.	- Field inspection	- Highway Activities Tracking System (HATS) is the platform staff use for recording level of service entries, whether or not trucks are equipped with AVL systems. Trucks equipped with AVL systems do not automatically gather the information needed to determine level of service.

Figure 3: State winter performance management practices – Example: Washington DOT
(Source: Project 10.5 North/West Passage Winter Performance Practices (2016))

Related Effort: NCHRP 20-44(37) Workshops on Performance Measures in Snow and Ice Control Operations

In the early planning stages of this project, there was interaction with a related effort that will be conducted as an NCHRP Implementation project to encourage implementation of the NCHRP 14-34 report. The objective of NHCRP 20-44(37) is to develop and hold an initial workshop (to be followed in the subsequent year by a series of workshops) for DOTs to receive an overview of the outcomes of the NCHRP 14-34 report and to discuss potential changes to performance measures used by workshop participants. Members of this project agreed to track the NCHRP 20-44(37) effort, and consider participating in workshops is possible.

3.2 Comparison of Performance Measures from Related Resources and Efforts

During one of the webinars, the performance measures used by North/West Passage members (as identified in the 2016 project and reconfirmed in this effort) were compared to the performance measures recommended in NCHRP 14-34. The only performance measure recommended in NCHRP 14-34 that is not identified as being used by North/West Passage members was the performance measure defined as "Five-year rolling average of fatalities and injuries (number, rate) during a winter season".

See Figure 4 for an illustrative mapping of performance measures used by North/West Passage members and measures recommended in the NCHRP 14-34 report.

NCHRP 14-34 Performance Measures

Objective	Identified Performance Measures
Maintain level of service during event	Percent of time road segments meet agency-defined level-of-service thresholds during winter storms
Meet recovery criteria set by agency	Percent of segments meeting time to regain or recover to acceptable criteria for agency defined segments after the end of event
Meet reliability targets for specific routes	Percent of trips within accepted difference between measured travel time index and additional expected travel time index for snow and ice events for selected routes
Support safe operations of the roadway	Five-year rolling average of fatalities and injuries (number, rate) during a winter season
Meet customer satisfaction ratings	Customer satisfaction ratings for snow and ice response
Support efficient use of resources to meet operational objectives	Cost of snow and ice control to meet established performance criteria for a given winter severity
Support environmental stewardship goals by optimizing material use	Agency within acceptable difference between expected and actual use of salt and other materials in a season

Performance Measures Identified as Used by North/West Passage Members

State	LOS	Winter Performance Index	Winter Mobility Index	Winter Maintenance Service Level Guidelines	Customer Satisfaction Assessment / Public Satisfaction	Return to Bare Pavement	Normal Condition Regain Time	Snow and Ice Costs	Material Usage	Speed Recovery
Washington	■									
Idaho		■	■							
Wyoming	■									
South Dakota	■				■					
Minnesota					■	■	■			
North Dakota					■			■	■	■

Figure 4: Comparison of performance measures recommended in NCHRP 14-34 and those identified as being used by North/West Passage members

4.0 Current Performance Measures, Gaps/Desired Changes, and Consistent Performance Measures Challenges

This section describes current performance measures, gaps/desired changes, and challenges with consistent performance measures discussed by the project team during the project webinars.

LOS was identified as a performance measure used by all member agencies. In addition, recovery or some derivation of recovery was mentioned by many of the agencies. Some specific examples of other performance measures included:

- Soil sampling for impacts on the environment
- Tracking material use and costs
- Tracking fatalities and serious injuries to defend winter material uses
- Tracking snowplow hits
- Recovery based on time to bare lane or 80% bare lane

Gaps or desired performance measure changes included:

- It was noted that winter performance measures are often tied to and overlap with other efforts such as Transportation System Management Operations (TSMO)
- Additional outreach to determine customer satisfaction on snow removal is desired
- A more objective LOS approach is needed (e.g., one that does not rely on manual reporting/assessment of the condition of the road – possibly travel speed).
- Increase automated assessment of performance measures is desired
- Additional deployment of Automatic Vehicle Location (AVL) on snowplows was discussed as a possible approach towards automating performance measures
- Increased data collection to support more comprehensive and accurate before/during/after data for an event is needed
- Automated Traffic Recorders (ATR) were noted as a data source to support assessment of performance measures, but gaps in coverage were noted
- Additional deployment of friction sensors is desired

It was agreed that there are many challenges with corridor consistent performance measures because what works well in one state or area of a state may not work well in another state. However, there is value in learning from other agencies and sharing information.

Appendix A includes notes taken during the webinar discussion on current member performance measures, gaps/desired changes to performance measures, and challenges with consistent corridor performance measures.

5.0 LOS and Recovery Approaches

There are a many different recovery and LOS performance measurement approaches that were presented to the project team during the webinars. Table 3 highlights a few key takeaways from the presentations. Slides used during the presentations are included in Appendix B.

