U.S. Department
of Transportation
Federal Highway
Administration

Data-Driven Work Zone Process Reviews Case Study: Maryland Department of Transportation State Highway Administration

October 2021

Notice

Quality Assurance Statement

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HOP-21-051	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Data-Driven Work Zone Program Reviews Case Study: Maryland Department of Transportation State Highway Administration		5. Report Date October 2021 6. Performing Organization Code:
7. Author(s) Param Sankar, Ram Boyapati, Alan Pate		8. Performing Organization Report No.
9. Performing Organization Name and Address Battelle 505 King Avenue Columbus, OH 43201		10. Work Unit No. 11. Contract or Grant No. DTFH6116D00049 / 693JJ319F000284
12. Sponsoring Agency Name and Address United States Department of Transportation Federal Highway Administration 1200 New Jersey Ave. SE Washington, DC 20590		13. Type of Report and Period 14. Sponsoring Agency Code HOP

15. Supplementary Notes
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16. Abstract
Federal regulations in 23 CFR part 630 subpart J require State highway agencies to conduct a Work Zone Process Review (WZPR) every 2 years to evaluate work zone processes and procedures, as well as identify systematic improvements to current and future projects. The Federal Highway Administration now encourages agencies to use a data-driven approach to make WZPRs more outcome- and performance-driven, while bringing about a continuum mindset to WZPRs as opposed to isolated point-in-time reviews. This type of approach uses quantitative data and analyses including exposure, safety, mobility, and inspection data, as well as qualitative information in WZPRs. This case study is one of a series of resources on data-driven WZPRs. It was developed in collaboration with the Maryland Department of Transportation State Highway Administration (MDOT SHA) and focuses on three major program areas: safety, mobility, and field reviews. Anonymized data from crash reports, traffic sensors, probe vehicles, work zone field reviews, and work zone project tracking were used to conduct the analyses, derive metrics and trends, and identify key issues. The case study used data from 2018 through 2020. This case study demonstrates how MDOT SHA successfully uses crash, traffic, field review, and construction data to streamline its WZPRs and provide a repeatable quantitative basis for more systematic reviews that extend across multiple process review cycles.

17. Key Words Work zone process review, work zone management, exposure data, safety data, field review data, mobility data	18. Distribution Statement No restrictions.		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 32	22. Price

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List of Acronyms

AMD	Access Management Division
CMF	Capability Maturity Framework
DOT	Department of Transportation
FHWA	Federal Highway Administration
MDOT SHA	Maryland Department of Transportation State Highway Administration
OOTS	Office of Traffic and Safety (within MDOT SHA)
PDA	Probe Data Analytics
RITIS	Regional Integrated Traffic Information System
TMA	Truck mounted attenuator
TMP	Traffic management plan
VHD	Vehicles hours of delay
VHT	Vehicle hours traveled
VMT	Vehicle miles traveled
WZ	Work zone
WZM	Work zone management
WZPR	Work zone process review

Introduction

Federal regulations in 23 CFR part 630 subpart J require State highway agencies to conduct a Work Zone Process Review (WZPR) every 2 years to evaluate work zone (WZ) processes and procedures, as well as identify systematic improvements to current and future projects.[1] WZPRs apply to all project development and implementation phases, including planning, preliminary engineering, impact assessment, design, implementation/construction, and performance monitoring and management. Recognizing the importance of data for effective WZPRs, the Federal Highway Administration (FHWA) incorporated another provision in Subpart J requiring States to use available data, observations, and information to manage WZ impacts of individual projects, as well as to continually pursue broader improvement of WZ processes and procedures through WZ data analysis (e.g., crash/safety data, mobility data, construction metrics, operational metrics).[2]

The FHWA published guidance in April 2015 to assist State highway agencies in conducting effective WZPRs.[3] That guidance document recommends a nine-step approach for performing a WZPR, as shown in figure 1. In the guidance document, FHWA also emphasizes the importance of using data and performance measures in WZPRs to make the process reviews more comprehensive, actionable, and effective.

Suggested Process Review Steps in FHWA's Guidance for Conducting Effective Work Zone Process Reviews (2015 Publication)

1. Assemble a multidisciplinary team
2. Develop a review plan
3. Conduct review
4. Analyze and interpret results
5. Develop inferences, recommendations, and lessons learned
6. Prioritize recommendations and lessons learned
7. Develop an action plan to implement the prioritized recommendations
8. Present findings
9. Initiate the action plan

Source: FHWA

Figure 1. List. Suggested Process Review Steps in FHWA's Guidance for Conducting Effective Work Zone Process Reviews

However, many State departments of transportation (DOTs) have found it challenging to include data consistently and effectively in their WZPRs due to a lack of awareness and access to data, as well as limited resources for conducting streamlined data driven process reviews. A renewed focus on performance-based work zone management (WZM), new industry paradigms, and the emerging data sources from connected, autonomous, and probe vehicles present State DOTs many new opportunities to leverage data in their WZPRs. A data-driven WZPR approach will enable agencies to make WZPRs more

[1] 23 CFR part 630 subpart J. https://www.ecfr.gov/current/title-23/part-630/subpart-J.
[2] 23 CFR part 630 subpart J § 630.1008. https://www.ecfr.gov/current/title-23/chapter-I/subchapter-G/part-630/subpart-J/section-630.1008.
[3] FHWA. Guidance for Conducting Effective Work Zone Process Reviews (2015). https://ops.fhwa.dot.gov/publications/fhwahop15013/index.htm.

outcome- and performance-driven, while bringing about more of a continuum mindset to WZPRs, as opposed to isolated point-in-time reviews.

This Maryland Department of Transportation State Highway Administration (MDOT SHA) case study was developed by FHWA to demonstrate a data-driven, systematic, and comprehensive approach to conducting WZPRs. It provides examples of how State DOTs can leverage existing data sources and performance assessment findings to incorporate data into steps two to five of the nine-step WZPR approach (shown in figure 1). It does not represent FHWA guidance or an example WZPR report and is not intended to replace the WZPR report formats that State DOTs follow. As presented in figure 2, the data integration approach comprises identifying data needs for each program area, conducting data analyses, identifying trends for issues and best practices, collecting contextual information about trends identified, selecting action plans based on trends, developing metrics to assess action items, implementing continuous data collection, and analyzing the impacts of implemented action items on program outcomes.

MDOT SHA conducted its previous WZPRs by focusing on select strategies implemented during the process review cycle. The discussions in those WZPRs were driven by qualitative observations, with limited focus on quantitative data assessments of outcomes. Although data were not included in prior WZPRs, MDOT SHA has been routinely collecting WZ-related data as part of MDOT SHA's internal performance management efforts. In addition, MDOT SHA uses the Regional Integrated Traffic Information System (RITIS), which collects mobility data (as well as provides transportation system performance measures). This presents a significant opportunity for MDOT SHA to use these data resources to make its WZPRs more data-driven, with the goal of using quantifiable benchmarks for performance management.

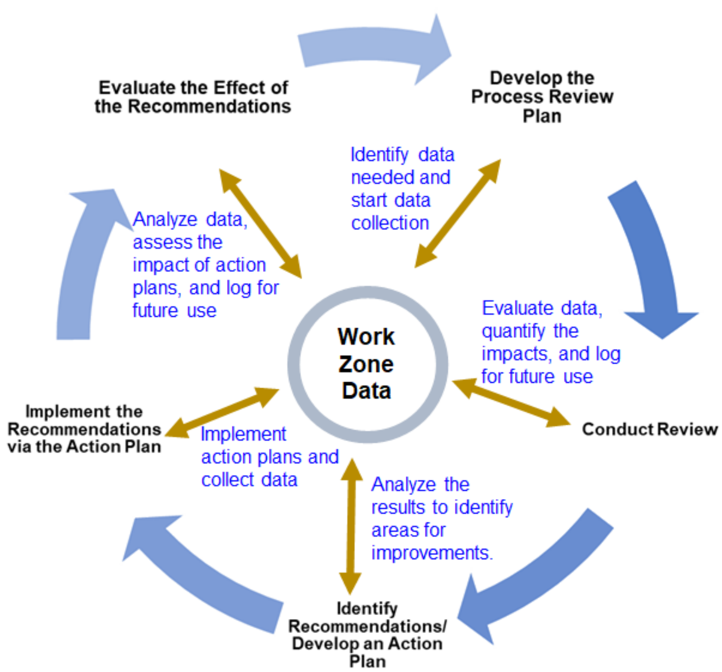

Figure 2. Diagram. An integrated approach for data-driven Work Zone Process Reviews
Source: FHWA

Performance Areas Selected for the Work Zone Process Review Case Study

The project team chose safety, mobility, and field inspections as the three main WZ performance areas for this WZPR case study. Anonymized data from crash reports, traffic sensors, probe vehicles, WZ field reviews, and WZ project tracking were used to conduct the analyses, derive metrics and trends, and identify key issues. For the mobility and field inspection performance areas, MDOT SHA provided the project team with data from 2018, 2019, and 2020 to use in the case study. Similarly, for the WZ safety performance area, the team used data from 2016 through 2019. WZ crash data for 2020 was not available at the time this case study was conducted. The project team did not perform any statistical significance testing due to inconsistencies in data availability. Findings from the case study for each focus area are presented in the following sections. The discussion starts with an overview of the WZ exposure data that MDOT SHA tracks, which provides a basis for assessing performance based on the volume of WZ activity.

