

# Development of an Analytical Tool for Work Zone Performance

**Final Report**  
**August 2025**



**Sponsored by**  
Smart Work Zone Deployment Initiative  
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| <b>16. Abstract</b><br><p>Highway work zones are vital for infrastructure maintenance but often disrupt traffic flow, affecting safety and efficiency. While traditional evaluation methods—such as delay, queue length, and crash data—offer insights, they lack comprehensiveness. Despite improved data collection technologies, agencies struggle to interpret and apply large volumes of raw data effectively. An analytical tool was developed for work zones to address this by identifying essential performance indicators and measurements. The research included a thorough literature review of existing studies and state-level initiatives to identify critical performance indicators. The findings informed the development of the Work Zone Performance Metrics Analytical Tool (WZPERFOMAT), a user-friendly, standards-based tool that presents performance data through tables, diagrams, and downloadable reports. This report includes an overview of the development of WZPERFOMAT and a user guide describing how to use the tool for individual projects or systemic performance measures. The tool is freely available online and operable locally. WZPERFOMAT supports agencies in evaluating work zone performance more efficiently.</p> |                                                                    |                                                                                |                                |                                   |                                   |                 |                            |                |                      |                                                              |  |
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# **DEVELOPMENT OF AN ANALYTICAL TOOL FOR WORK ZONE PERFORMANCE**

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## EXECUTIVE SUMMARY

Work zones are essential to maintaining and upgrading transportation infrastructure, but they often result in disruptions to traffic flow, impacting both efficiency and safety. Traditional metrics, such as queue length, delay, travel time, and crash statistics, are commonly used to evaluate work zone performance. Recent advances in detection technologies and data collection have enabled agencies to gather extensive data more easily, but translating these data into meaningful performance metrics remains a challenge. To fully leverage these rich data sources, a systematic, data-driven tool is essential.

In addition to the need to monitor work zone performance, the Federal Highway Administration (FHWA) has introduced new requirements for work zone performance as part of each state's programmatic review. Under 23 C.F.R. Part 630 Subpart J, state transportation agencies must evaluate and report on work zone performance using both mobility and safety metrics. To meet these federal requirements, agencies are expected to develop policies that incorporate these measures, conduct annual monitoring, and complete a comprehensive review every five years.

The objective of this project was to develop an easy-to-use analytical tool for work zones that effectively visualizes key performance indicators and metrics. To support this effort, the research team conducted a comprehensive review of the literature and state-level initiatives related to work zone performance and analytical tools. From this review, a detailed list of relevant data sources and performance measures was compiled. The identified data sources include crash data, probe vehicle data from providers such as INRIX and HERE, and connected vehicle data, all of which support the robust evaluation of work zone conditions.

After identifying relevant data sources and performance metrics, the research team developed the Work Zone Performance Metrics Analytical Tool (WZPERFOMAT), a web-based application designed to calculate and visualize work zone performance. The tool leverages standard data formats to generate detailed summaries of safety and mobility performance measures for each work zone. Users begin by uploading work zone location data using the Work Zone Data Exchange (WZDx) format. To ensure the maximum effectiveness of the calculated work zone performance metrics, the WZPERFOMAT app conflates work zone locations to the road system. If a work zone includes only a start and end location, then the system maps the locations into a line string along the roadway. Users then upload safety and mobility data, such as crash data, probe data, and connected vehicle data, using a standard format. WZPERFOMAT then associates the safety and mobility datasets with the corresponding work zone and calculates performance metrics automatically. Work zone performance metrics are reported both systemically, offering agencies a broad view of network-wide performance, and at the individual project level, allowing practitioners to assess specific work zone conditions. Work zone performance measures are displayed in the WZPERFOMAT web application and are also available as downloadable reports for further review and documentation.

The WZPERFOMAT web application developed through this project significantly streamlines the process of calculating work zone performance metrics for transportation agencies. Users do not need advanced data analysis skills to work with large amounts of data; instead, users simply

upload work zone data in standard formats. WZPERFOMAT automatically processes the data and calculates relevant safety and mobility performance metrics. This enables work zone practitioners to better understand the performance of work zones, communicate results with stakeholders, and meet federal reporting standards. By simplifying data integration and analysis, WZPERFOMAT empowers agencies to make informed decisions and improve work zone management.

# **1. INTRODUCTION**

Highway work zones are essential to maintaining and upgrading transportation infrastructure, but they often result in disruptions to traffic flow, leading to reduced efficiency and increased safety risks. Traditional evaluation methods, such as measuring queue length, delay, travel time, and crash statistics, offer valuable insights but fall short of providing a comprehensive and adaptable performance monitoring system. Although advancements in detection technologies and data availability have made data collection easier, agencies still face challenges interpreting large volumes of raw data from diverse sources. There is a growing need for a systematic, data-driven tool to transform these data into actionable performance metrics.

Intelligent transportation systems (ITS) have enhanced traffic monitoring and management abilities. Still, work zones remain a critical point of vulnerability due to their potential to cause nonrecurring congestion and increase crash risk. Effective performance monitoring supports traffic impact assessment, safety messaging, decision-making, and planning. It also enables agencies and contractors to respond quickly when performance goals are unmet. As data sources such as probe vehicle data, crash records, and connected vehicle data become more accessible, the challenge shifts to integrating and analyzing this information efficiently.

Over the past decade, research has focused on identifying key performance measures, developing data pipelines, and creating tools for work zone evaluation. Studies have demonstrated the value of using multiple data sources and automated systems to monitor mobility and safety metrics. However, most existing approaches rely on single data streams or require specialized expertise. This project addresses these gaps by developing a user-friendly analytical tool that leverages standardized data formats to compute and visualize work zone performance metrics, helping agencies improve operations and meet emerging federal reporting requirements.

## **1.1 Purpose**

This report documents the development of a comprehensive, user-friendly analytical tool designed to evaluate the performance of highway work zones. As work zones continue to impact traffic flow, safety, and mobility, transportation agencies require effective methods of monitoring and assessing these impacts. This report outlines the need for a systematic, data-driven approach to work zone performance monitoring and reviews existing practices and technologies. It presents the creation of the Work Zone Performance Metrics Analytical Tool (WZPERFOMAT), a web-based application that simplifies the calculation and visualization of key performance metrics using standardized data formats.

## **1.2 Goals and Objectives**

This project's primary goal was to enhance transportation agencies' ability to monitor and evaluate work zone performance by developing an easy-to-use analytical tool for work zone performance measures using available data sources. The goal was accomplished by meeting the following objectives:

- Identify essential performance metrics for work zone evaluation, focusing on safety and mobility, through a literature review and state-level initiatives.
- Compile a comprehensive list of data sources suitable for work zone performance analysis.
- Develop an easy-to-use analytical tool for work zone performance that allows data to be uploaded in a standard format. The tool will calculate and visualize performance metrics at system- and project-specific levels.

### **1.3 Report Summary**

This final report documents the research and development of an analytical tool for calculating work zone performance measures. It begins with a literature review highlighting current practices and commonly used data sources for monitoring work zone performance. Following this, the report summarizes the input data identified by the research team for use in the WZPERFOMAT application. Next, the report details the performance measures calculated by the tool, including a breakdown of each metric and its availability at both the project and system levels.

Building on the foundation of data sources and performance metrics, the report introduces a comprehensive user guide for WZPERFOMAT in Chapter 5. This chapter provides instructions for uploading work zone data and accessing calculated performance results, separated by tabs in the tool. Following the user guide, the report presents the technical framework of WZPERFOMAT, offering background information to help users understand how the tool functions behind the scenes. The report concludes with a discussion on future development opportunities and potential applications for WZPERFOMAT to further support work zone practitioners in performance monitoring and decision-making.

## 2. LITERATURE REVIEW

### 2.1 Work Zone Performance Measures

A literature review was conducted to identify standard performance measures commonly used to evaluate work zones and to examine the data sources available to support such evaluations. According to Ullman et al. (2011), work zone performance measures generally fall into three categories: exposure, safety, and mobility/traffic operations.

- **Exposure** performance measures quantify the extent and duration of traveler and infrastructure interactions with work zones. Examples include the number of vehicles passing through a work zone and the total hours of active work.
- **Safety** performance measures assess the impact of work zones on crash risk. Examples include crash frequency, crash severity, and surrogate indicators such as the percentage of speeding vehicles.
- **Mobility** performance measures describe how travel conditions are impacted. Examples include travel delay, queue length, and speed reductions.

The selection of appropriate performance measures directly influences the data types required for analysis. As Ullman et al. (2011) highlight, aligning data sources with targeted metrics is essential for effective and meaningful performance evaluation.