Table 3: LOS and Recovery Approaches Presentation Notes

State	Presenter	Presentation Notes
Minnesota	Mitch Webster and Joe Huneke 11/15/21	• Bare lane indicators were derived by Minnesota DOT from public engagement years ago. • Operators are trained to report bare lanes. • There is a six-hour rule for new vs. continuation of event. • Minnesota DOT is considering "return to target speed" as a more objective measure. • Expectations of travelers are changing.
Wyoming	Vince Garcia 2/7/22	• Wyoming DOT conducted a pilot project that resulted in creating different performance measures for different areas in the state. Each district identified 2 locations during the pilot. The pilot project resulted in reviewing of the entire storm, accounts for service level, and allows combining of costs associated with a storm severity of the storm to arrive at a performance measure and allowed for normalized storm severity. • Some routes in Wyoming don't justify getting to bare pavement. LOS and snow plan priority are utilized.
North Dakota	Brandon Beise 11/15/21	• North Dakota DOT is testing the use of speed data from Automatic Traffic Recorders (ATRs) compared to Maintenance Decision Support System (MDSS) reports of weather to determine if speeds are an effective measure of recovery from winter events. • North Dakota DOT defines recovery as 90% of pre storm speeds maintained for 6 hours. • Since 11/15/21, North Dakota DOT has expanded data collection and North Dakota State University (NDSU) has automated the process. A speed recovery dashboard is available at: https://www.arcgis.com/apps/dashboards/569d13ed66554a01b16afd7897dc53c5 This is publicly available. North Dakota DOT does not provide a link from their website, but it is accessible if someone knows how to navigate through NDSU's websites.
South Dakota	Dave Huft 11/15/21	• South Dakota DOT is testing the concept of purchasing and using speed data as a source to determine recovery time and LOS. • There are three categories identified by South Dakota DOT that may accurately be predicted by speed (bare pavement, 80% bare pavement, snow on road).
Montana	Mike Warren 12/6/21	• Montana DOT analyzes serious and fatal crash data and the severity index to compare one winter to the next based on precipitation and temperature (Clear Roads) to determine if there is a correlation. • Montana DOT utilizes a material dashboard to track labor equipment and materials, provide real-time data on material use by

State	Presenter	Presentation Notes
		different sections, and usage goals are set with the ability to view in real time usage compared to set goals.
Washington	James Morin 11/15/21	• Washington State DOT uses Utah DOT's LOS approach to apply RWIS data to an algorithm (developed by Narwhal) to categorize road conditions for real-time reporting and to summarize LOS during events.
Utah	Jeff Williams 12/6/21	• Utah DOT described benefits to a LOS approach: statewide resource optimization, budget and planning, public response to road conditions under intense storm conditions, justify overtime and salt usage, paint striping, snowplow signal preemption. • Tools used in real time by Utah DOT include statewide maintenance forecast, storm performance reports, storm management tool, statewide snow and ice, snowplow costs and benefits.

6.0 Next Steps

Based on the project team webinar discussions and presentations on LOS and recovery approaches the following next steps were identified for North/West Passage to consider for the corridor.

1. **Potential Future Projects.** There were three projects identified by the project team as potential future projects.
    - *Project #1: Increase Automation of Current Data Collection to Support Winter Performance Measures on the Corridor.* The purpose of this project is to understand North/West Passage current data collection activities that may be used to increase automation of performance measures (e.g., LOS or recovery performance measurement) and identify the steps needed to transition to the use of these data sources.
    - *Project #2: Expand Test of Travel Speeds as a Measure of LOS and/or Recovery Time*. The project purpose is to leverage and expand findings of South Dakota DOT and North Dakota DOT (as well as other non-NWP states) to categorize LOS or recovery by travel speed (either speed data from RWIS/ATR/WIM sites or network speed from third-parties).
    - *Project #3: Predictive Performance Management and Integration into Winter Maintenance Activities.* The purpose of this project is to understand the tools and technology (e.g., artificial intelligence) for predicting near-term level of service conditions in order to adjust winter maintenance activities before and during events.

    These three project ideas were presented to the North/West Passage Steering Committee but were not funded for the next work plan. However, there are members of North/West Passage that are also members of the Clear Roads Pooled Fund Study and it was agreed to bring Project #2 to Clear Roads for consideration as this project is of interest to both. Project #2 was prioritized the highest by the Steering Committee followed by Project #1 and then Project #3.

2. **Sharing LOS and Recovery Performance Measures.** As noted in this report, presentations on LOS and recovery were provided by North Dakota, South Dakota, Minnesota, Montana, Washington, Wyoming, and Utah. Idaho will present at a future North/West Passage webinar. The project team will be invited to attend. During the webinar or another scheduled webinar upon request, member states will be given the opportunity to share and update about their winter performance measures.

3. **Tracking NCHRP 20-44(37) Workshops on Performance Measures in Snow and Ice Control Operations.** The intent of NHCRP 20-44(37) is to develop and hold an initial workshop (to be followed in the subsequent year by a series of workshops) for DOTs to receive an overview of the outcomes of the NCHRP 14-34 report and to discuss potential changes to performance measures used by workshop participants. North/West Passage will track the workshop schedule and member states may be included in the workshops as they are arranged.

Appendix A: Webinar Notes – Current Practices, Gaps/Desired Changes, and Consistent Performance Measures Challenges

Table A-1: Webinar #1: October 25, 2021 Webinar Notes – Current Performance Measures, Gaps/Desired, Changes, and Consistent Performance Measures Challenges