Exposure Data

A comprehensive data driven WZPR allows comparison of WZ performance across multiple years, as well as normalization of WZ performance by the volume of WZ activity (i.e., WZ exposure) in any given year. WZ exposure data include metrics such as the number of WZs, WZ vehicle miles traveled (VMT), mileage of construction/maintenance activity, project duration, lane closure hours, and traffic volume affected by WZs.

Exposure Data Used in Case Study

Source: MDOT SHA Project Portal

Metric: Number of WZ construction projects

MDOT SHA collects and publishes current and historic construction WZ project information on the MDOT SHA Project Portal.[4] The main focus of MDOT SHA's WZ exposure data collection is on road construction projects including road widening, bridge and waterline replacements, new road constructions, and total roadway reconstructions. MDOT SHA implemented 55, 56, and 64 WZ construction projects in 2018, 2019, and 2020, respectively. Most of the increase in WZ construction projects in 2020 occurred on Maryland routes (figure 3). MDOT SHA was able to accelerate activities on road construction projects by taking advantage of the reduced traffic demand during the COVID-19 pandemic, which led to the increased number of WZs implemented in 2020.

[4] MDOT SHA Project Portal. https://mdot-sha-project-portal-maryland.hub.arcgis.com/pages/project-list-and-links.

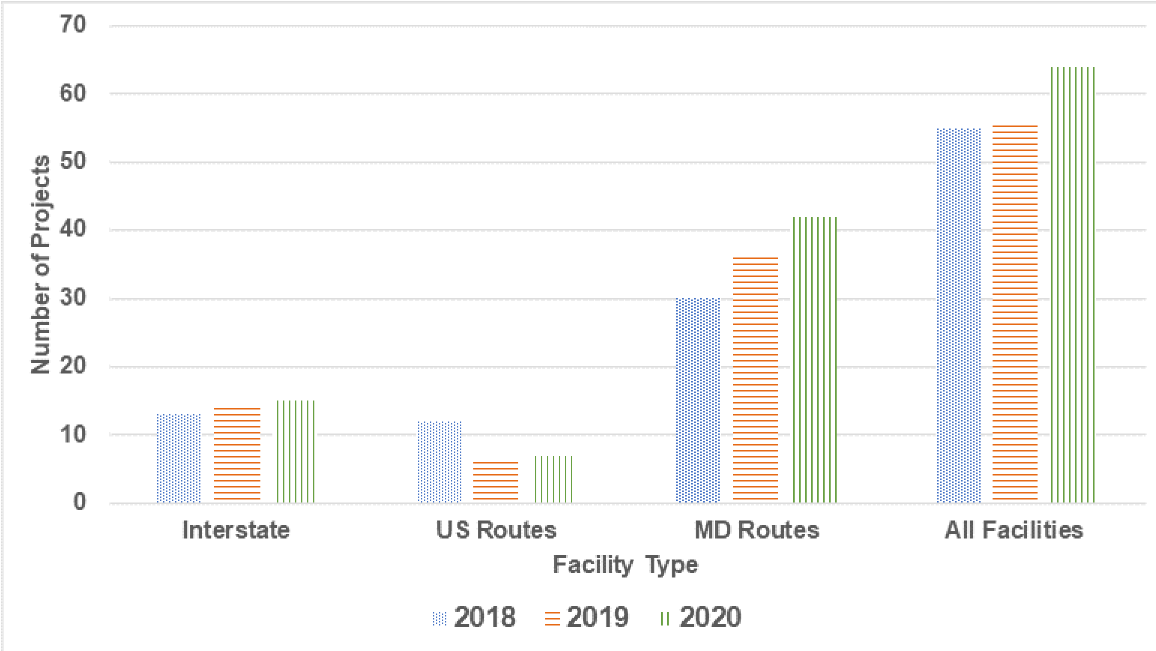

Figure 3. Chart. Total number of work zone construction projects
Source: MDOT SHA

Key Findings and Observations for Data-Driven WZPRs

- MDOT SHA tracks, digitizes, and publishes information about its WZ construction projects on the MDOT SHA Project Portal, which is a good start towards collecting WZ exposure data. Expanding this WZ project tracking to other WZ types such as maintenance, MDOT SHA Office of Traffic Safety (OOTS), and access management will enable MDOT SHA to conduct comprehensive performance assessments of all WZ activity.
- MDOT SHA accelerated its road projects in 2020 to take advantage of reduced traffic demand due to COVID-19 pandemic conditions.
- From a WZPR standpoint, MDOT SHA should consider tracking additional WZ exposure metrics, including the number of WZs, mileage affected, duration, lane closure hours, and traffic volume metrics such as VMT and vehicle hours traveled (VHT). Having these data will allow MDOT SHA to get a complete picture of WZ exposure and compare, contrast, and normalize WZ performance trends and conduct
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Performance Area 1 – Work Zone Safety

The project team analyzed WZ-related crash data to assess the safety performance of WZs implemented in Maryland from 2016 to 2019 (figure 4). The project team did not have access to 2020 crash data. Overall, MDOT SHA experienced 1,569 and 1,573 WZ crashes in 2016 and 2017, respectively, which were on par with the 4-year average of 1,579 crashes. The

Safety Data Used in Case Study

Source: Maryland Crash Reports

Metrics: Number of WZ crashes (total, fatal, injury, possible injury, and non-injury number of WZ crashes in 2018 was 1,499, which was a five-percent reduction compared to the 4-year average. This 2018 WZ crash reduction was primarily observed on Maryland routes. In 2019, MDOT SHA experienced 1,674 WZ crashes, which was a six-percent increase compared to the 4-year average.

The project team also analyzed WZ crashes by facility type. Compared to the 4-year average, WZ crashes on interstates remained marginally lower between 2016 to 2018 and increased in 2019. Maryland routes experienced a marginal increase in WZ crashes in 2016, 2017, and 2019 and a noticeable decrease in 2018. U.S. routes experienced a marginal increase in crashes from 2016 to 2018 and a decrease in 2019. The variation in the number of crashes across the years may be attributable to the changes in travel demand experienced in the MDOT SHA WZs. One way to verify this is to compare the total WZ VMT across the years. However, MDOT SHA does not currently collect and record VMT through WZs.