### 2.2 Work Zone Data Sources

Various data sources are commonly used to support the evaluation of work zone performance, with each source contributing unique insights into safety, mobility, and operations impacts. Common data sources identified in the literature include the following:

- **Crash data:** This is a foundational and traditional source for assessing safety-related performance measures. These data provide information on crash frequency, severity, and contributing factors within or near work zones.
- **Probe data:** These data are collected via Global Positioning System (GPS)-based devices in a sample of vehicles. The probe data provide an estimate of traffic conditions across an entire network by reporting the average and historical speeds for a given segment of roadway. This type of data source is particularly useful for analyzing travel time, speed, and delay across large areas without the deployment of any hardware.
- **Connected vehicle data:** These data are generated by vehicles equipped with communication technology that enables the real-time transmission of operational metrics for individual vehicles. The data are provided at a high frequency for a sample of vehicles and include metrics such as speed, acceleration, and hard braking. These data enable a more granular analysis of driver behavior and traffic dynamics.
- **Sensor data.** These include data collected from roadside infrastructure such as loop detectors, radar sensors, and Bluetooth/wi-fi tracking devices. Sensor data provide continuous information on traffic volume, speed, lane occupancy, and vehicle classification.

These data sources are valuable for real-time traffic monitoring and for evaluating work zone impacts on traffic flow at specific locations.

These types of data have been widely adopted in recent research. For instance, Sakhare et al. (2024) used connected vehicle data to assess delays at United States-Mexico border crossings, and Mekker et al. (2019) integrated connected vehicle data into dashboards to monitor Indiana work zones. Sensor and probe data have also proven valuable in queue detection and delay analysis. Zhao et al. (2022) used these sources to detect work zone queues, and Pesti and Brydia (2017) applied sensor data to evaluate delays and travel time on I-35. Other studies, such as Du et al. (2016), have leveraged probe data to train neural networks for delay modeling. Haseman et al. (2010) used Bluetooth tracking to assess work zone-related delays. In FHWA (2014b), cases of multiple types of sensor data in state departments of transportation (DOTs) are presented.

## **2.3 Federal Guidance and Compliance**

The Federal Highway Administration (FHWA) has introduced new regulatory requirements under 23 C.F.R. Part 630 Subpart J, which require work zone safety and mobility performance monitoring. This rule is designed to update each state's programmatic review process to ensure consistent evaluation of work zone impacts across the country. State transportation agencies are now required to evaluate and report on work zone performance using both mobility and safety metrics.

To comply with these federal requirements, agencies must do the following:

- Establish a formal work zone safety and mobility policy
- Track at least one safety and one mobility performance measure for each project
- Use field observations and available data (e.g., crash records, speed differentials, queue lengths) to assess work zone impacts
- Conduct a work zone programmatic review every five years and submit results to FHWA

As part of the rulemaking, FHWA recommends specific performance measures, including the following:

- Number of fatal and injury crashes in work zones
- Percent of projects exceeding preestablished crash rates
- Number and rate of highway worker injuries and fatalities
- Percent of projects with queues above threshold levels
- Percent of time with speeds below predefined thresholds

The analytical tool developed through this project is designed to support these compliance requirements. The tool is based on diverse data types identified in the literature, which will support the calculation of mobility and safety performance measures.

### 3. INPUT DATA OVERVIEW

This chapter provides an overview of the data inputs required to operate the WZPERFOMAT application. This includes an outline of the general structure and formatting of the data necessary for agencies to utilize the tool. WZPERFOMAT is designed to enhance the calculations of work zone performance metrics by leveraging established data standards. These standards simplify adoption across agencies, many of which already use the defined formats or can easily convert their data to meet the requirements.

This chapter also introduces the accepted input formats for WZPERFOMAT, as summarized in Table 1. The only mandatory input is the location data for work zones. All other data inputs, such as crash data, probe data, and connected vehicle data, are optional. If these datasets are not provided, the corresponding performance metrics will simply not be displayed.

**Table 1. Analytical tool input data requirements**

| Input Type                                        | Required | Format Description                                                                                               |
|---------------------------------------------------|----------|------------------------------------------------------------------------------------------------------------------|
| Work zone locations<br>(linestrings or endpoints) | Yes      | Work Zone Data Exchange (WZDx)-formatted JSON or GeoJSON file                                                    |
| Crashes                                           | No       | ZIP file with Fatality Analysis Reporting System (FARS) or Crash Reporting Sampling System (CRSS) formatted CSVs |
| INRIX (probe data)                                | No       | CSV file with speed table, and a ZIP file with location shapefiles                                               |
| HERE (probe data)                                 | No       | CSV with speed table, and CSV with location data                                                                 |
| Connected vehicle data                            | No       | CSV with connected vehicle data                                                                                  |

For users seeking a deeper technical understanding, [Chapter 6](#) includes detailed explanations of how WZPERFOMAT performs regular and spatial joins, as well as how it utilizes application programming interface (API) calls to process and associate data with work zone locations

#### 3.1 Work Zone Locations

The U.S. Department of Transportation’s WZDx specification (U.S. DOT 2025) established a standardized format for reporting work zone locations, descriptions, and durations. With more than 20 states currently adopting this format, WZDx was selected as the standard input structure for the WZPERFOMAT application to ensure broad compatibility and ease of use.

The WZDx specification requires work zone data to be provided as a GeoJSON file, where each work zone or project is represented by a linestring or by start and end points. Since WZPERFOMAT relies on linestring geometry for accurate spatial analysis, the tool includes a built-in process to convert endpoint data into linestrings. This is achieved using the All Roads Network of Linear Referenced Data (ARNOLD) API (FHWA 2014a), which is used to query the road network and match points to the appropriate roadway segment.

The conversion process is illustrated in Figure 1 and described in detail in [Section 6.1](#). By adopting standardized formats and automating data preparation steps, WZPERFOMAT simplifies the integration of work zone data and enhances the accuracy of performance metric calculations.



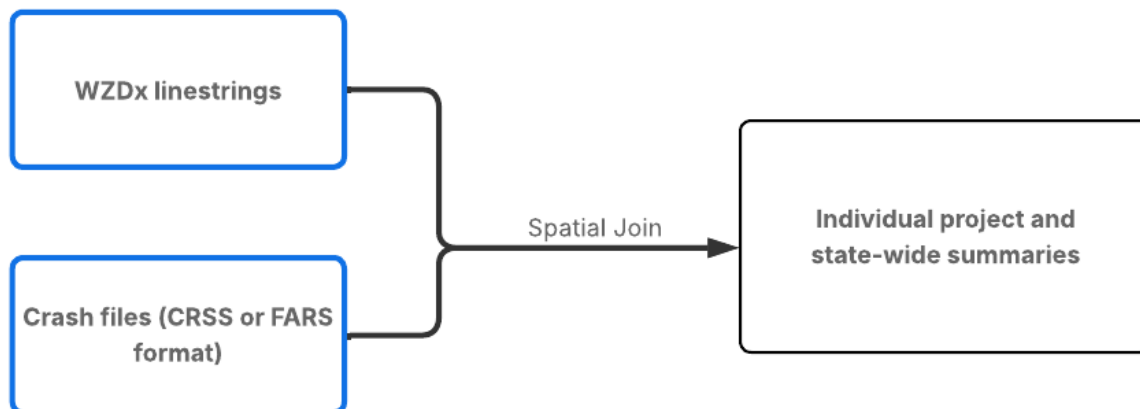
**Figure 1. Conversion process to ensure that work zone data locations are linestrings, necessary for spatial joins**

### 3.2 Crashes

Every state reports crash fatalities to the National Highway Traffic Safety Administration (NHTSA) through FARS (NHTSA n.d.-b). FARS is closely aligned with the structure of NHTSA's CRSS (NHTSA n.d.-a), creating a standardized format that reduces the data collection and reporting burden on agencies. Agencies likely have processes to convert collected crash data to the CRSS format based on existing reporting requirements. By adopting this standardized approach, agencies can leverage these processes to provide data to WZPERFOMAT.

Both FARS and CRSS include multiple data tables, including crash-level, person-level, and unit-level tables, among others. WZPERFOMAT is designed to accept these datasets in the form of a ZIP file containing CSV files. Once uploaded, the tool processes the data and performs a spatial join to associate crash records with corresponding work zone locations.

The data integration process is illustrated in Figure 2, with technical details provided in [Section 6.2](#).