State	Current Performance Measures	Gaps / Desired Changes	Consistent Performance Measures Challenges
Washington	• Experimenting with LOS last few years • Use AVL to determine how long does it take a truck to response once a storm starts (beginning and end). • Keep speed down so material is effective. • Prefer a condition assessment. • Experimented with "Utah model" (RWIS fully equipped w/friction, ran historical data to define LOS). Liked it but challenge is getting 120 RWIS up to this level. COVID has slowed it down. Hoping for outcome based LOS. • Do a lot of soil sampling at the beginning and end of the season to eval impacts on environment. Track usage, but don't always apply to LOS.	• Hoping for outcome based. • Ties to TSMO and overlap with winter PM – how information is communicated to the public and how quickly recover operations will become more important in future. Huge cost component.	• Clear Roads has looked at consistent approaches. 36 states is challenging (there are differences in weather patterns). • What works well in Puget sound may not work in Eastern WA.
Montana	• Track material and cost with snow and ice. • LOS guidelines (how long it takes to clear based on LOS for that roadway). • Have done return to speed, it is a very manual process. Depends if WIM next to RWIS. • Track fatalities and serious injuries over winter moths to defend winter material use.	• Get away from subjective LOS to more objective (return to speed great way to measure). • Do customer satisfaction survey on snow removal	
South Dakota	• Cost to route (can sort by shop any unit). There is a weakness with relaying on self-reporting. • Tracking winter related crashes (weight with WSI). • Track snowplow hits by VMT (about 10/MVMT). • Recovery is time based to 80% bare lane (2 or 4 hour cycle) • There is ongoing research into measuring LOS winter events.	• Moving to VSL, have interest in understanding if VSL are effective. Grant to help deploy and evaluate. • Prefer automated PMs vs relying on drivers to convey. • Costs, how to automated LOS. All plows to have AVL	• Consistency on how some states are measuring

State	Current Performance Measures	Gaps / Desired Changes	Consistent Performance Measures Challenges
	• Last winter, pilot project that purchased real-time cell speeds to correlate recovery – question is if there is enough traffic. • Customer satisfaction survey conducted every 2-3 years. Research into customer expectations: recommended minor modifications to what doing.		
Minnesota	• Variety of measures, few to base decisions. • Time to bare lane observed by driver (ADT based, LOS component to it). Used it 20 yrs, only not met one year. • Customer satisfaction (omnibus survey), typically meet. • Winter severity is based seasonally to figure material usage and costs. Used to be wind, snow, and ice. Now have variety based on RWIS and NWS (air temp, dew pt, frost, wind speed, precip type, blowing snow). MDSS recommends (there were years we were overapplying). The goal is to use 100% of recommendations since historically used more. • Miles of snow fence (living and structure) new expanding PM. • DTN is forecast/MDSS starting project to automate (clear lane) – report internally in MDSS to allow us to use modeling to understand when bare lane was lost and regained. • Adding non-intrusive friction in RWIS (have about 25 statewide) • TAM incorporating, will automate from MDSS to TAM. Goal is dashboard before decision makers to see how addressing PM targets. Haven't heard of PM from general public expectations for traveler information (use it download it, different category, service).	• Like to get to return to normal travel speed. Has questions "what is normal?" overspeed limit? ADT/TOD variables. • Discussed friction in past • Like to get to more before/during/after • Material usage (has been self reported, like to get to MDSS measured – project for more slurry/liquid)	• More interested in best practice vs. consistency. What is the best approach.

State	Current Performance Measures	Gaps / Desired Changes	Consistent Performance Measures Challenges
North Dakota	• Material tracking and cost tracking. • Snow and Ice Manual indicates LOS (6 levels) and how much time to remove snow for different roads. However, it is not tracked enough. • Speed recovery PM (how long does it take to get back to certain level after a storm). Currently MDSS and traffic recorders are used. Recently a grant was received to fund automating recovery monitoring. Additional sites will be added which will produce better data.	• Even when the additional sites are added to assist in speed recovery there will still not be full coverage. The ATRs are in good locations now and it is a challenge to understand with additional sites if speed recovery will improve. North Dakota does not operate 24/7. Storms many not be addressed until the morning. • Adding friction sensors to RWIS sites (recovery-Y LOS-Y). Approximately 29 RWIS and most have friction sensors. Half of the sites have in pavement sensors. • Using Clear Roads Severity Index, want to correlate to speed recovery.	• Consistency being a benefit, but how to gear up for it? What can we share/purchase on our own.
Wyoming	• Piloted a project to tie into AMP system (manpower and equipment) to determine what it takes to recover (snow plan is tied to ADT). • Important to normalize. An area of the state with lots of wind can be compared to an area that gets a lot of snow, but no wind. • Account for time of year, ditches are full, duration of storm, ambient temp	• Pilot was difficult across the state. Each region had to pick 2 to 3 sites for the pilot.	

Appendix B: Slides from State DOT LOS and Recovery Approaches Presentations

- Wyoming DOT
- North Dakota DOT
- Montana DOT
- Utah DOT
- Washington State DOT

Wyoming DOT

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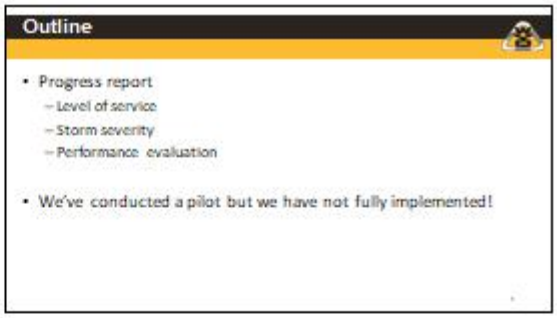

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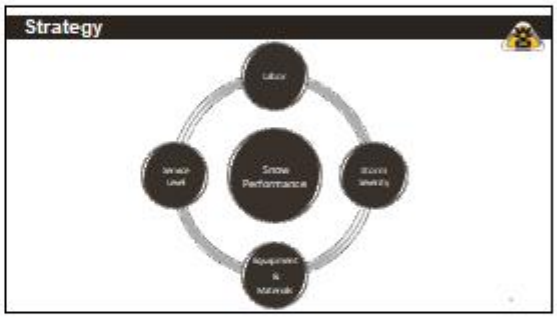