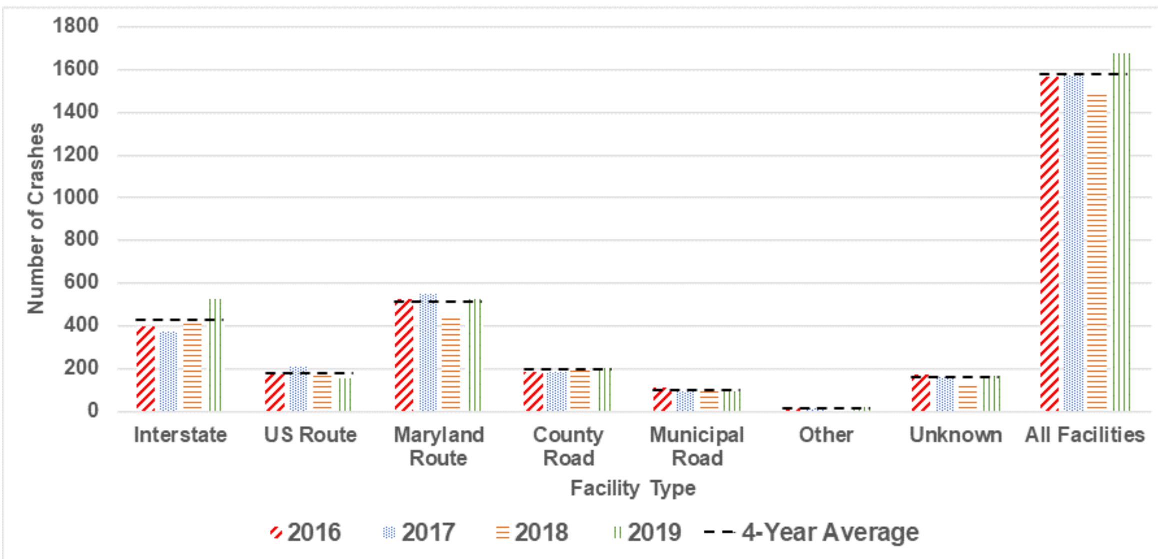

Figure 4. Chart. Number of work zone crashes
Source: MDOT SHA

Next, the project team analyzed WZ crashes by crash type. Findings indicated that rear-end crashes and side-swipe crashes on interstates contributed to more than 40 percent (an increase of 81 crashes) of the overall increase of 175 WZ crashes in 2019 when compared to the 4-year average (figure 5). Preliminary qualitative discussions with MDOT SHA's OOTS suggested that increased congestion and speed differentials in WZs may have contributed to the increase in rear-end and side-swipe crashes in 2019. In its next WZPR assessment, the MDOT SHA WZPR team plans to thoroughly analyze the key factors contributing to the rear-end and side-swipe WZ crashes and their mitigation strategies.

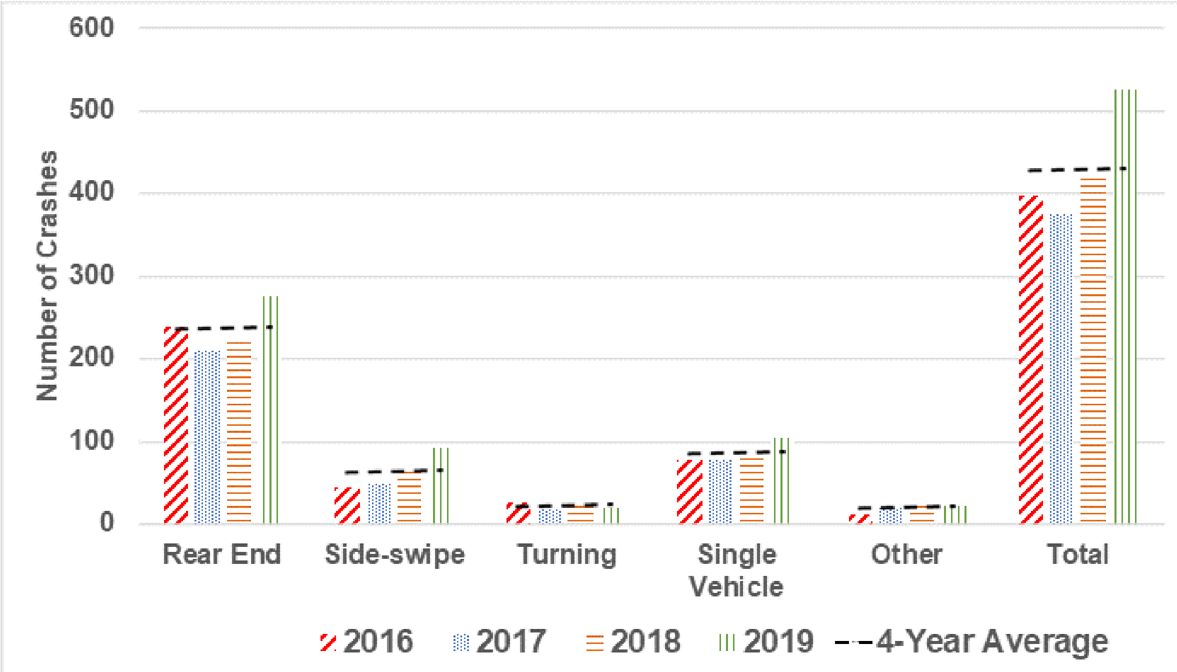

Figure 5. Chart. Number of work zone crashes
Source: MDOT SHA

Finally, the project team analyzed WZ crashes by severity type including fatal, injury, possible injury, and non-injury crashes. The numbers of fatal crashes experienced by MDOT SHA were 5, 13, 10, and 7 in 2016, 2017, 2018, and 2019, respectively (figure 6). Similar variations were observed for injury (figure 7), possible injury (figure 8), and non-injury crashes (figure 9). Although there is some variation in the number of crashes across the years, it was not possible to compare trends and assess variation across the different crash severity types due to lack of WZ exposure data (e.g., WZ mileage, VMT, VHT). As mentioned previously, tracking such WZ exposure data would allow MDOT SHA to conduct more comprehensive WZPRs that lead to meaningful trend, pattern, and causation analyses. The project team performed a deeper dive into the 2019 crash distribution to understand the most recent safety performance in Maryland WZs. Findings indicated that the overall WZ crashes increased in 2019, whereas the crash severity reduced compared to the 4-year average. One possible explanation for lower severity of crashes is that MDOT SHA began using truck-mounted attenuators (TMAs) on the shoulders in 2018 and 2019. MDOT SHA requires its WZ teams to place TMAs at a safe buffer distance from the WZ activity area. These TMAs act as a protective cushion, absorbing high-energy kinetic impacts of the WZ crashes and thereby reducing their severity.