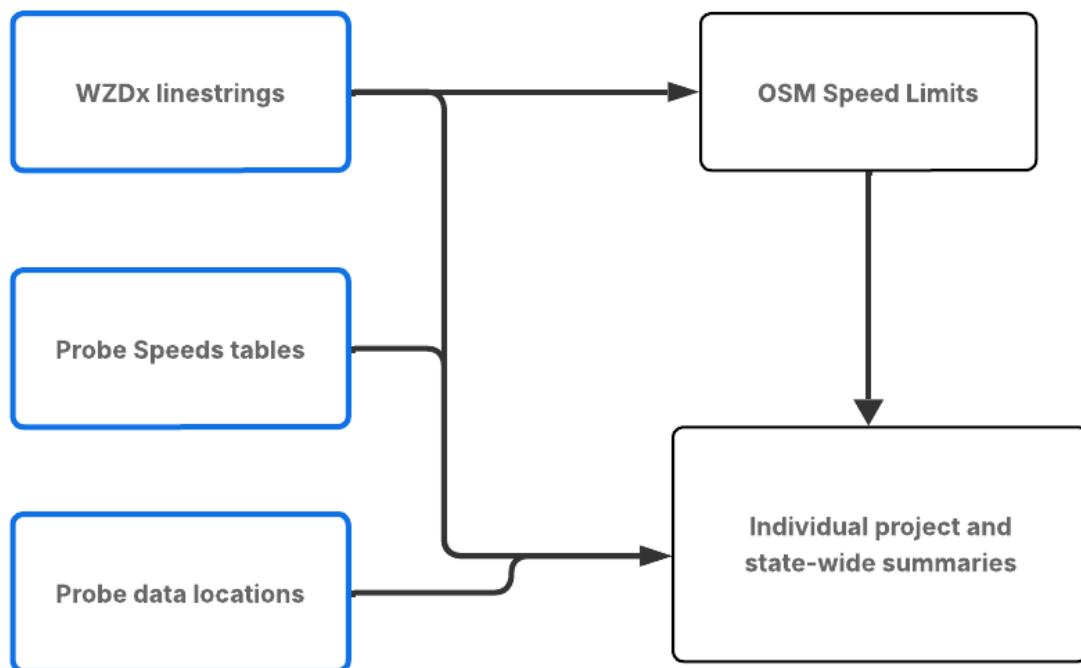
**Figure 2. Crash data processing**

### 3.3 Probe Data

Several providers offer probe data, with HERE (HERE Technologies 2025) and INRIX (INRIX, Inc. 2025) recognized as two of the most widely used sources. To develop the WZPERFOMAT tool, INRIX data were accessed for Iowa, and HERE data were accessed for Missouri. These datasets include observed speed, historical speed, and free-flow speeds, which WZPERFOMAT uses to calculate key performance metrics such as queue length, speed reductions, and congestion levels. Other sources of probe data include the National Performance Management Research Data Set (NPMRDS). This dataset was not included in the analytical tool due to limited access. However, the process used by the tool is designed around TMC format exports available through the Regional Integrated Transportation Information System (RITIS) platform, so NPMRDS could potentially be integrated into the HERE-based workflow, provided that the export structure matches.

To supplement these metrics, speed limit data were retrieved from OpenStreetMaps (OSM) using the R package “osmdata” (Padgham et al. 2017). The methodology for extracting and applying speed limits is detailed in [Section 6.5](#). WZPERFOMAT compares the observed speeds from probe data to the posted speed limits to determine the duration and percentage of time vehicles are traveling at least 15 mph below the speed limit, an indicator of significant slowdowns.

Because probe data are provided by road segments, they must be both temporally and spatially joined with work zone locations. This joining process is described in [Section 6.3](#) and [Section 6.4](#), and a flow diagram illustrating this process is presented in Figure 3.



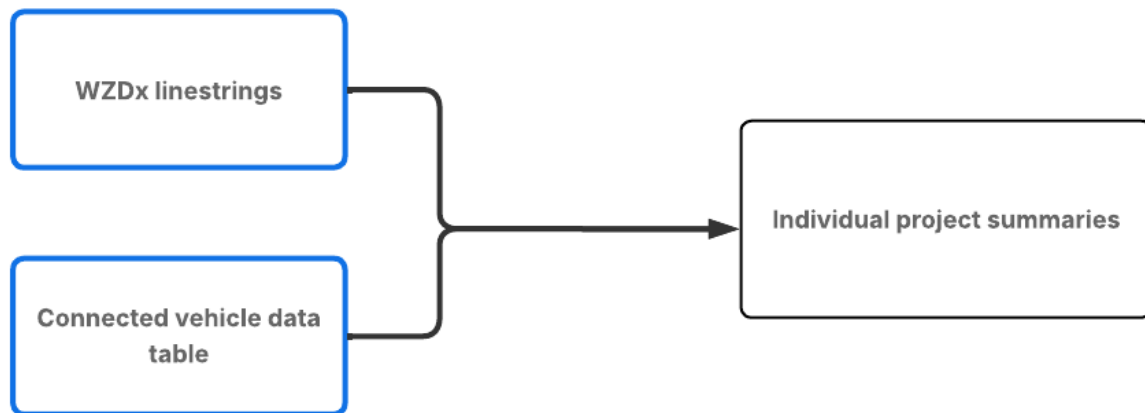
**Figure 3. Probe data processing**

### 3.4 Connected Vehicle Data

While probe data are available for specific road segments, connected vehicle data offer broader coverage, capturing information from any location where vehicles have traveled. This allows for more precise matching of reported work zone location and direction, enhancing the accuracy of performance evaluations.

However, the large volume of data generated by connected vehicles presents challenges for uploading and processing within WZPERFOMAT. Aligning these data with road geometry and work zone boundaries requires careful handling. To manage this complexity, it is recommended that users upload connected vehicle data one project at a time, ideally segmented by single-day intervals.

For more details on the connected vehicle data processing workflow, refer to [Section 6.6](#) and Figure 4. Additionally, a visual representation of the data processing flow is shown in Figure 4.



**Figure 4. Connected vehicle data processing**

## 4. SELECTION OF PERFORMANCE METRICS

The foundation of this project is the integration of work zone attributes provided in WZDx format (required) alongside other data sources such as crash data, probe data from INRIX (INRIX, Inc. 2025) or HERE (HERE Technologies 2025), and/or connected vehicle data. These inputs enable the WZPERFOMAT tool to calculate a range of performance metrics that assess the impact of work zones on mobility and safety.

The core requirement for using WZPERFOMAT is a properly formatted work zone file in WZDx format (U.S. DOT 2025). Additional data inputs enhance the tool's analytical capabilities. When provided, these datasets allow WZPERFOMAT to compute metrics at both the individual project level and at the system level, offering agencies a flexible and scalable solution for performance monitoring.

### 4.1 Project-Level Metrics

Performance metrics at the project level assess the impact of individual work zones on safety, mobility, and traffic flow. This section includes a description of the metrics available within WZPERFOMAT for individual projects. The metrics are grouped by data source and evaluated over relevant time periods and spatial extents.

#### *4.1.1 Performance Metrics Based on Crash Data*

- Count of crashes by severity level (K = fatality, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, O = property damage only)
- Total number of fatalities
- Total number of injuries

#### *4.1.2 Performance Metrics Based on Probe Data*

The accepted probe data included in WZPERFOMAT come from HERE and INRIX. Both data providers supply observed speed, average speed, and free-flow (reference) speed. This information is then used to calculate speed-based metrics, with the speed limit obtained from OSM, as well as metrics related to delay, congestion, and queue performance. The OSM data are accessed through the “osmdata” R package (Padgham et al. 2017).

##### 4.1.2.1 Speed-Based Metrics

- **Percentage of vehicle speeds 15 mph below the posted speed limit.** The percentage of measurements for which the probe data observed speeds are 15 mph under the OSM speed limit.
- **Percentage of vehicle speeds below 15 mph.** The percentage of measurements for which the probe data observed speeds are 15 mph or lower.

- **Five-number speed summaries per hour.** Every hour, the five-number summaries (minimum, 25th percentile, median, 75th percentile, and maximum) are reported based on the observed speeds.
- **Median speed per segment by time period.** For each segment and each of the following time periods: weekday morning peak (6:00 a.m. to 9:00 a.m.), evening peak (4:00 p.m. to 6:00 p.m.), and off-peak (all other times), the median of the observed speeds is reported.
- **Hourly median by segment and hour.** For each segment and each hour, the median of the observed speed is reported.

#### 4.1.2.2 Delay-Based Performance Metrics

- **Minutes of delay mean, 95th percentile, and maximum delay (minutes), computed relative to historical average speeds:**
  - a. At every minute-segment,
    - i. Calculate the observed travel time: divide the segment length (in miles) by the observed speed. Then, convert the result to minutes.
    - ii. Calculate the historical travel time: divide the segment length (in miles) by the historical speed. Convert to minutes.
    - iii. Compute minutes of delay: historical speed minus observed travel time if the latter is less than the former, and zero otherwise.
  - b. At every minute, add up all of the segment delays.
  - c. Report mean, 95th percentile, and maximum delay of the quantities above.
- **Mean, 95th percentile, and maximum delay (minutes), computed relative to reference speeds.** Repeat the steps above, but use the reference speed instead of the historical speed.

#### 4.1.2.3 Congestion-Based Performance Metrics

- **Total minutes with congestion detected:**
  - a. At each minute-segment, determine if there is congestion if the observed speed is less than or equal to 60 percent of the reference speed.
  - b. At every minute, determine if there was congestion in any segment.
  - c. Add up all of the congestion minutes above.
- **Percentage of total time under congested conditions.** Report the percentage of congested minutes (from b above).
- **Congested mile-hours.** Add up the product of congestion duration and spatial extent.

#### 4.1.2.4 Queue-Based Performance Metrics

- **Mean queue length (miles).** Average the product of congestion duration and spatial extent.
- **95th percentile of queue length (miles).** Calculate the 95th percentile of the product of congestion duration and spatial extent.
- **Percentage of time a queue is present.** Percentage of time when there was congestion in any segment of the work zone.

- **Percentage of time the queue length exceeds one mile.** Percentage of time when there was a mile-long or longer area of congestion in the work zone.

#### *4.1.3 Connected Vehicle Data Metrics*

The current iteration of WZPERFOMAT provides an hourly average of the speed. Connected vehicle data summaries are not available for statewide performance metrics.