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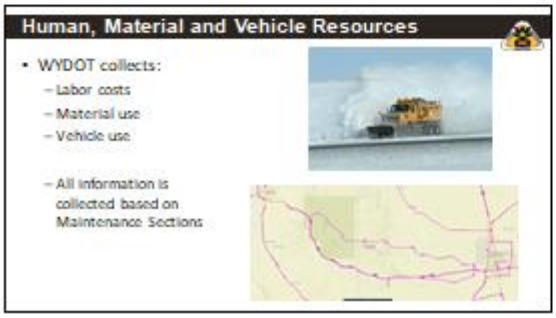

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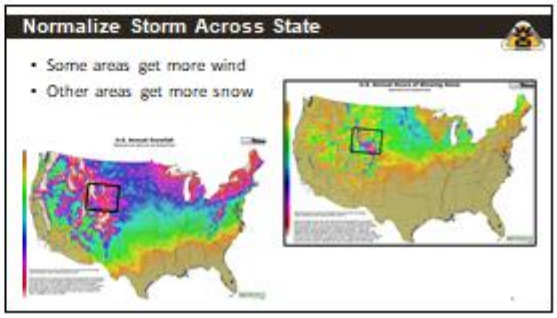

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Service Level

- Look at Service Level based on snow plan priority
- Not necessarily trying to get every section to bare pavement

6

Local Winter Storm Scale and Storm Severity

LWSS = sum [w(k) * sk] sk = [(s - cl)/(cu - cl)] + C

Average Wind (knots)
Max Gust (knots)
Total Snowfall (inches)
Freezing Rain (inches)
Lowest Visibility (miles)
= Storm Severity Index (LWSS)

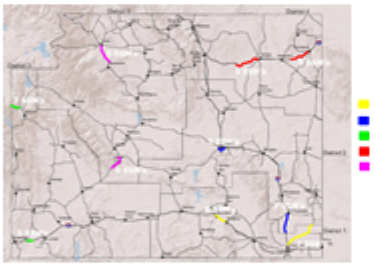
Source: The Local Winter Storm Scale – A Measure of the Intrinsic Ability of Winter Storms to Disrupt Society, Brian J. Comer and Steven C. Decker, Bulletin of the American Meteorological Society, January 9, 2011.

Storm Severity Measurement = LWSS x FDUR x FTOD x FTOY x FSS x FDS x FTEM

FDUR = Factor for Storm Duration. 1.0 for <24 hrs, 1.1 for >24 hrs, 1.2 >48 hrs
FTOD = Factor Time of Day. 1.05 for night, 1 for daylight, .9 for day
FTOY = Factor time of Year(account for number of daylight hours) 9hrs =1.05, 10/11hrs =1, 12hrs =.9, 14hrs =.7, 16hrs =.5
FSS = Factor Snow Fence Storage. 1.0 if not full, 1.1 for full snow fence
FDS = Factor Ditch Storage. 1.0 if not full,1.1 for full ditches
FTEMP = Average ambient temperature during snowfall event <10° =1.0, 10°-15° =0.9,

7

Pilot Sections



8

Pilot Results

- Assessment works: 77% initial agreement with 98% final agreement. The one storm that a final agreement wasn't obtained was due to category name.
- Evaluation of events throughout the year worked well, including spring events, in which the majority of the snow melted on the roadway. Weighting factors for time of year and ambient temperature worked for spring storms, and will apply to early fall storms as well.
- Visibility readings from RWIS seem to be high when we get into whiteout or near whiteout events, but also had one reading which was significantly too low.

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Pilot Results (Cont.)

- Storm duration weighting is a little high. Dropping > 24hr storm weighting to 1.1 from 1.2 and > 48hr to 1.2 from 1.4 .
- Snow fence & ditch storage is pre-storm storage, and adding a third category for partially full, and a 1.05 weighting could be appropriate?
- Instead of category names, use a storm scale of zero to five to eliminate misperception of category names.

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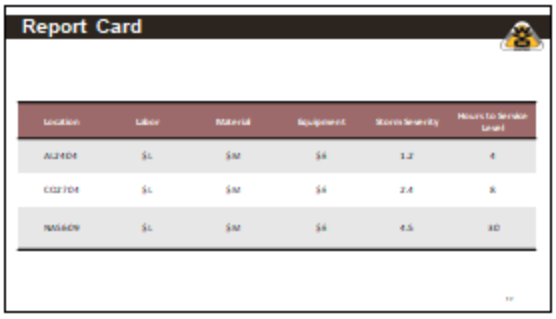
Benefits

- Allows review of the entire storm
  - Not completely dependent on site specific RWIS
- Accounts for Service Level
  - Manpower is not available to focus on bare pavement on every route
- Allows combining of costs associated with a storm and severity of the storm to arrive at a Performance Measure
- Allows for normalized storm severity
  - Account for high wind and high snow volume areas

11



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North Dakota DOT

SNOW & ICE CONTROL
SPEED RECOVERY
PERFORMANCE MEASURE

NORTH Dakota | Transportation

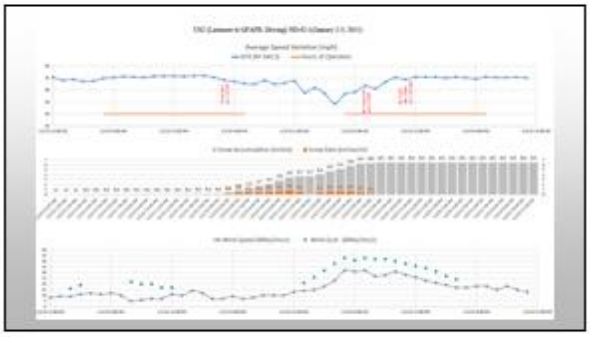
BRANDON BEISE
NDDOT MAINTENANCE DIVISION
NOVEMBER 15, 2021