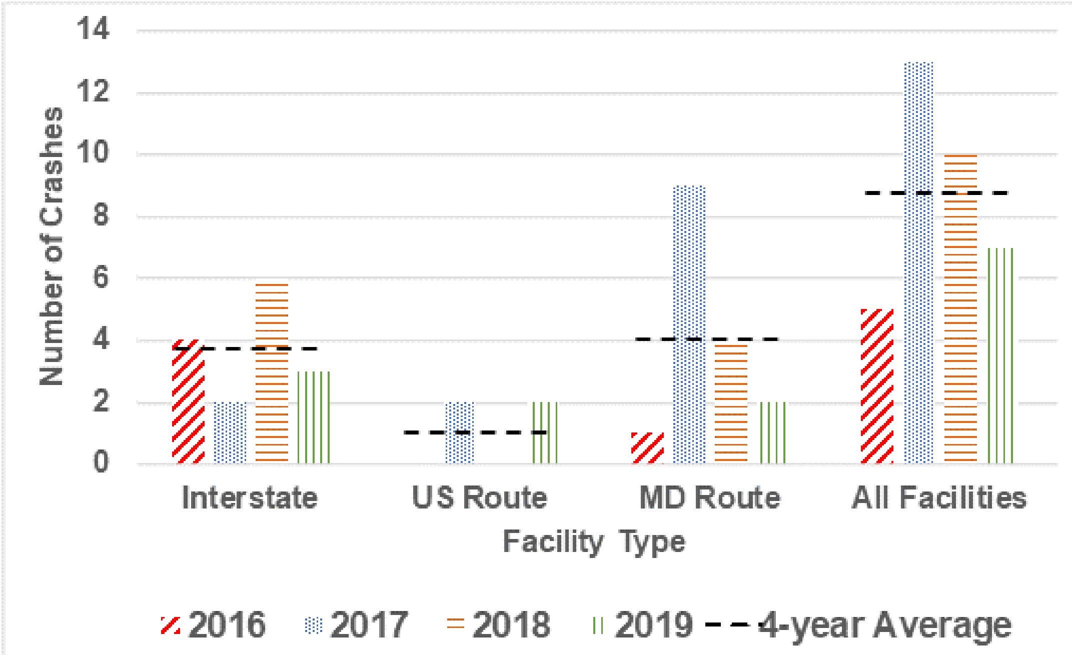

Figure 6. Chart. Number of fatal work zone crashes
Source: MDOT SHA

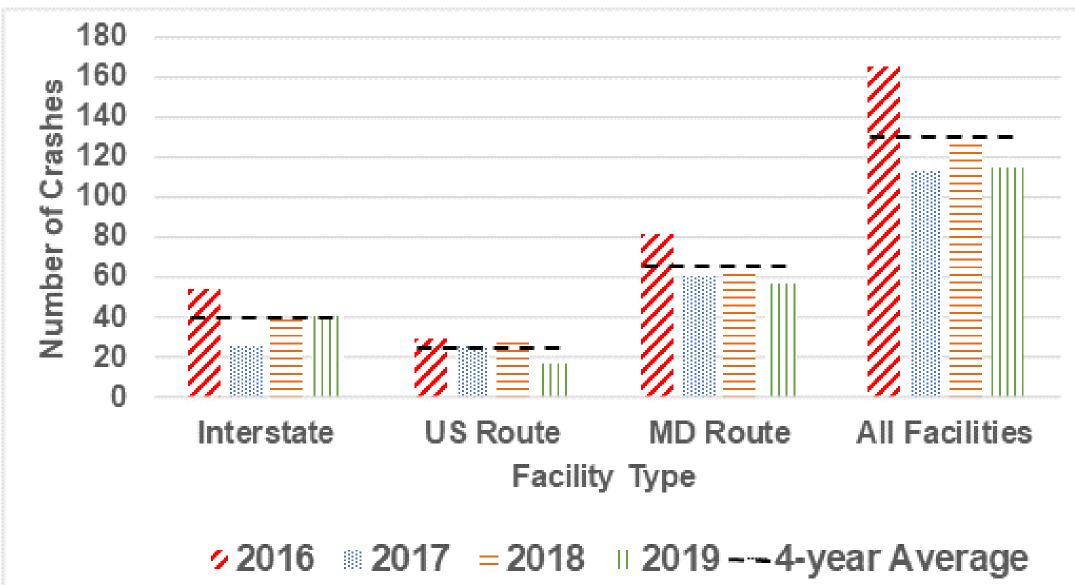

Figure 7. Chart. Number of injury work zone crashes
Source: MDOT SHA

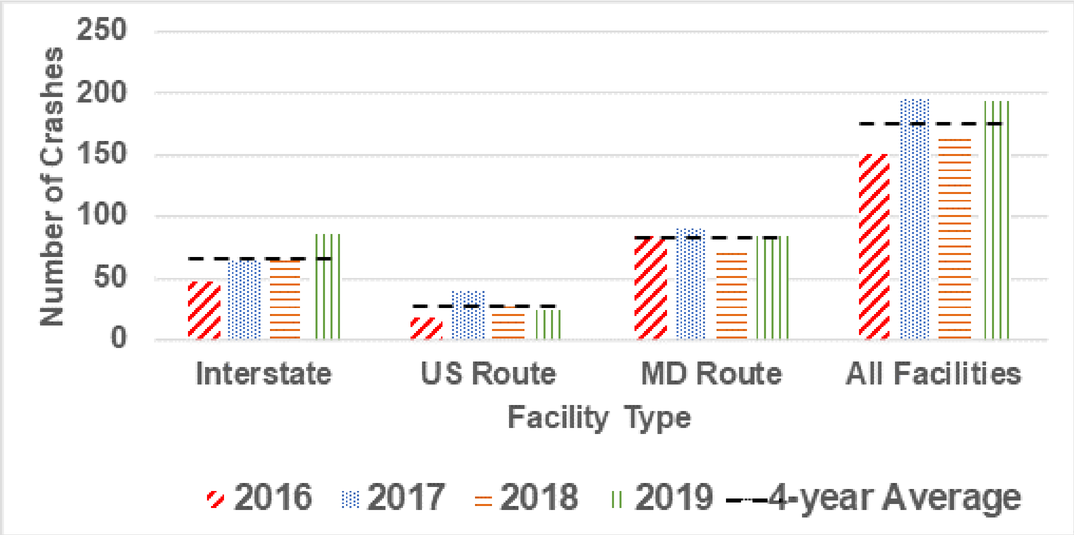

Figure 8. Chart. Number of possible injury work zone crashes
Source: MDOT SHA

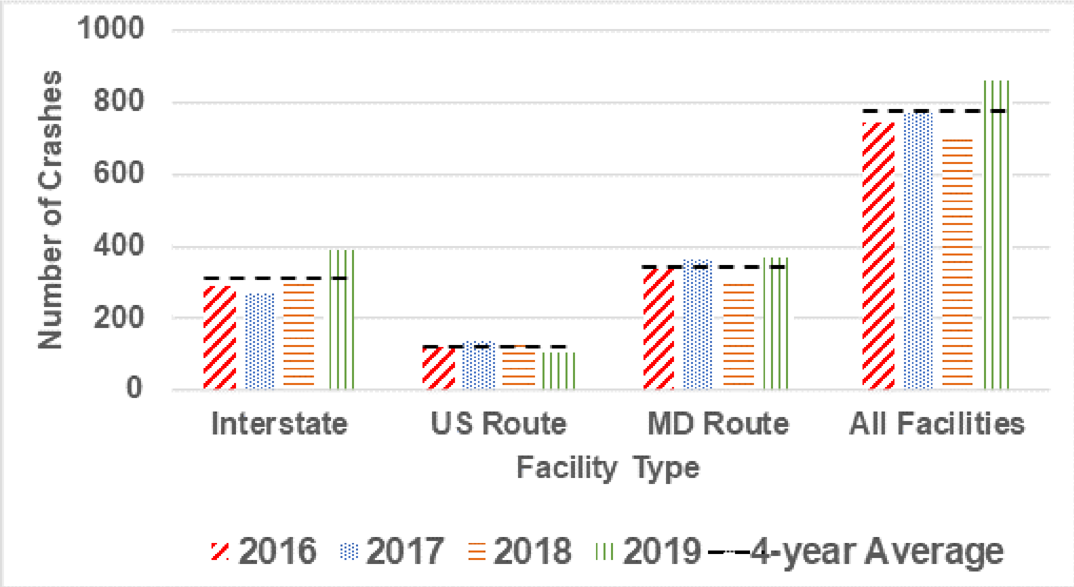

Figure 9. Chart. Number of non-injury work zone crashes
Source: MDOT SHA

Key Findings and Observations for Data-Driven WZPRs

- Compared to the 4-year average, the number of WZ crashes in Maryland was on par in 2016 and 2017, decreased in 2018, and increased in 2019. Due to lack of WZ exposure data, the project team could not perform a normalized comparison of crash rates across the years.
- A further analysis into most recent (2019) crash type distribution indicated that rear-end and side-swipe crashes on interstates contributed to more than 40 percent of the overall increase in 2019 WZ crashes, when compared to the 4-year average. Qualitative discussions with MDOT SHA's OOTS suggested that increased congestion and speed differential in 2019 may have contributed to the increase in rear-end and side-wipe crash numbers. In its next WZPR assessment, the MDOT SHA WZPR team plans to thoroughly analyze the key factors contributing to the rear-end and side-swipe WZ crashes and their mitigation strategies.
- The crash distribution analysis indicated some variation in each facility type and crash severity type across the years. However, it was not possible to compare trends and assess these variations due to lack of WZ exposure data (e.g., WZ mileage, VMT).
- MDOT SHA tracks the number of WZ construction projects, which is a good start toward collecting WZ exposure data. Tracking additional exposure information such as WZ VMT, VHT, mileage, lane closure/activity hours, number of lanes closed, percent capacity reduced, etc. will be very helpful in providing a common frame of reference to measure WZ performance across years and incorporate those findings into WZPRs.

Performance Area 2 – Work Zone Mobility

Mobility Data Used in Case Study

Source: RITIS PDA Suite and MDOT SHA Project Portal

Analysis: Bottleneck Ranking and User Delay

Metrics: Number of WZ traffic congestion events, Vehicle Miles Traveled per Project, Vehicle Hours of Delay

The mobility data presented in this case study are from WZ construction projects implemented in 2018, 2019, and 2020. As previously mentioned, the construction projects tracked by MDOT SHA include road widening, bridge and waterline replacements, new road constructions, and total roadway reconstructions.

MDOT SHA uses maximum WZ queue length as a key measure to assess the mobility impact of WZs on travelers. MDOT SHA's mobility policy specifies that WZ impacts are unacceptable if they result in a queue length longer than 1.0 mile for more than 2 hours, or longer than 1.5 miles for any time period.[5] These thresholds are applied for lane closure planning and daily WZM. However, this case study could not evaluate WZ projects against the mobility policy, because data on queue lengths were not available.

Based on the WZ project information available from the MDOT SHA Project Portal, the project team conducted a comprehensive mobility analysis using the RITIS Probe Data Analytics (PDA)

[5] https://www.roads.maryland.gov/OOTS/02SafetyMobilityPolicy.pdf

Suite.[6] Given that many State DOTs have access to the RITIS PDA Suite, the project team used this tool to demonstrate the application of available resources for mobility-based WZ performance analysis. The project team conducted two types of analyses—bottleneck and delay. The bottleneck analysis focused on identifying the number of WZ traffic events and the WZ segments with the highest bottleneck and queuing impact resulting from WZ traffic events. The delay analysis combined probe speed data with volume data to estimate the overall mobility impact experienced by drivers resulting from congestion at WZs. The facility types selected for the mobility analysis were interstates, U.S. routes, and Maryland routes.