- **Mean speed by hour.** Average of connected vehicle speeds by hour.
- **85th percentile of speed.** 85th percentile of connected vehicle speeds by hour.

### **4.2 System-Level Metrics**

Performance metrics at the system level allow agencies to assess the overall performance of multiple work zones at either a statewide or regional level. The ability to assess system-level metrics can enable the identification of areas of improvement and guide corrective actions. This section includes a description of the metrics available within WZPERFOMAT for system-level metrics. The metrics are grouped by data source and evaluated over relevant time periods and spatial extents.

#### *4.2.1 Performance Metrics Based on Crash Data*

- Number of crashes of each severity (O, C, B, A, K) for each type of work present in the data.
- Overall number of crashes of each severity (O, C, B, A, K).

#### *4.2.2 Performance Metrics Based on Probe Data*

##### **4.2.2.1 Speed Performance Metrics**

- Percent 15 mph below the speed limit (minimum, median, maximum) for each type of work present in the data.
- Percent 15 mph below the speed limit (overall minimum, median, maximum).
- Percent below 15 mph (minimum, median, maximum) for each type of work present in the data.
- Percent below 15 mph (overall minimum, median, maximum).

##### **4.2.2.2 Delay Performance Metrics**

- Mean delay based on the historical average speed (minutes) (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the mean delay based on the historical average speed (minutes).

- Mean delay based on the reference speed (minutes) (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the mean delay based on the reference speed (minutes).
- Minutes of congestion (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the minutes of congestion.
- Percent of time with congestion (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the percent of time with congestion.

#### 4.2.2.3 Congestion Performance Metrics

- Congested mile-hours (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum congested mile-hours.

#### 4.2.2.4 Queue Performance Metrics

- Mean queue length (miles) (minimum, median, and maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the mean queue length (miles).
- Percent of time with a queue (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the percent of time with a queue.
- Percent of time with a queue longer than one mile (minimum, median, maximum) for each type of work present in the data.
- Overall minimum, median, and maximum of the percent of time with a queue longer than one mile.

## 5. WZPERFOMAT USER GUIDE

WZPERFOMAT is a web-based analytical tool developed using Shiny (Chang et al. 2024) and R (R Core Team 2024). It is freely accessible at <https://reactor-shiny.intrans.iastate.edu/wzperfomat/>, and the accompanying R scripts can be easily executed locally or hosted on a private server for customized use.

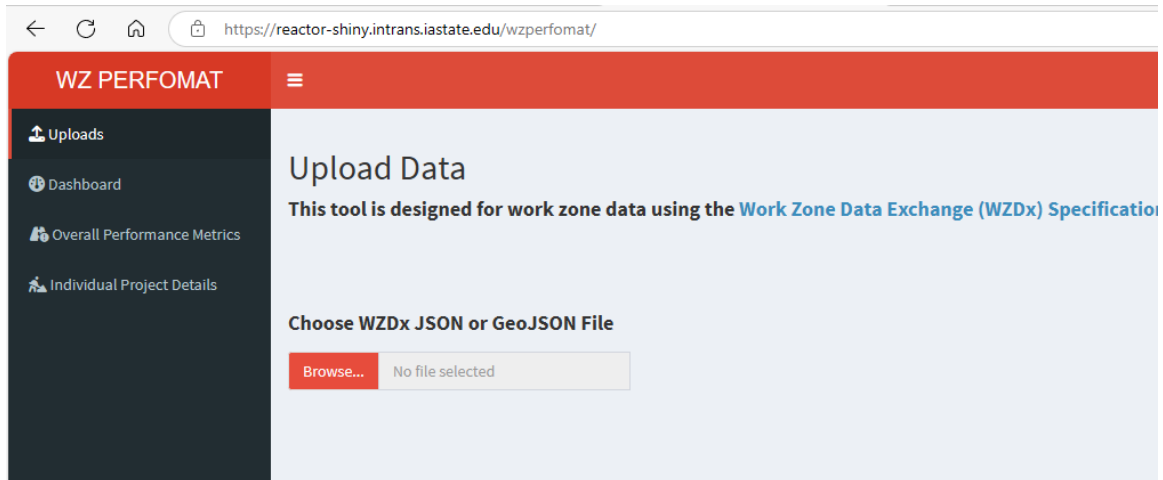
Once data are uploaded, WZPERFOMAT automatically merges, summarizes, and visualizes the input data. Users can explore detailed metrics for individual work zone projects and download project-specific reports. The dashboard also provides a system-level summary, which can be used for a statewide summary of performance metrics that can be exported as a downloadable report for broader analysis and stakeholder communication.

Appendices A and B present examples from Iowa and Missouri, showcasing input data types and illustrating both project-level and system-level performance metrics.

This section outlines, step-by-step, how to use WZPERFOMAT, including how to upload data sources, view dashboards, and download reports.

When users access WZPERFOMAT, they are presented with a welcome page. After the welcome page, users will see four main tabs in the left-hand panel, as shown in Figure 5. The four tabs include the following primary functions of the tool:

- **Uploads:** This section is where data will be uploaded, including the locations of work zones along with the available crash data, probe data (from INRIX and HERE), and connected vehicle data.
- **Dashboard:** This section visualizes all of the work zone projects at a glance through a table with relevant data extracted from the WZDx-formatted locations and an interactive map.
- **Overall performance metrics:** This section includes tables and figures of system-level performance metrics, with an option to download the report as a Word document.
- **Individual project metrics:** This section provides performance metrics as tables and figures for a given work zone project selected from the “Dashboard” tab, with an option to download the report as a Word document.



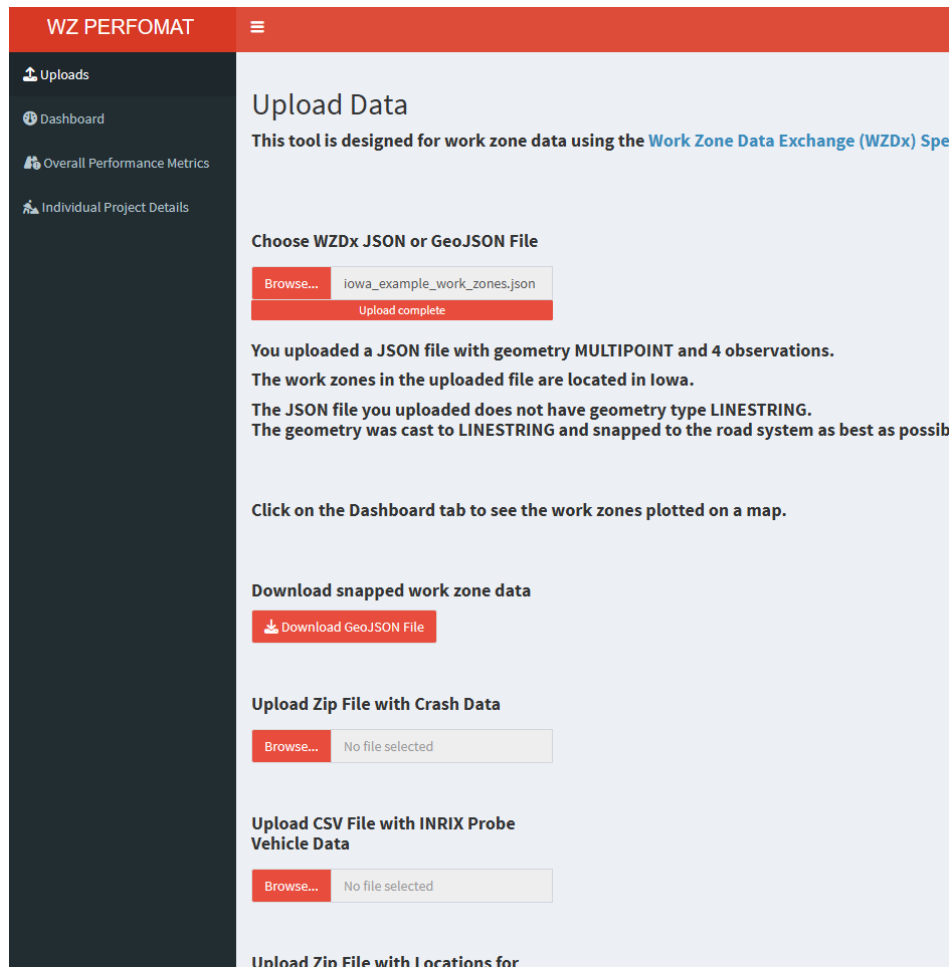
**Figure 5. WZPERFOMAT tabs**

## 5.1 Uploads

As shown in Table 1, work zone locations must be submitted in either JSON or GeoJSON format, adhering to WZDx specifications. This format allows for the inclusion of linestrings or the endpoints of each work zone, as described in [Section 6.1](#). This requirement is located under the “Uploads” tab.

If only the start and end points are provided, the ARNOLD API calls are used to create a linestring. In these situations., the process could take a bit longer, depending on the number of projects. Once the linestrings are finalized, the OSM speed limits are acquired.

After uploading and processing the work zone locations, a list of optional data uploads will be presented to the user, as shown in Figure 6. Practitioners have the option to upload crash data, INRIX data, HERE data, and connected vehicle data. Each upload button includes a progress bar to indicate when the data have been successfully uploaded. Once all desired data sources are uploaded, the user must click the “Calculate WZ Performance Metrics” button. WZPERFOMAT will then process the inputs and notify the user once the performance metrics have been calculated.