1

HISTORY

- STARTED PERFORMANCE MEASURE FOR THE 2013-2014 WINTER
- ESTABLISHED STORM CRITERIA
- 16 WEATHER & SPEED COLLECTION LOCATIONS
  - ATR LOCATIONS ON MDSS ROUTES
  - TWO LOCATIONS PER DISTRICT
  - MIX OF RURAL HIGHWAY CLASSIFICATIONS
- VERY MANUAL PROCESS

2



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STORM CRITERIA

Storm Trigger Requirements:

NDDOT Storm Category	Description	Precipitation	Duration	Wind Speed
1	Snow Accumulation	≥ 1"	All	All
2	Freezing Rain	All	All	All
3	High Winds	≥ Trace	≥ 2 hours	≥ 35 mph

- When weather conditions meet at least one of the above three Storm Categories, the weather event is to be considered a storm.

Storm Expiration Requirements:

NDDOT Storm Category	Description	Precipitation	Duration	Wind Speed
1	Snow Accumulation	< Trace	All	< 35 mph
2	Freezing Rain		All	
3	High Winds		All	

- When weather conditions meet all three of the above Storm Categories the storm is to be considered finished (meeting all Precipitation, Duration and Wind Speed requirements).

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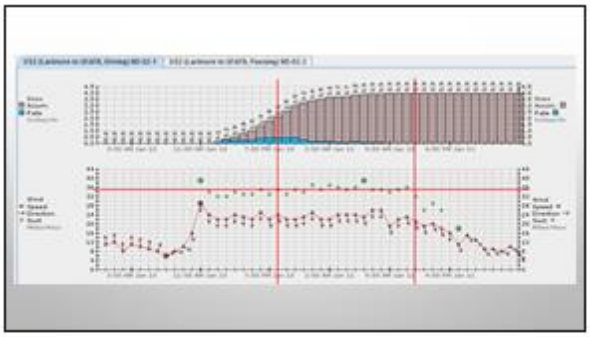

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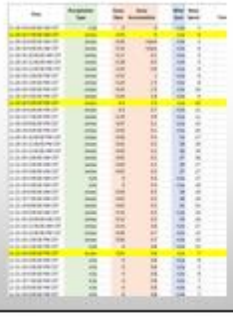

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SPEED DATA

- COLLECTED FROM ATR LOCATIONS DURING STORM DAYS
- PRE-STORM SPEED
  - 4-HOUR AVERAGE SPEED PRIOR TO FIRST TRACE OF STORM PRECIPITATION
- RECOVERY SPEED
  - 90% OF THE PRE-STORM SPEED
  - MAINTAINED FOR AT LEAST 6 HOURS

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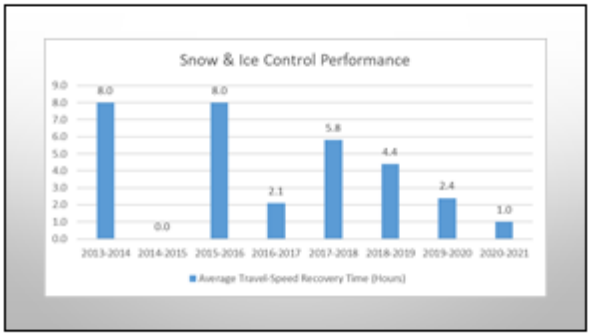

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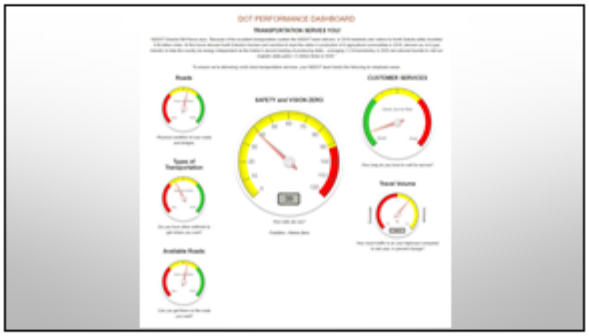

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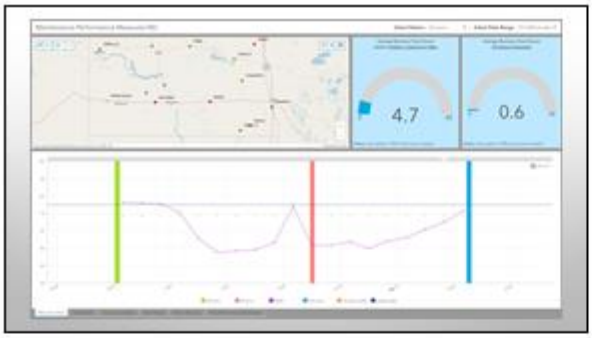
STIC GRANT (2020-2021 WINTER)

- AWARDED STIC GRANT IN AUGUST 2020
  - AUTOMATE SPEED RECOVERY PROCESS
- DTN
  - AUTOMATE STORM DATA COLLECTION BASED ON STORM CRITERIA
  - PROVIDE STORM DATA FOR SPEED ANALYSIS
- ATAC (ADVANCED TRAFFIC ANALYSIS CENTER)
  - COLLECT AND AUTOMATE SPEED DATA BASED ON STORM DATA
  - CREATE DASHBOARD TO PROVIDE SPEED RECOVERY RESULTS