Vehicle Miles Traveled per Project

This metric presents the VMT for all vehicles traversing through the WZ segments. RITIS calculates the VMT of a segment by multiplying the hourly volume of the segment by its length. Overall, MDOT SHA WZ construction projects experienced 2.38, 2.55, and 2.14 billion VMT in 2018, 2019, and 2020, respectively. To account for the variability of WZ activity across the years, the project team normalized the WZ VMT by the number of WZ construction projects implemented by MDOT SHA each year. Across all facilities, the WZ VMT per project were 143.7 and 119.3 million in 2019 and 2020, respectively, which was a 0.4-percent increase and 17-percent decrease compared to the 143.1 million VMT per project experienced in 2018 (figure 10). The project team also looked at the WZ VMT distribution by facility type. WZ VMT per project on interstates increased by 10 percent in 2019 and decreased by 1 percent in 2020 compared to 2018. U.S. and Maryland routes experienced a decrease in VMT per project across the years from 2018 to 2020. The reduction in WZ VMT experienced by all facility types in 2020 is likely due to the impact of the COVID-19 pandemic on travel demand.

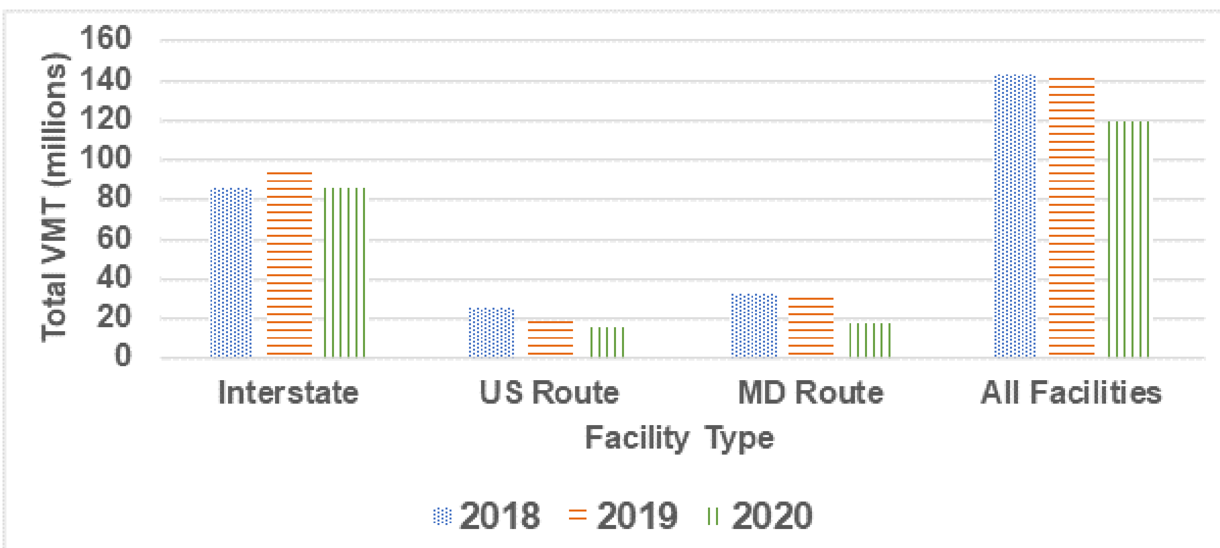

Figure 10. Chart. Vehicle miles traveled (VMT) per project
Source: MDOT SHA

[6] RITIS Probe Data Analytics Suite. https://pda.ritis.org/suite/

Number of Traffic Events

This metric provides the number of traffic events that occurred on WZ segments. RITIS defines traffic events as the total number of events and incidents that occurred within the space of the bottleneck of a defined WZ segment at any time during the analysis period. The types of events covered by RITIS PDA Suite in the bottleneck analysis tool are presented in figure 11.

RITIS defines traffic events as the total number of events and incidents that occurred within the space of the bottleneck of a defined WZ segment at any time during the analysis period.

Figure 11. Graphic. Types of traffic events covered in the RITIS PDA Suite's Bottleneck Analysis tool
Source: RITIS PDA Suite

Overall, the number of traffic events (figure 12) decreased from 73,489 and 88,667 in 2018 and 2019, respectively, to 55,518 in 2020 (i.e., 24- and 37-percent decreases). The reduction in the number of events in 2020 was experienced across all facility types and is likely the result of reduced travel demand caused by the COVID-19 pandemic. After normalizing the number of traffic events by WZ VMT, 35 and 26 traffic events per million VMT occurred in 2019 and 2020, respectively, which was a 13-percent increase and 16-percent decrease, respectively, when compared to the 35 traffic events per million VMT that occurred in 2018 (figure 13). Referring to figure 12 and figure 13, a point to note is that more than 40 percent of the events in 2018, 2019, and 2020 occurred on the multi-year road-widening WZ construction projects implemented on I-495, I-695, I-70, I-270, US-29, MD-5, and MD-210. These road-widening projects require multiple lane closures on different segments on these heavily traveled routes with high truck volumes. These lane closures are likely a primary contributing factor for delay events related to reduced capacity and queuing. One way to verify this is to analyze the event type distribution for each project. However, RITIS PDA Suite does not provide event-level granular data to perform this analysis.