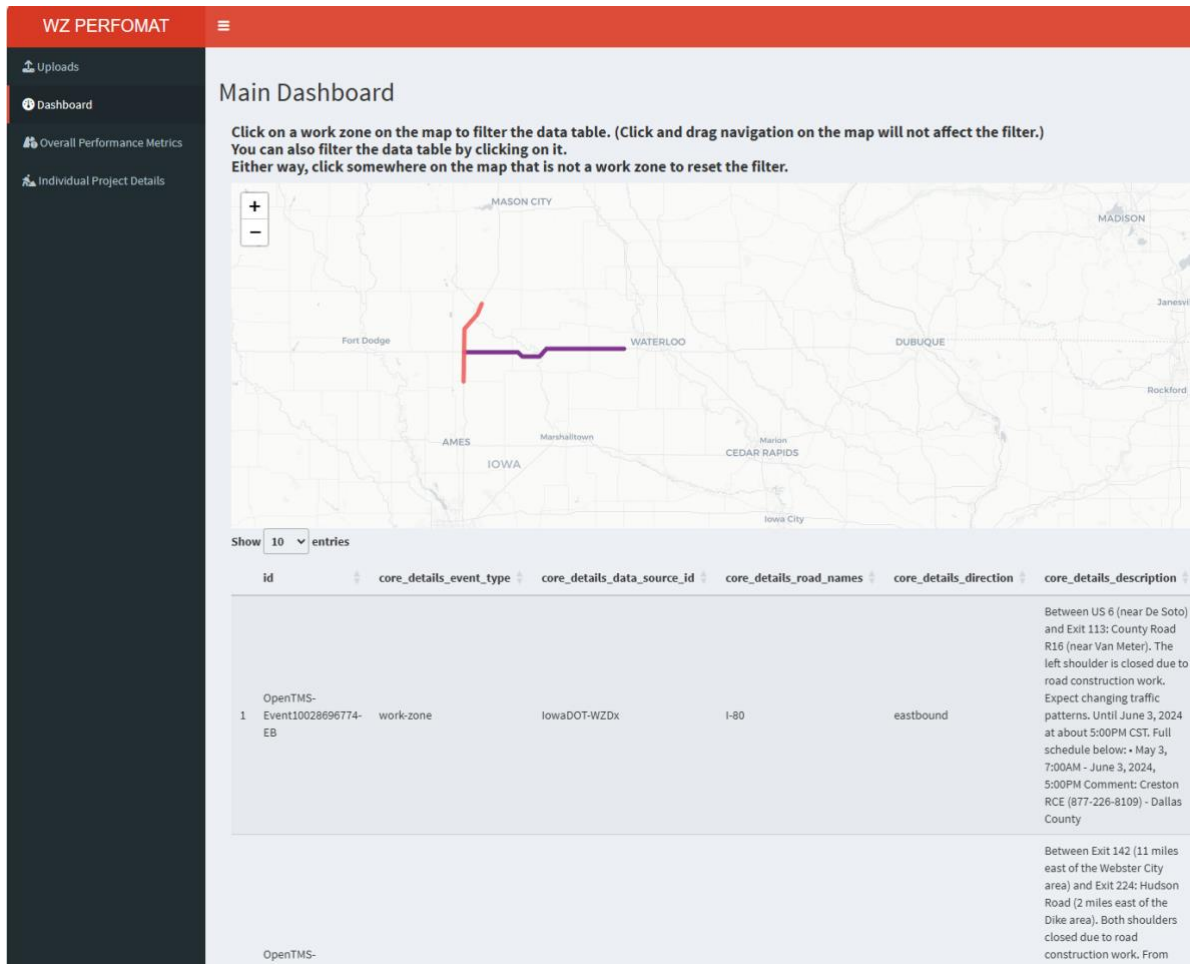
**Figure 6. Options to upload crash, probe, and CV data after locations are uploaded**

As shown in Table 1, most data sources used in WZPERFOMAT follow standardized formats. However, connected vehicle data tend to vary more significantly in structure and content across providers. To account for this variability, WZPERFOMAT includes additional specifications for processing connected vehicle data, which are shown in Figure 7.

**Figure 7. Dropdown menus to select the correct columns, settings, and units for connected vehicle data**

### 5.3 Dashboard

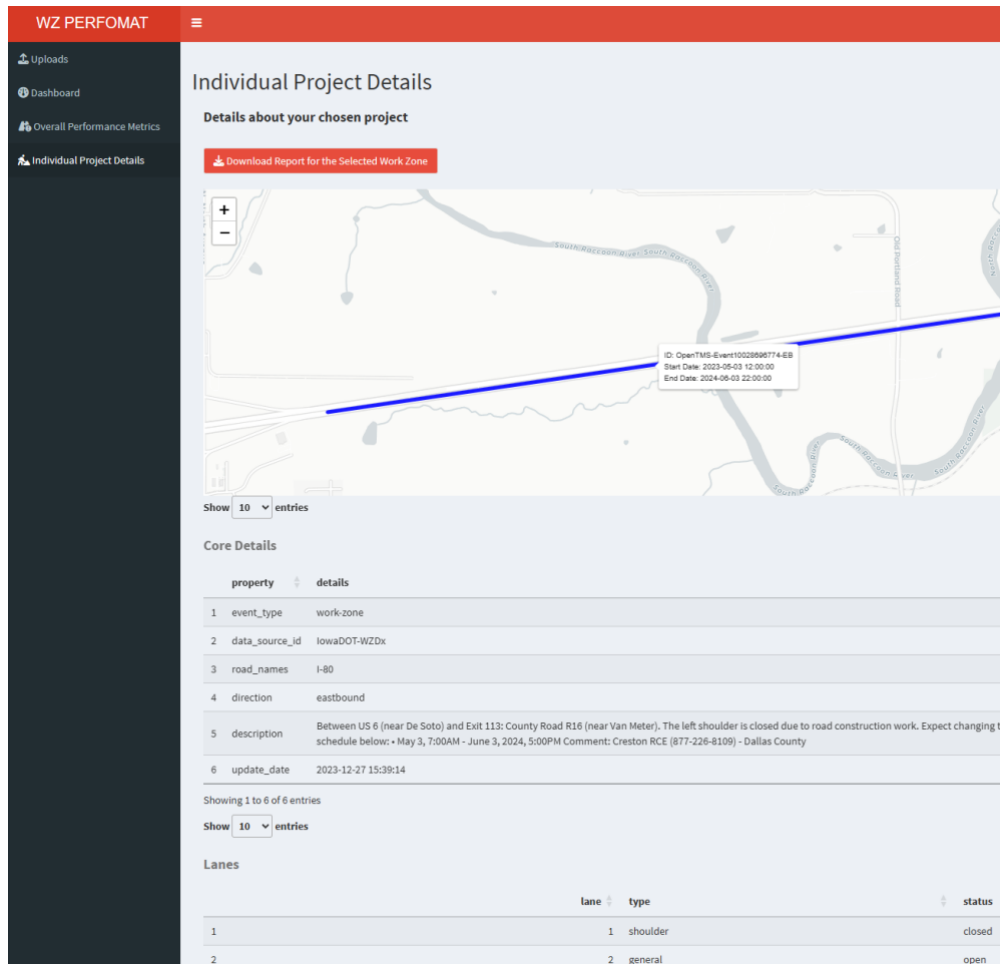
The core details of each work zone are displayed in an interactive map and table within the “Dashboard” tab, as shown in Figure 8. This view allows practitioners to verify that work zones are accurately represented, which is especially important when the work zone start and end points have been provided.



**Figure 8. Interactive map and table in the “Dashboard” tab**

## 5.4 Individual Project Details

Within the interactive map or table under the “Dashboard” tab, users can click on a specific work zone to view detailed information. This action will populate the “Individual Project Details” tab, as shown in Figure 9. This tab is where individual work zone performance measures are displayed, showing the safety and mobility metrics based on the uploaded data. At the top of this tab, a “Download Report” button allows users to export the contents of the tab as a Word document.