12



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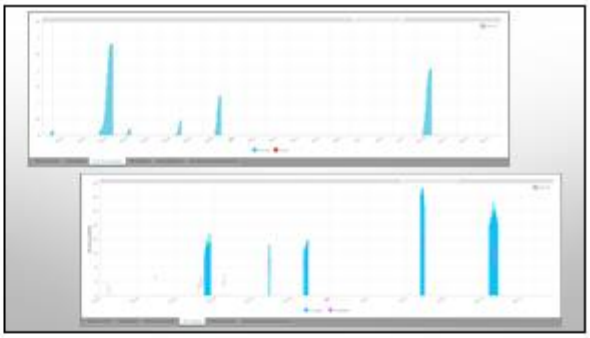

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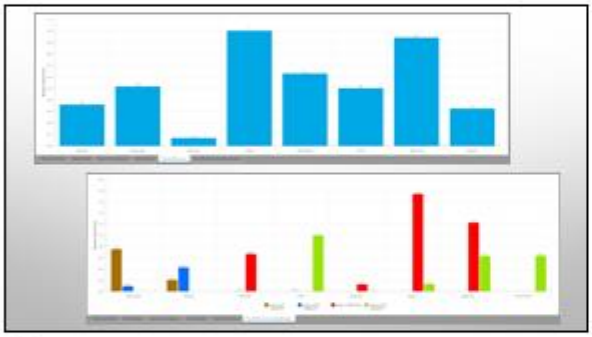

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UPCOMING ADDITIONS

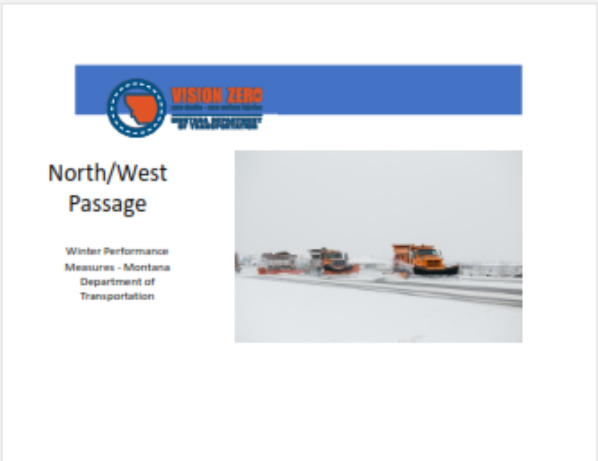
- INCREASE COLLECTION LOCATIONS FROM 16 TO 73
  - COLLECT SPEED DATA FROM 66 ATR LOCATIONS
  - COLLECT SPEED DATA FROM 7 ESS LOCATIONS
  - CREATE 24 NEW MDSS ROUTES FOR WEATHER DATA
  - 7 TO 13 COLLECTION LOCATIONS PER DISTRICT
- ADD GRAPHS WITH FRICTION DATA FROM 19 ESS LOCATIONS
- ADD GRAPHS WITH CLEAR ROADS WINTER SEVERITY INDEX BY COLLECTION LOCATION & DISTRICT

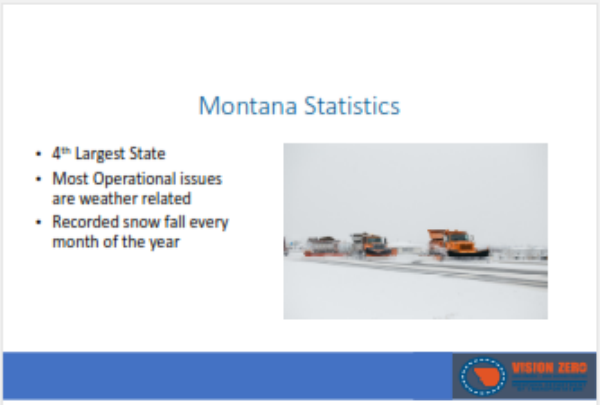
16

QUESTIONS

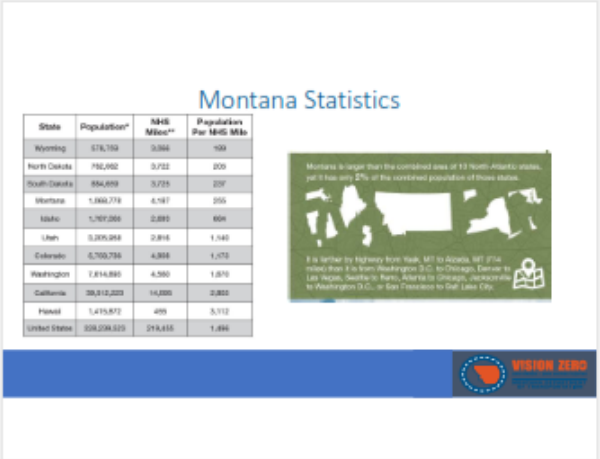
17

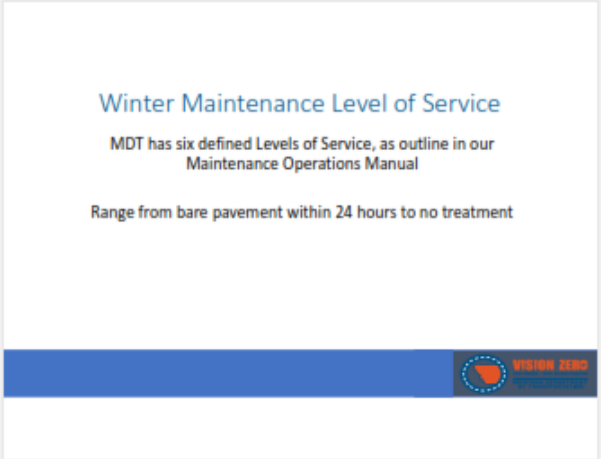
Montana DOT


North/West Passage
Winter Performance Measures - Montana Department of Transportation