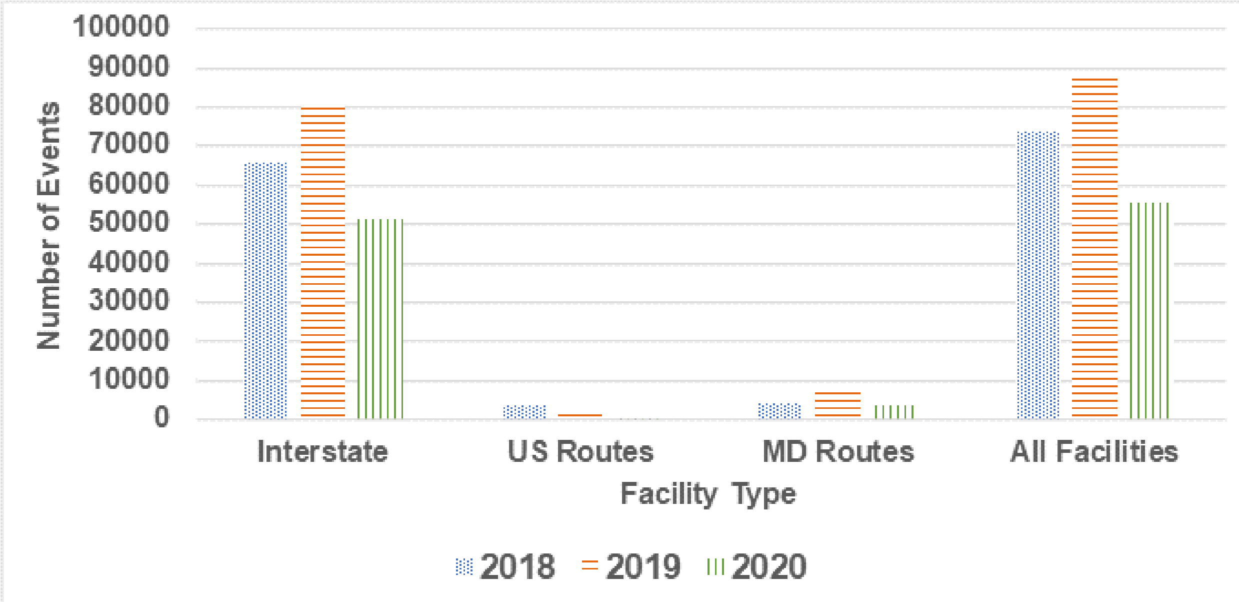

Figure 12. Chart. Number of traffic events
Source: RITIS PDA Suite

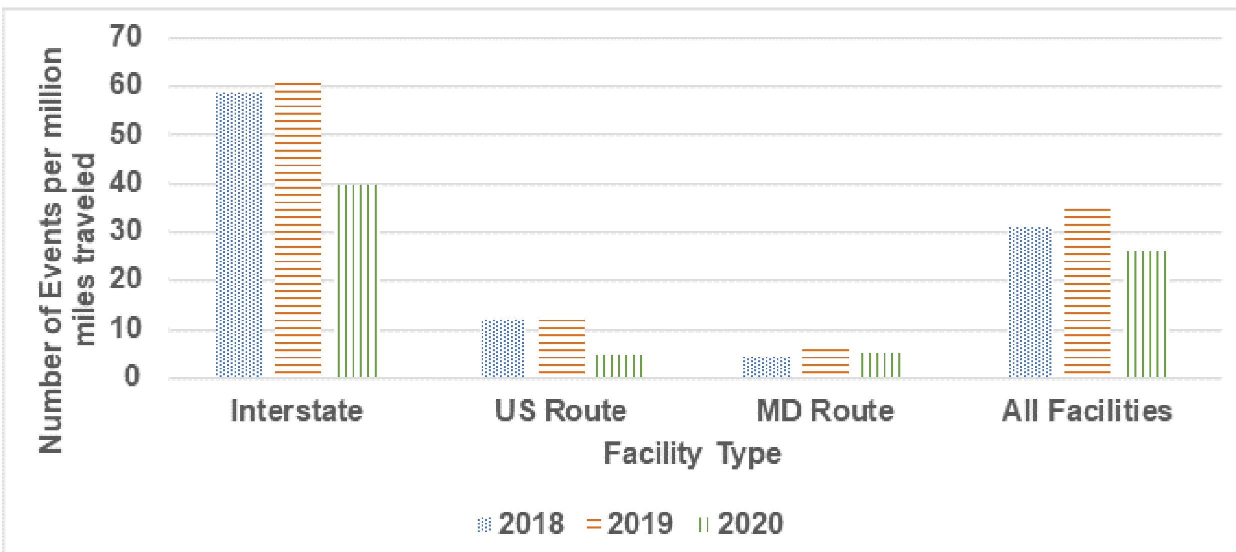

Figure 13. Chart. Number of traffic events per 1 million vehicle miles traveled
Source: RITIS PDA Suite

Vehicle Hours of Delay

This metric presents an estimate of the total delay experienced by travelers traversing through MDOT SHA construction WZs. RITIS calculates the vehicle hours of delay (VHD) by totaling all delays experienced by vehicles traversing the WZ segments in a selected timeframe. Across all facility types, travelers experienced 2.42, 2.06, and 0.6 million vehicle hours of delay in 2018, 2019, and 2020, respectively, in MDOT SHA WZs. During the COVID-19 pandemic in 2020, traffic demand was greatly reduced during peak periods of the day, which likely lessened the delay impact of traffic events during those time periods. Ideally, the VHD would be normalized by exposure metrics such as WZ volume or trips to get a comparable metric across the years such as delay per vehicle or delay per trip. However, the RITIS PDA Suite does not provide traffic volume data to conduct this normalization.

The overall improved mobility trends in 2020 (including reduced delay and events) can be attributed to the reduced traffic demand (i.e., decrease in VMT) on the Maryland roadway facilities. Especially, the reduced demand during peak hours due to remote work during the COVID-19 pandemic had a significant impact on the delay experienced by travelers. Continuing to perform mobility analyses will provide MDOT SHA with an improved comparison of WZ mobility performance pre-COVID (2018 and 2019) and post-COVID (2022 and 2023).

Key Findings and Observations for Data-Driven WZPRs

- MDOT SHA uses maximum WZ queue length as a key measure to assess the mobility impact of WZs on travelers. MDOT SHA's mobility policy specifies that WZ impacts are unacceptable if they result in a queue length longer than 1.0 mile for more than 2 hours, or longer than 1.5 miles for any time period.
  - MDOT SHA applies these thresholds for lane closure planning to identify restricted hours for lane closures. MDOT SHA should consider applying the queue length mobility metric for real-time monitoring and post-implementation analysis.
- Based on the WZ project information available from the MDOT SHA Project Portal, the project team conducted a comprehensive mobility analysis using the RITIS PDA Suite, which uses third-party probe vehicle speed and travel time data. The mobility metrics analyzed for this study included WZ VMT, number of traffic events per VMT, and VHD. Combining these mobility performance metrics, MDOT SHA can draw a comprehensive picture of the number of traffic events and the associated delay impact on the MDOT SHA WZs. This information can provide insights on the project, as well as program level mobility focus areas, key issues, and actions for WZPRs.
  - Due to limited data availability, the mobility analysis was limited to WZ construction projects implemented by MDOT SHA in 2018, 2019, and 2020.
- Across the years, an improved mobility performance was experienced in WZ VMT, events, and VHD. The improved mobility performance in 2020 is likely due to the reduced travel demand induced by COVID-19 pandemic conditions. Ideally, the VHD would be normalized by exposure metrics such as WZ volume or trips to get a comparable metric across the years such as delay per vehicle or delay per trip. The project team did not have access to the traffic volume data to perform this normalization. RITIS PDA Suite does not currently make the traffic volume or trip data accessible through its mobility (delay and bottleneck) analyses, which would enable MDOT SHA to normalize by WZ VHD.

Key Findings and Observations for Data-Driven WZPRs (continued)

- As the bottleneck analysis offered by RITIS PDA Suite ranks each WZ based on its overall delay impact, the project team was able to identify that WZ projects implemented on I-495, I-695, I-70, I-270, US-29, MD-5, and MD-210 contributed to more than 40 percent of traffic events across all years.
- MDOT SHA's initiative to track and publish all of its WZ construction projects enabled the project team to identify the WZ projects and perform the mobility analysis. Expanding this WZ tracking to other project types (e.g., maintenance, access management) will allow MDOT SHA to conduct a comprehensive analysis of all WZ activity performed across the years.

Performance Area 3 – Work Zone Field Inspections

Work Zone Field Inspection Data Used in Case Study

Source: MDOT SHA Temporary Traffic Control Inspection Rating System

Metrics: Number of field inspections, Percentage of projects receiving each grade by project type and year

MDOT SHA conducts WZ field inspections to review the implementation and operation of WZs. Field inspections encompass all types of projects (e.g., construction, signal, area-wide, access management), and multiple inspections sometimes occur on a project. Ideally, MDOT SHA would inspect all projects; however, staffing issues and the high volume of projects in some Districts limit the number of projects that can be inspected. On average, MDOT SHA inspects approximately two-thirds of projects in a year. The traffic control strategies reviewed by MDOT SHA include safety devices, pavement markings, work zone compliance with traffic control figures, flagging, temporary traffic signals, signs, traffic management, and barriers. MDOT SHA aggregates the individual ratings assigned for all strategies associated with a WZ project to provide an overall project score.

MDOT SHA conducted 5,366, 4,666, and 4,745 field inspections in 2018, 2019, and 2020, respectively (figure 14). The project team collected and analyzed ratings from MDOT SHA's Temporary Traffic Control Inspection Reports to identify the WZ areas with Grade A (exceeding standard), Grade B (meeting standard), Grade C (below standard), and Grade F (fatal flaw). Ratings of 4, 3, 2, and 1 are assigned for Grades A, B, C, and F, respectively.

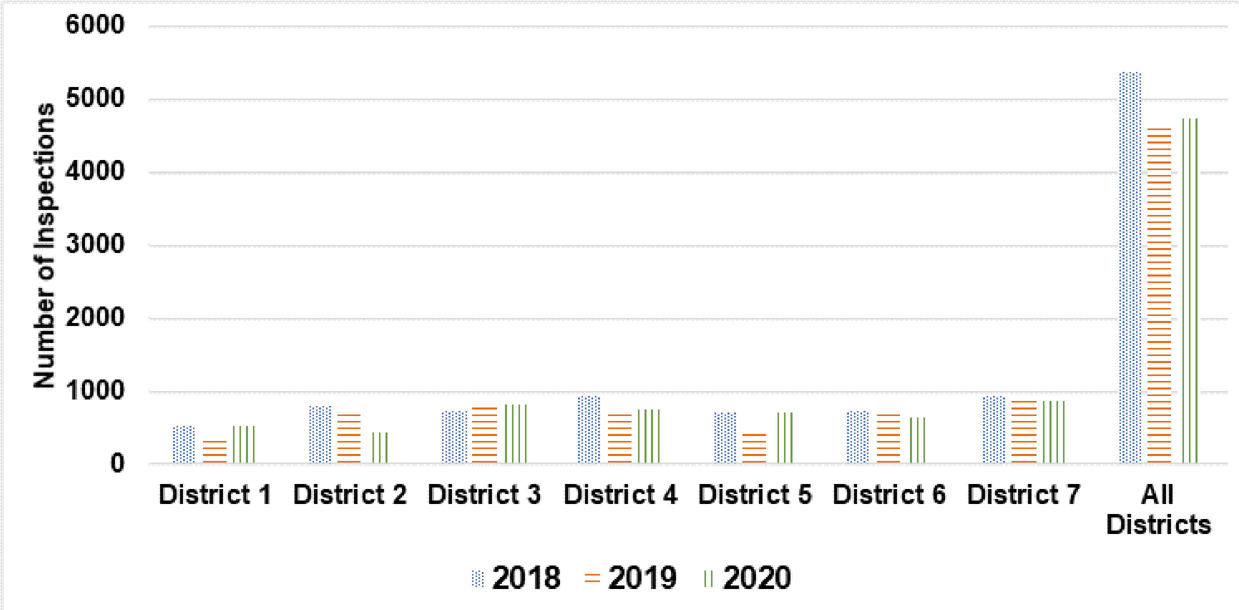

Figure 14. Total number of field inspections by District
Source: MDOT SHA

The average WZ field inspection scores by District are presented in figure 15. The scores for all Districts were consistent across the years with minimal variations. Projects in Districts 3, 5, and 6 received improved ratings in 2020 compared to 2018 and 2019. Projects in Districts 1 and 6 received slightly lower average ratings across the years compared to other Districts.