**Figure 9. “Individual Project Details” tab, populated when a work zone is selected**

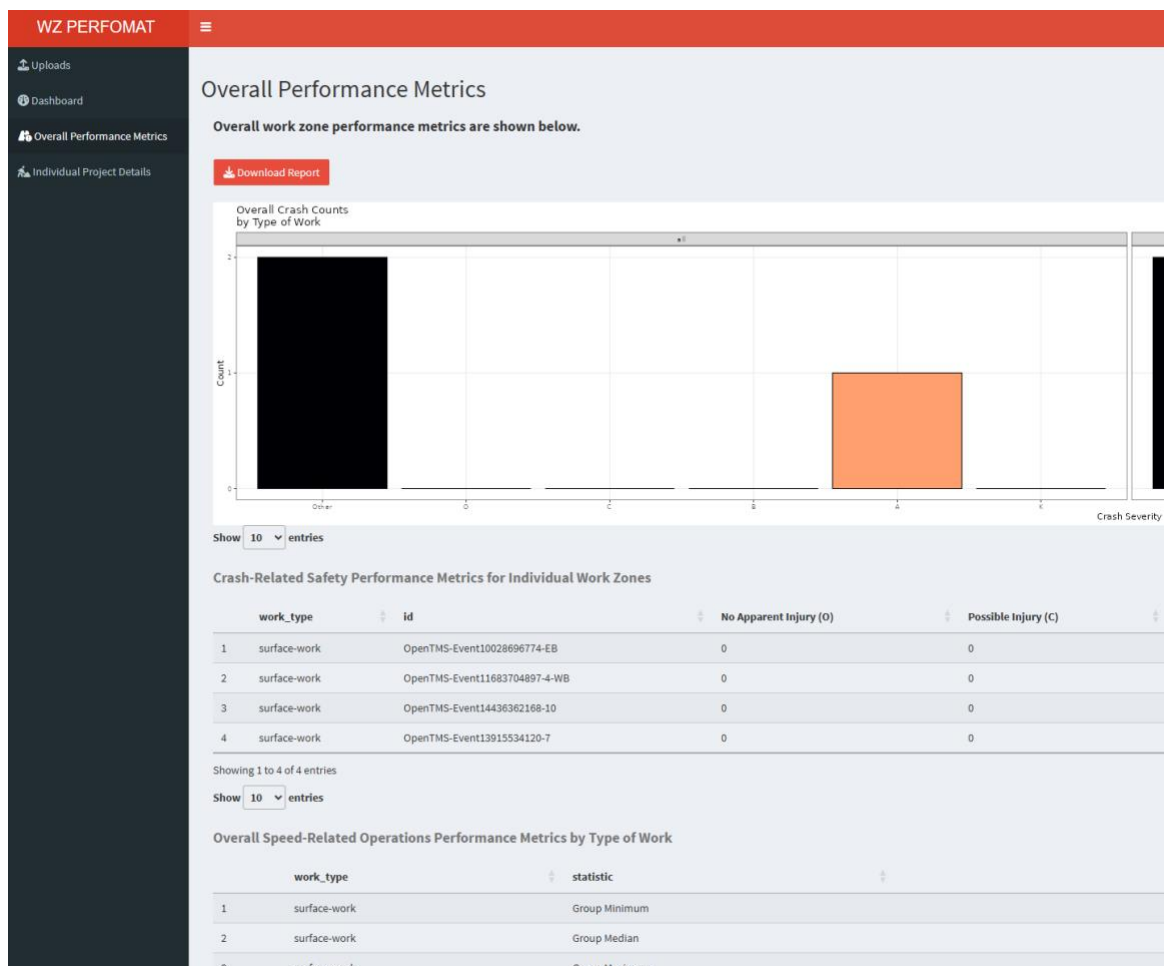
Below is a summary of the various items listed in this tab based on the order in which they appear:

- **Individual work zone interactive map:** This map displays the selected work zone along with its start and end dates. Note that the map will become static when exported to a Word document.
- **Core details table:** This table presents the core details in a well-organized format.
- **Lane details table:** This table provides information about lane work, extracted from the WZDx-formatted work zone data.
- **Crash-based metrics:**
  - **Crash map:** The map is interactive within the dashboard but is static in the final report.
  - **Crash table:** Crash summaries with case number, fatalities, injuries, and crash severity.
- **INRIX- or HERE-based metrics:**
  - Speed adherence table (using OSM speed limits).
  - Plot with hourly five-number summaries.
  - Table with five-number summaries.

- Plot with median speed on each INRIX/HERE segment by time period (morning peak, evening peak, off-peak).
- Heatmap with hourly median speed by INRIX/HERE segment.
- Table with delay summaries.
- Table with congestion summaries.
- Table with queue summary.
- **Connected vehicle hourly summaries.**

## 5.5 Overall Performance Metrics

The final tab in WZPERFOMAT is the “Overall Performance Metrics” tab, which provides system-level performance measures across all work zones uploaded. Figure 10 shows a portion of this tab, which features a combination of tables and figures based on the data uploaded. At the top of this tab, a “Download Report” button allows users to export the contents of the tab as a Word document.



**Figure 10. “Overall Performance Metrics” tab**

Below is a summary of the various items listed in this tab based on the order in which they appear:

- **Crash-based metrics:**
  - A bar chart displaying crashes by severity, both overall and categorized by type of work.
  - A table showing the number of crashes categorized by severity for each project.
- **INRIX- or HERE-based metrics:**
  - A table presenting the minimum, median, and maximum speed compliance, both overall and by type of work.
  - A scatterplot of speed compliance metrics with project ID labels.
  - An error bar plot illustrating the minimum, median, and maximum delay metrics.
  - A table with performance metrics for delay, congestion, and queue, both overall and by type of work.
  - A breakdown of delay, congestion, and queue performance metrics by project.

## 6. WZPERFOMAT TECHNICAL DEVELOPMENT

The development of the WZPERFOMAT tool was accomplished as an R Shiny dashboard (Chang et al. 2024). WZPERFOMAT requires users to upload work zone location data and various relevant attributes in WZDx format. Upon uploading the data, a processing step is initiated to verify that the provided work zone locations correspond accurately with the linear reference system (LRS) utilized for the road system in the relevant state. This verification is crucial to ensure the integrity and reliability of the data.

In addition to work zone location data, users may upload crash data that pertain to the work zones. These crash data play a significant role in assessing the safety and performance of the work zones. Furthermore, users have the option to upload additional types of data, such as probe or connected vehicle data. The inclusion of these data types allows the calculation of various work zone performance metrics.

The subsequent sections outline the data processing procedures employed for each data source and detail the performance metrics that are calculated. This information aims to provide users with a clearer understanding of how their data are utilized and the insights that can be derived from them.

### 6.1 Work Zone Locations

User-uploaded work zone data in WZDx format can have either a linestring or multipoint geometry type. The linestring geometry outlines the work zone as a polyline, while the multipoint geometry only indicates the start and end points of the work zone. Combinations of these geometry types are not permitted within WZPERFOMAT.

The preferred geometry type is linestring, providing a sequence of points that typically aligns with the road system. In contrast, multipoint geometry is less suitable because it offers only the start and end points. Directly converting multipoint geometry to a linestring may not yield valid results; a linestring connects two points and may not accurately follow the road's curves. Therefore, work zones with multipoint geometry must be converted to linestring geometry and matched to the road system before performance metrics can be calculated.

Matching work zones with multipoint geometry to the road system involves several steps. First, multipoint geometry is transformed into linestring geometry to create a line between the provided start and end points. The LRS from the Highway Performance Monitoring System (HPMS) ARNOLD REST API (FHWA 2018) serves as the road system to which the work zones will be associated.

Next, the availability of the REST API is checked. An error message displays in the WZPERFOMAT app if the API is unavailable. If the API is available, the start and end points of the work zone are identified based on the created linestring. A query is then made to the REST API to locate the road segments that contain the work zone's start and end points. The API

returns the road segments that geospatially encompass these points and the route IDs associated with the segments.

The shared route ID is identified among these road segments. Since the road segments may extend beyond the work zone, they are cut off at the work zone's start and end points. A second query retrieves any intermediate road segments located between these points. Finally, the relevant road segments are combined into a single linestring that accurately follows the road system. This new linestring will be used for all subsequent analyses involving a geospatial component.

## 6.2 Crash Data

To facilitate crash data input, WZPERFOMAT accepts crash data in a ZIP file that includes CSV files containing crash data in FARS or CRSS format.

The ZIP file must include CSV files. Only the accident ("accident.csv") and person ("person.csv") files are extracted; all others are ignored. Table 2 specifies the fields that must be present in each file; additional fields are ignored.

**Table 2. Required fields from CRSS or FARS data**

| Field                 | File         | Note                                                  |
|-----------------------|--------------|-------------------------------------------------------|
| st_case or casenum    | accident.csv | "casenum" is required by CRSS, "st_case" by FARS      |
| latitude              | accident.csv |                                                       |
| longitude or longitud | accident.csv | "longitud" is accepted in the CRSS/FARS coding manual |
| year                  | accident.csv |                                                       |
| month                 | accident.csv |                                                       |
| day                   | accident.csv |                                                       |
| crash_time            | accident.csv |                                                       |
| hour                  | accident.csv |                                                       |
| minute                | accident.csv |                                                       |
| st_case or casenum    | person.csv   |                                                       |
| inj_sev               | person.csv   | Injury severity at the person level                   |

After the crash data are analyzed, the injury severity for each individual is used to assess the overall severity of each crash by identifying the most severe injury reported. This information also aids in calculating the total number of fatalities and injuries related to each crash. At this stage, a table is created where each record represents a separate crash.

The crashes' dates, times, and locations are used to connect them with work zones. A crash is linked to a work zone if it occurs within the date range of the work zone's activity and is within 10 m (33 ft) of it.

### 6.3 INRIX Data

To utilize INRIX data, users must upload two files to WZPERFOMAT to calculate mobility performance metrics. The first file is a CSV file that contains speed observations from INRIX segments. These speed data include temporal changes in speed but do not include any location information for the segments, which is essential for matching the INRIX speed data to the correct work zones. Therefore, a ZIP file containing a shapefile with the segment location information must also be uploaded.