Montana Statistics
4th Largest State
Most Operational issues are weather related
Recorded snow fall every month of the year


Montana Statistics


Montana Statistics

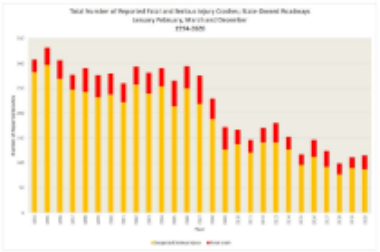

Winter Maintenance Level of Service
MDT has six defined Levels of Service, as outline in our Maintenance Operations Manual
Range from bare pavement within 24 hours to no treatment


Winter Maintenance Level of Service

Winter Maintenance Level of Service

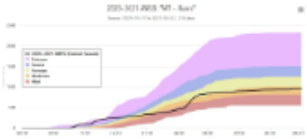
Winter Maintenance Level of Service

Data Driven Decisions in Montana



Data Driven Decisions in Montana

- This year we began to use data from our TMC to understand our operations
- MDT uses a Winter Severity Indices
  - Accumulated Winter Season Severity Index
- The index measures temperature and precipitation



Data Driven Decisions in Montana

- MDT uses a Materials Dashboard to look at the Material use for winter Maintenance
- This with our Winter Severity Index is how we compared winters
- Little understanding of Public Perception
- Enter, the TMC

Data Driven Decisions in Montana

- Had no idea how the public perceived our Winter Level of service
- TMC tracks the Call type—Complaint or our Partners such as EMS or MHP
- Base year tracking now we will have subjective and objective data for our operations

	Division									
Call Type	11	12	21	22	31	32	42	43	51	55	Grand Total
REQUEST OTHER	8	6	9	7	1	4		1	6	5	47
REQUEST PLOW/SAND	154	93	124	250	92	40	13	35	157	30	988
Grand Total	162	99	133	257	93	44	13	36	163	35	1035


RWIS / WIM Pilot
• RWIS with non-invasive sensors
• Includes Road Grip measurement
• Nearby WIM site
• Hope to collect data relative to return to speed
VISION ZERO

Utah DOT

1

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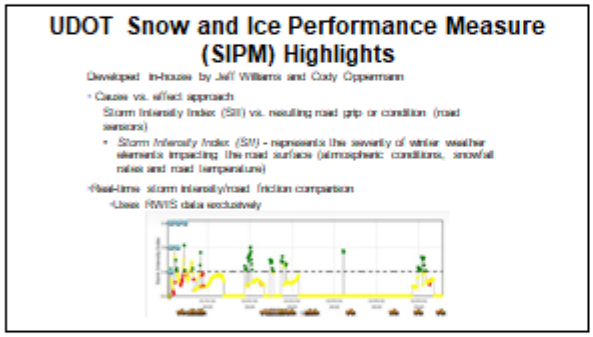

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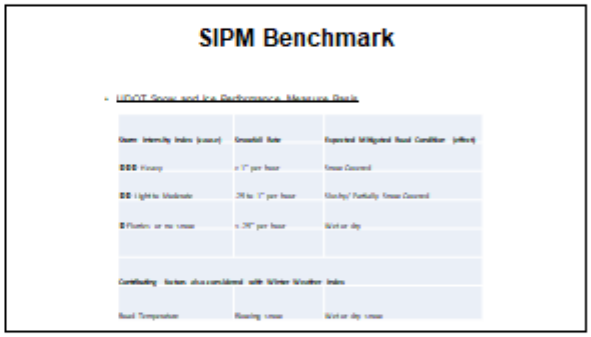

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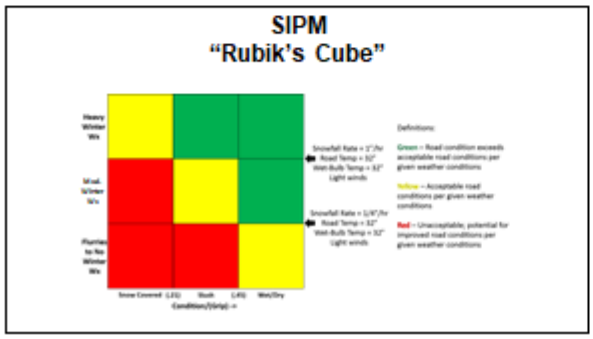

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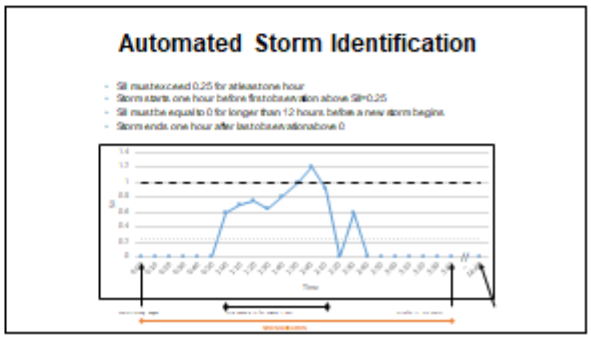