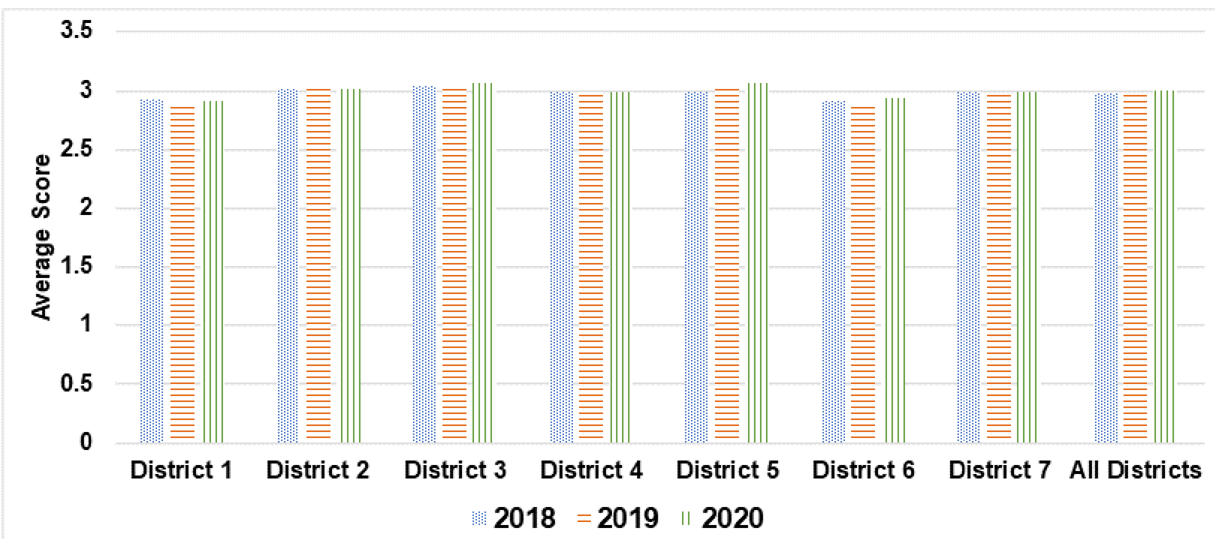

Figure 15. Average field inspection score by District
Source: MDOT SHA

The project distribution by field review grade is presented in table 1. Results are summarized as follows:

- Construction and Maintenance projects received higher ratings across all years.
- Access Management Division, Bridge, Construction, and MDOT SHA OOTS projects received lower ratings in 2019 compared to 2018.
- MDOT SHA OOTS, Utilities, and Other projects received lower ratings in 2020 compared to 2018.
- Overall, more than 95 percent of the projects met or exceeded MDOT SHA's standards, while less than 4 percent of projects did not meet the standards.

As previously mentioned, MDOT SHA reviews, rates, and digitizes an extensive list of traffic control strategies. However, MDOT SHA aggregates the individual ratings assigned for all strategies associated with a WZ project to provide an overall project score. These aggregated ratings provide a high-level context of the overall WZ performance. However, to gain an extensive understanding of the excelling and underperforming WZM processes (e.g., planning, design, traffic management), MDOT SHA should consider expanding its WZ field review analysis to include evaluation of individual traffic control strategies (e.g., lane closures, signs, arrow boards, traffic management, detours, mobile WZs, transition areas, worker safety). This information would enable MDOT SHA to identify recurring and non-recurring WZM issues (e.g., shorter transition areas, inaccurate signs, lack of flagger training) at the project and program level.

Table 1. Project Distribution by Field Review Grade

Project Type	Grade A			Grade B			Grade C			Grade F		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
AMD*	1.24	0.00	0.89	98.14	95.74	97.32	0.62	4.26	1.79	0.00	0.00	0.00
Bridge	0.93	1.30	0.73	97.45	96.09	98.53	1.62	1.95	0.73	0.00	0.65	0.00
Construction	1.47	2.52	3.94	96.83	95.04	94.55	1.44	1.91	1.19	0.26	0.53	0.32
Maintenance	3.05	1.68	5.62	93.77	94.95	92.46	2.20	2.60	1.56	0.98	0.76	0.36
MDOT SHA OOTS**	0.78	0.78	1.78	96.47	94.67	93.97	1.96	1.78	3.45	0.78	1.78	0.86
Utilities	2.54	5.66	2.61	91.92	90.60	90.81	4.04	2.83	5.62	1.50	0.90	0.96
Other	0.56	2.19	2.63	90.96	86.86	82.46	6.78	8.03	10.53	1.69	2.92	4.39
Unknown	0.00	0.00	11.76	97.14	92.65	76.47	2.86	2.94	5.88	0.00	4.41	5.88

* AMD = Access Management Division;

** MDOT SHA OOTS = Maryland Department of Transportation State Highway Administration Office of Traffic and Safety

Key Findings and Observations for Data-Driven WZPRs

- Field reviews, traffic control safety reviews, and WZ safety and mobility audits are valuable information sources that provide both qualitative and quantitative assessments of WZ performance. MDOT SHA collects and digitizes quantitative and qualitative feedback from field reviews, which encompass all types of WZ projects (e.g., construction, signal, area-wide). These field review data allow MDOT SHA to evaluate the efficiency and effectiveness of WZM practices and processes from time to time. MDOT SHA is motivated to expand its performance driven assessment of WZ processes by increasing the number of field reviews conducted annually.
- MDOT SHA aggregates its field review ratings by the type of WZ project (e.g., maintenance, bridge, construction). To gain an extensive understanding of the excelling and underperforming WZM processes (e.g., planning, design, traffic management), MDOT SHA should consider expanding its WZ field review rating process to include evaluation of individual traffic control strategies (e.g., lane closures, signs, arrow boards, traffic management, detours, mobile WZs, transition areas, worker safety). This information would enable MDOT SHA to identify recurring and non-recurring WZM issues (e.g., shorter transition areas, inaccurate signs, lack of flagger training) at the project and program level.
- Overall, more than 95 percent of the inspected projects met or exceeded MDOT SHA standards across all years.
- MDOT SHA should follow-up on the findings from the field reviews and incorporate next steps and actions in its WZPR to identify the excelling and underperforming strategies that led to improved and degraded scores for each project type. Potential items to address include:
    - Identifying and mitigating the root causes that led to repeated underperformance of certain WZ project types.
    - Identifying the underlying practices and procedures that contributed to exceptional performance of certain project types and applying those practices and lessons across other project types.
    - Investigating why performance went down for certain project types while it went up in others between 2018 through 2020, as well as the variability in performance of the same project types. The results of the investigation may be used to identify issues and trends (e.g., issues specific to different facility/project types, variation in practices across districts) and improve WZ processes and procedures.

Application of Case Study Results to Future Work Zone Process Reviews

Results of the quantitative analyses conducted for the three performance areas provide MDOT SHA with a basis to make decisions on how to focus efforts for future work zone process reviews. MDOT SHA has formed a team that will use these results, supplemented by qualitative data and additional quantitative data sources, to implement a new approach for conducting work zone process reviews, as well as other follow-up activities.

Qualitative Data

MDOT SHA uses three sources of qualitative information (i.e., WZ Capability Maturity Framework [CMF] workshop outcomes, district and field personnel interviews, and field reviews) for determining key issues and topics for evaluation during WZPRs.