To match INRIX segments to a work zone, a 5 m buffer is created around the work zone linestring. INRIX segments that intersect this buffer are then identified. The matching process is refined by retaining only the road segments with the most frequently occurring road name matching the name provided for the work zone in the WZDx file. The INRIX speed data are filtered to include only the data from these matching road segments for each work zone.

For maximum effectiveness, certain performance metrics displayed in WZPERFOMAT require the INRIX segments to be ordered. The INRIX segment location data include the current segment ID and the IDs for the previous and next segments in the sequence. The ordering process begins once the INRIX segments associated with a specific work zone are determined.

The segment whose previous segment is not included in the set is identified as the initial INRIX segment for the work zone. The ID of the next INRIX segment following the initial one is then located and placed next in the order. This procedure continues by identifying the ID of the segment that comes after the second segment, and so forth, until all INRIX segments corresponding to the work zone are correctly ordered.

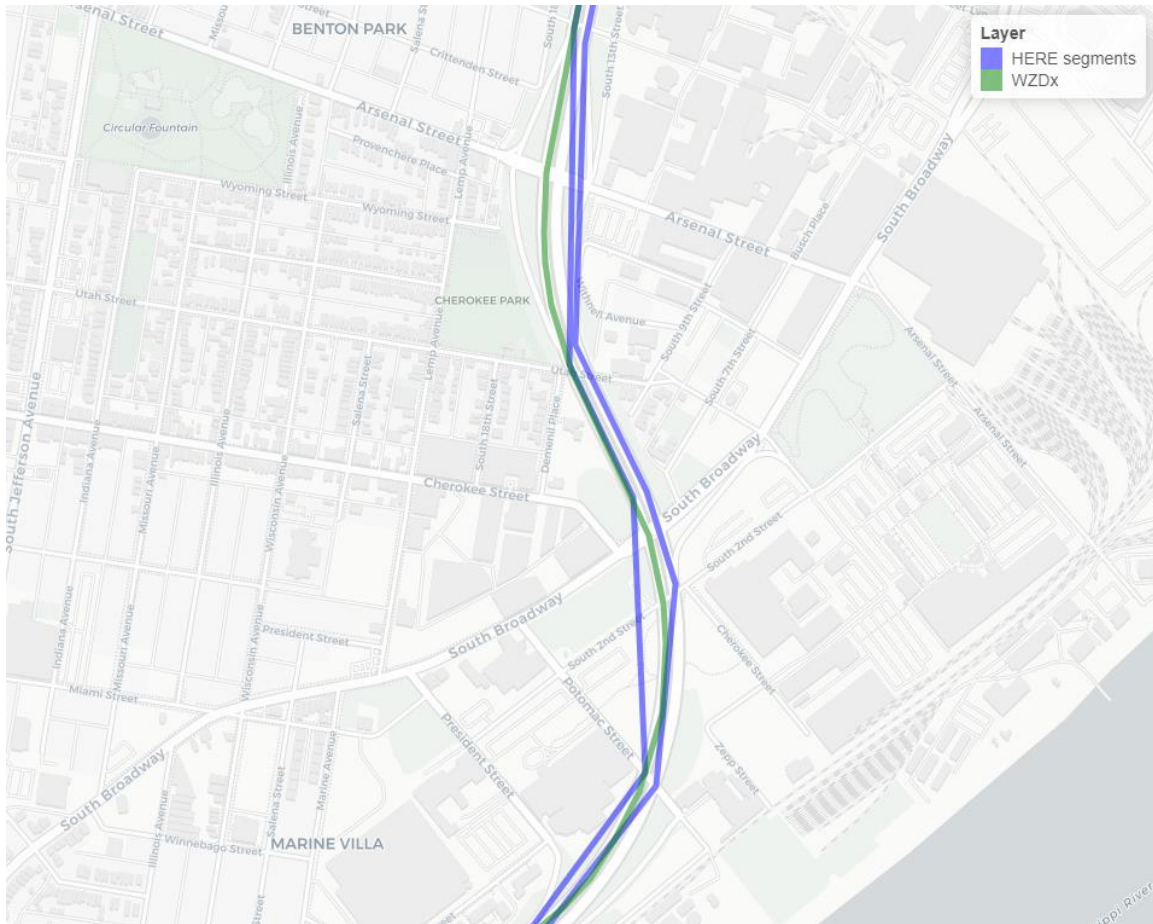
### 6.4 HERE Data

Similarly to INRIX data, HERE data come from two primary sources: a speed table linked to a road segment and a second table that includes the segment descriptions. A key distinction is that the road segments are presented in a table format with endpoints rather than as linestrings. The testing data used in the WZPERFOMAT project were obtained from HERE via the RITIS platform (University of Maryland CATT Lab 2025). Users can expect to download a ZIP file of segments from the RITIS platform, which can then be used in WZPERFOMAT. The ZIP file will contain two CSV files: one with speed data and the other with segment descriptions and endpoint coordinates.

Below are the steps that WZPERFOMAT conducts when HERE data are uploaded.

- **Differentiate the speed table from the HERE segments table.** RITIS produces a ZIP file with CSV files and “Contents.txt,” which, when uploaded to WZPERFOMAT, reads the CSV files from the ZIP file. WZPERFOMAT looks for the “speed” field to identify the speed table; the second table is assumed to be the probe data location information.

- **Match segment identifiers.** The segment identifier in the speed table is called “tmc,” whereas it is called “tmc\_code” in the segment description table. WZPERFOMAT renames them to match.
- **Create a linestring from HERE with loose segments.** In the segment description table, each row includes the coordinates of the segment endpoints. These coordinates are first converted into a table where each record represents a multipoint. Next, they are treated as graph networks. If two edges touch and their directions match, they are assigned to the same stringline.
- **Match the WZDx linestring to the HERE linestring.** At this stage, the HERE segments are represented as linestrings that must match the WZDx-formatted work zone locations. To accomplish this, WZPERFORMAT checks whether each node of the HERE linestring falls within a 4 m buffer around each WZDx work zone. Each HERE linestring is assigned to the work zone that contains the most nodes. Figure 11 demonstrates the necessity of this approach by illustrating two HERE linestrings and two work zone linestrings. The figure illustrates how a standard spatial join might fail due to complications arising from the two work zones and curves. It highlights that a more effective approach is to focus on the nodes of the HERE segments in relation to the entire WZDx linestrings. Only segments that are near work zones are taken into account.
- **Aggregate the data by the HERE segment.** Now that each HERE segment is associated with a work zone, a process similar to the one described in [Section 6.3](#) can be followed.



**Figure 11. HERE matching to WZDx-formatted work zone locations**

## 6.5 Speed Limit Acquisition

The WZDx framework does not require agencies to provide work zone speed limits. However, it is essential to recognize that these speed limits can vary, especially in longer work zones, such as those associated with major construction activities on primary roadways. While some states have comprehensive databases that include official speed limits, locating these limits in other areas, particularly beyond Interstate highways, can be more challenging.

WZPERFOMAT utilizes speed limits from OSM because they are generally consistent. However, since the data are community-contributed, they can sometimes contain inaccuracies.

Additionally, because speed limits are not a requirement of WZDx, obtaining them can be difficult. This is why WZPERFOMAT reports the percentage of time vehicles are traveling at or below 15 mph under the speed limit. Typically, work zone speed limits are set at 10 mph below the usual speed limit, while typical reduced speeds on high-speed roads range from 45 to 55 mph.

When probe data are available, WZPERFOMAT utilizes this information to compute speed adherence metrics. Once the procedure outlined in [Section 6.1](#) is completed, a random selection process is employed, where five points are extracted from the WZDx linestring nodes. Following this selection, the OSM road information is accessed using the “osmdata” R package (Padgham et al. 2017). These data show that the most frequently identified speed limit is chosen to represent the work zone effectively. This method of selecting five points serves to streamline the querying process for the OSM database, thus minimizing time and resources spent on data retrieval while ensuring accurate representation of speed limits in work zones.

## **6.6 Connected Vehicle Data**

Uploading connected vehicle data is optional. Due to differences among connected vehicle data from different providers, users must designate specific columns to ensure that the tool correctly analyzes the data. Namely, users must specify the columns containing speed and heading data. They must also provide the unit for the speed (miles per hour or kilometers per hour) and the direction corresponding to a heading of 0 degrees (north or east).

After users select a work zone, the tool matches uploaded connected vehicle data to the corresponding work zone. WZPERFOMAT calculates the average speed and the 85th percentile of speed for each hour the work zones were in operation. Speeds in kilometers per hour are converted to miles per hour before the statistics are computed.

## 7. DISCUSSION

The need for an intuitive tool to calculate various work zone performance metrics from multiple data sources motivated the development of this project. Although work zone data sources have become increasingly accessible, calculating performance metrics, especially at scale, remains a challenge. To address this, the project team thoroughly reviewed existing literature, state-level initiatives, and analytical tools to identify data sources and performance metrics that work zone practitioners can use.