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SIPM Benefits

- Statewide resource optimization
  - *Real-time Storm Management
- Budget and planning
  - Combine maintenance data to make better management tools
- Public response to road conditions under intense storm conditions
- Justify overtime and salt usage
- Misc – Paint striping, snow plow traffic signal preemption

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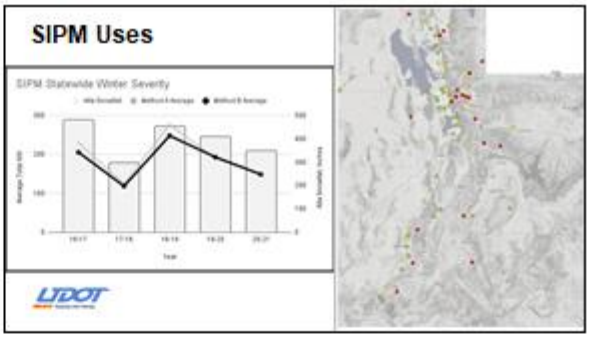
SIPM Uses



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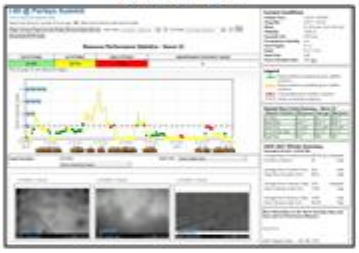
RWIS SIPM



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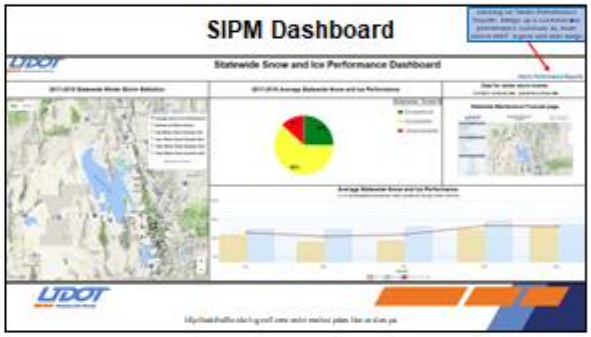
SIPM Dashboard



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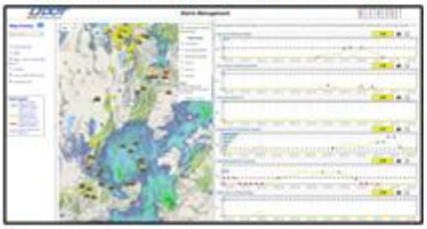
Storm Management Dashboard



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Limitations

- Based on a 12' sample area of a road
  - Connect vehicles, mobile weather observations and modeling could fill in the gaps
- Flurries in fog confuse the estimated snowfall rate algorithm
  - *New algorithm in place to reduce occurrences
- Instrumentation
  - Tough environment
  - Not all road surfaces are alike
  - Frequent calibration is needed
  - Ideal road to sensor geometry can be challenging

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Contact Info
Jeff Williams – UDOT Weather Operations Manager / Meteorologist
Cody Oppermann– UDOT Research Meteorologist / RWIS manager

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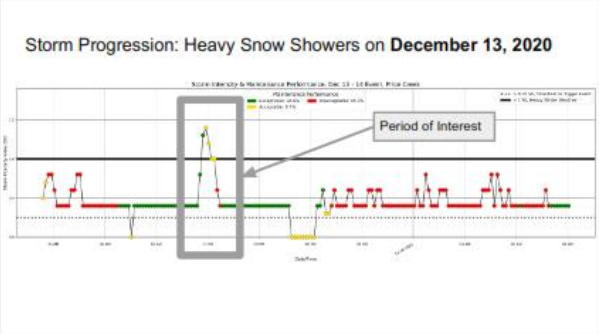
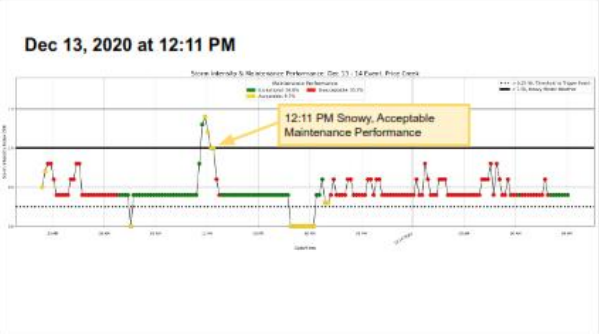
Washington State DOT



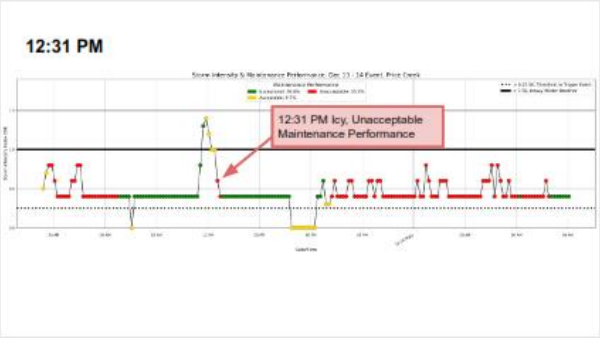


12:11 PM

Weather: *Moderate-heavy snow*

Road Condition: ***Snow** Warning*

Maintenance Performance: *Acceptable*



12:31 PM

Weather: *Much improved, light snow*

Road Condition: ***Ice** Warning*

Maintenance Performance: *Unacceptable*