MDOT SHA employees from a variety of agency divisions and districts, as well as FHWA representatives, participate in the WZ CMF workshops. During the most recent workshop (December 2019), participants completed the WZ CMF self-assessment to identify the agency's levels of capability in WZM. The participants assessed the agency's levels of capability in six separate process improvement areas on a scale from 1 (Ad Hoc) to 4 (Institutionalized). MDOT SHA's aggregate level of capability in each process improvement area is presented in table 2.

Table 2. Aggregated Level of Capability by Process Improvement Area

Process Improvement Area	Level of Capability			
	1	2	3	4
Business Processes			✓	
Systems and Technology		✓		
Performance Measurement		✓		
Organization and Workforce		✓		
Culture		✓		
Collaboration			✓	

Participants identified action items and compared them to the list of MDOT SHA's strengths and weaknesses captured at the beginning of the CMF workshop. After further discussion, the workshop participants refined and prioritized the list of action items. Once a final list of actions was selected, workshop participants discussed how these actions could be incorporated into the agency's next process review and what data and information would need to be collected to do so.

As documented in the CMF report, MDOT SHA identified a final list of action items for incorporation into future process reviews, as shown below.

1. Assess agency WZ policy on a regular basis to determine whether WZM safety and mobility impact mitigation goals and objectives are still appropriate.

2. Improve and mainstream the analytical toolbox to assist in the Transportation Management Plan (TMP) development process.
3. Improve methods to map, evaluate, and develop coordination of strategies of multiple projects by multiple agencies where the impacts of the various projects are expected to overlap.
4. Develop processes to systematically collect and collate data on TMP strategy effectiveness.
5. Periodically review effectiveness of TMPs and strategies implemented and revise processes for TMP development as needed.
6. Periodically review corridor/regional WZ traffic impact metrics to assess effectiveness of project coordination strategies and improve them as needed.

MDOT SHA conducts annual outreach meetings with district staff and identifies their key issues with design, planning, and implementation of WZs. Additionally, MDOT SHA conducts in-person field reviews to evaluate the implementation of traffic control strategies at the selected WZs. COVID-19 conditions have restricted the MDOT SHA WZPR team members from conducting in-person field reviews, but the team will resume conducting the reviews when conditions allow. MDOT SHA leverages the qualitative data from all workshops and outreach meetings to develop a detailed context for the quantitative data trends and identify the factors contributing to the trends.

Follow-up Work Zone Process Review Activities

MDOT SHA will leverage the findings from this case study to conduct follow-up WZPR activities including:

- Identifying undesirable and desirable trends in each performance area, as well as projects, issues, and improvements contributing to the trends.
- Conducting WZ committee and District meetings to collect contextual information (e.g., root cause identification, correlating factors, issue identification) behind the trends.
- Reviewing key areas of improvements from WZ CMF workshops.
- Identifying common issues observed at both State and District levels.
- Selecting and prioritizing issues to address during the next WZPR cycle.
- Identifying action items to address the prioritized issues.
- Selecting metrics for assessing the impact of the implemented action items.
- Establishing processes for collecting data required to calculate the metrics selected.

These activities are not an extensive or exhaustive list, nor are required under any FHWA regulation. MDOT SHA will tailor and conduct the activities to suit its WZPR goals and objectives.

Lessons Learned

Lessons learned from the MDOT SHA case study include:

- **State DOTs have access to data resources for different performance areas through their intra-agency data collection efforts.** A comprehensive data inventory of all data resources will enable State DOTs to select their internal performance measures for various WZ strategies and performance assessments based on available data sources.
- **Combining quantitative data trends with qualitative contextual information will lead to better root cause identification.** Neither quantitative trends nor qualitative contextual information alone depict a complete picture of WZ issues—synthesizing them enables stronger and more pointed identification of root causes and potential solutions to issues.
- **Developing quantifiable metrics will enable continuous performance tracking of WZ processes and procedures.** Developing and implementing metrics for different WZM outcome areas will enable States to quantify the impact of identified issues through qualitative data assessments. Depending on the level of impact, States can prioritize the most pressing issues. Further, these metrics will also help States to assess the effectiveness of implemented action items in resolving issues.
- **Data analytics and visualization tools can be leveraged to establish a continuously evolving WZ mobility assessment.** Such tools offer data and visualization applications that can be used to perform a wide variety of mobility assessments within and outside the realms of WZ performance. After the initial process of geolocating WZ projects, these tools can be leveraged to perform comparisons for varying spatial and temporal boundaries. These features will also help States learn about short-term and long-term impacts of different WZ strategies through historic comparisons.
- **MDOT SHA's detailed data collection and publication of WZ construction projects (geo-locations of WZ projects, project timeframe, length, and project type) enabled the project team to accurately select the project boundaries in the analytics and visualization tool and assign analysis parameters.** Expanding this WZ project tracking to other WZ types such as maintenance, MDOT SHA's OOTS, and Access Management Division will enable MDOT SHA to conduct comprehensive performance assessments of all WZ activity.
- **Field reviews, traffic control safety reviews, and WZ safety and mobility audits are valuable information sources that provide both qualitative and quantitative assessments of WZ performance.** MDOT SHA's rating and data collection process for field inspections focused on WZ project types lays a good foundation for continuous assessment of implemented WZ projects. Expanding the granularity of the field inspections to include the review of traffic control strategies (e.g., lane closures, traffic management, training) will allow MDOT SHA to conduct analyses and identify key issues, as well as best practices for various aspects of WZ planning and implementation.
- **MDOT SHA currently applies limited focus on collecting WZ exposure data (e.g., WZ VMT, VHT, mileage, and lane closure/activity hours).** This posed a challenge for the project team when attempting to normalize the safety metrics across years and across

project and facility types. Standardizing practices for collecting exposure data will improve the context of data assessment. Exposure data will be very valuable in normalizing WZ-related data for different focus areas. These data will also aid in establishing correlations between performance areas (e.g., how does mobility performance affect safety and vice-versa). At the very least, tracking WZ VMT and lane closure hours will provide a strong foundation for WZ exposure data.

Appendix A: Case Study Team and Follow-Up Activities

Work Zone Process Review Case Study Review Team

In its 2015 WZPR guidance document, FHWA recommends that State DOTs include representatives from various WZM areas in their WZPR teams (figure 16). The MDOT SHA WZPR team consists of members from MDOT SHA's Office of Traffic and Safety, Office of Structures, and Office of Maintenance, Office of Construction, Office of Design, FHWA Division Office, as well as project engineers from MDOT districts. Together, this multi-disciplinary team enables comprehensive decision making for WZPRs by covering all aspects of WZM. The core members of the WZPR group also contributed to MDOT SHA's WZM CMF assessment process.

Recommended Division/Office Representatives to Include on Work Zone Process Review Team

Planning
Occupational (Worker) Safety
Construction Administration
Roadway/Project Design
Materials
Traffic Operations/Management
Traffic Safety
Permitting
Maintenance
District Staff (Resident, Areas, and District Engineers)
Training/Workforce Development
Public Information Office
Design Consultants
FHWA Division Office

Source: FHWA

Figure 16. List. Recommended Division/Office Representatives to include on Work Zone Process Review Team

Follow-up from 2019 Work Zone Process Review

During its 2019 WZPR, MDOT SHA identified action items to:

- Update its Guidance on Identifying Significant Projects to explicitly state that projects involving intermediate closures also are included in the TMP template requirement for interstate WZ projects that last more than three consecutive days and fall within the boundaries of a designated transportation management area.
- Conduct a follow-up review of specific interstate projects implemented within a transportation management area for more than 3 days with intermittent lane closures to determine if a TMP template was completed.

In January 2020, MDOT SHA updated the Guidance document as described above and also updated the TMP template to document the transportation operations and public information components of the TMP for these types of projects. MDOT SHA plans to conduct field reviews beginning in Summer 2022 to verify the completion of TMP templates for required WZ projects.

For more information on FHWA's Work Zone Management Program, please visit: https://ops.fhwa.dot.gov/wz and https://workzonesafety.org/topics-of-interest/smart-work-zones/

The FHWA is engaging with State DOTs and conducting research to incorporate data-driven practices into work zone process reviews. The information will be used to increase awareness on data, tools, and methods for State DOTs to use to prepare effective work zone process reviews. Topics of interest include analysis and use of quantitative data including exposure, safety, mobility, and inspection data, as well as analysis and use of qualitative data for inclusion in work zone process reviews. This case study is one of a series of resources on work zone process reviews.

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October 2021
FHWA-HOP-21-051