The WZPERFOMAT web-based application streamlines the calculation process by allowing users to upload work zone data in standardized formats and automatically generating key performance metrics. The tool also produces downloadable reports that support the effective communication and documentation of work zone performance. These reports enable quick identification of issues and a deeper understanding of their impacts, helping practitioners apply lessons learned to future projects.

Several key benefits of the tool include the following:

- **Improved decision-making:** WZPERFOMAT helps users quickly identify problematic work zones or trends in performance metrics, facilitating data-driven decisions for safety and mobility interventions.
- **Standardization:** The tool promotes consistent evaluation methods for work zones by using standardized metrics and formats, which enhances comparability across projects and agencies.
- **Minimal technical expertise required:** Users do not need advanced data analysis skills or coding experience. The tool provides guided assistance through a streamlined upload and analysis workflow, utilizing intuitive menus and automated processing steps.
- **Downloadable and shareable outputs:** Users can export graphics and tables in formats compatible with reporting and presentation tools, making it easy to include results in internal reports and public communications.
- **Transparency and reproducibility:** All computations are performed using documented algorithms implemented in R. This allows users to inspect, reproduce, or extend the analyses as needed.
- **Freely available and accessible:** WZPERFOMAT is offered at no cost and can be operated online or locally using R and Shiny, enabling broad adoption across agencies, even those with limited resources

Connected vehicle data are included in WZPERFOMAT, but the tool's use of this data source could expand significantly based on the raw form of the data. The connected vehicle data were integrated but not prioritized during development to the same extent as the crash and probe data. This decision was intentional, as a key goal for the tool was for it to remain accessible and easy to use for a broad range of users, including those with limited technical expertise. Connected vehicle data would require extensive preprocessing before they could be loaded into the tool, or they would require a significant amount of time to run, which may result in other potential issues. These requirements exceed what a novice user could reasonably manage. While

WZPERFOMAT has the ability to process connected vehicle data, this was not emphasized in the final report to maintain the tool's focus on usability and efficiency.

While the initial development concentrated on work zones in Iowa and Missouri, WZPERFOMAT was designed with flexibility in mind. Because it supports standardized data formats, it can be adapted to accommodate work zone data from other states. Input from additional states regarding their specific data formats and performance metric needs would be valuable for expanding the tool's applicability.

Improving processing speed is another key area for future development. Several critical data processing steps, such as aligning work zones with the road network and determining speed limits, can be time-consuming. Additionally, processing connected vehicle data and calculating related metrics often requires significant time due to the large volumes of these data.

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## **APPENDIX A: REPORT WITH HERE DATA**

This appendix includes both statewide and individual downloadable reports from WZPERFORMAT. These reports are based on the WZDx work zone locations and the available HERE data. However, crash data, connected vehicle data, and INRIX data were not provided, which is noted in the reports.

The work zone activity period covered May 2024, and the HERE data cover the whole month.

## A.1 Statewide Report for Missouri

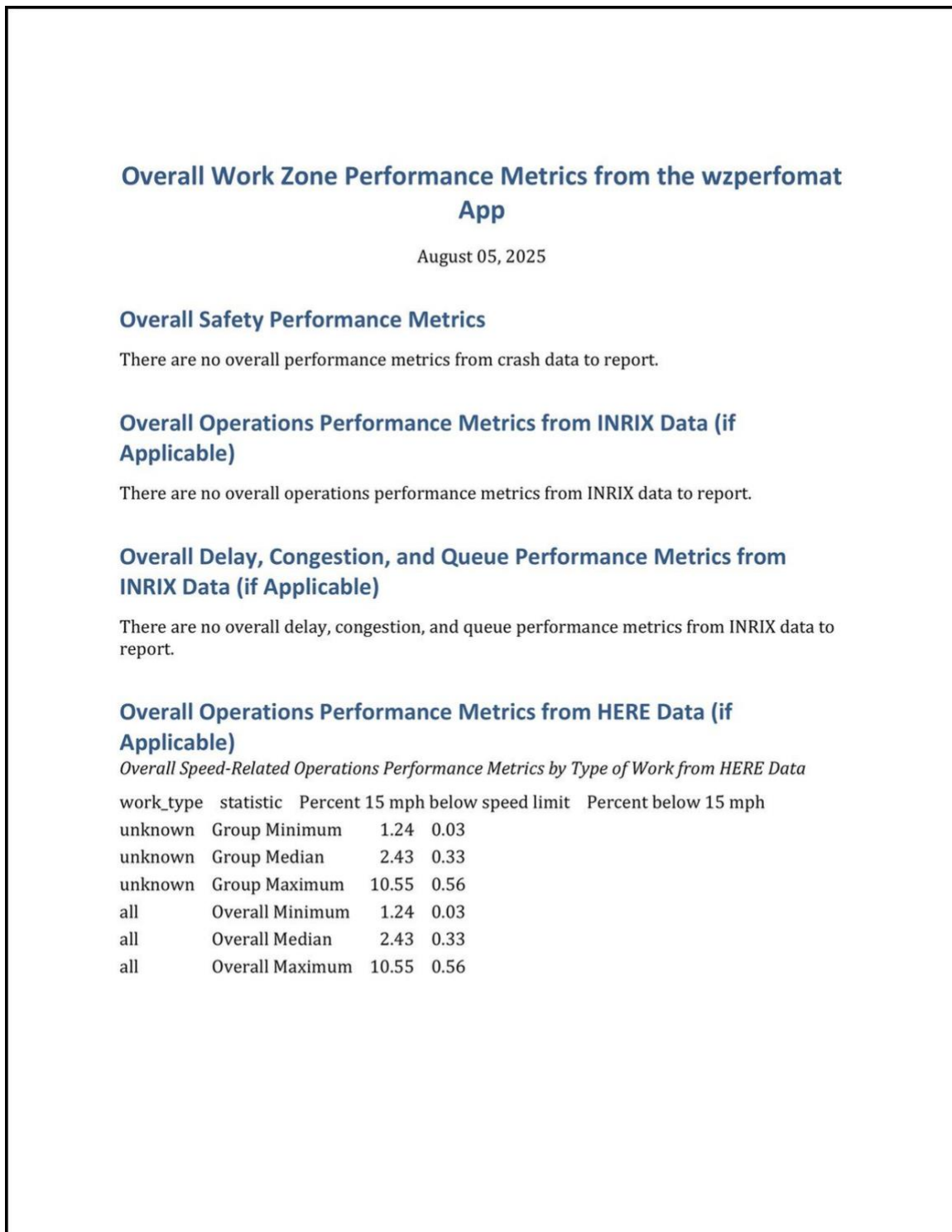


Figure A-1. Statewide downloadable report for four Missouri work zones, page 1/4

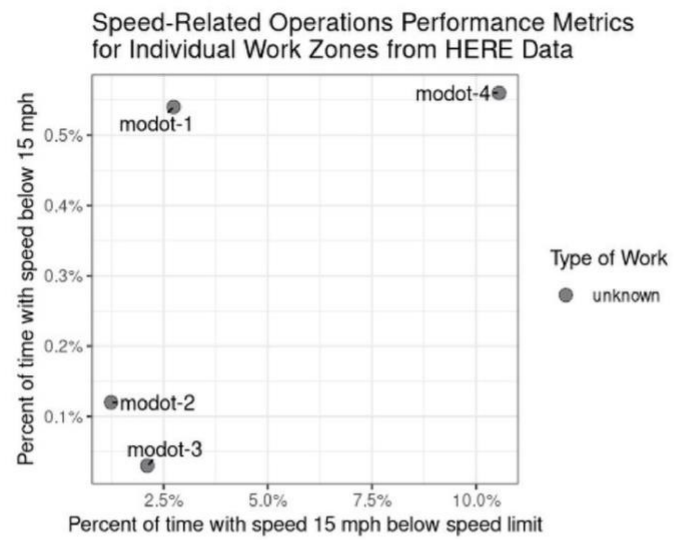
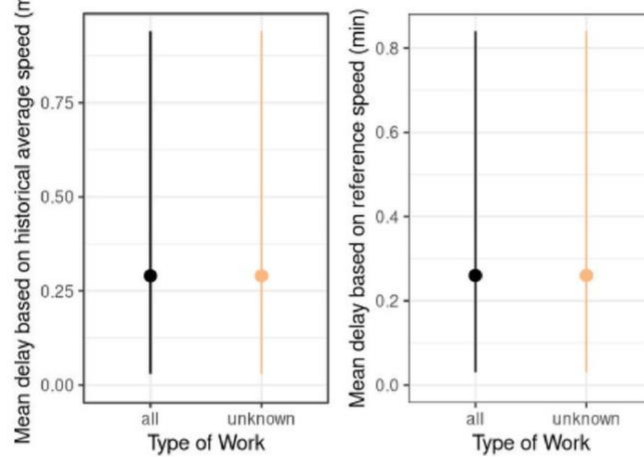


Figure A-2. Statewide downloadable report for four Missouri work zones, page 2/4

### Overall Delay, Congestion, and Queue Performance Metrics from HERE Data (if Applicable)

Minimum, Median, and Maximum of the Mean Delay for Each Type of Work from HERE Data



Overall Delay, Congestion, and Queue Performance Metrics by Type of Work from HERE Data

| work_type | statistic     | Mean delay based on historical average speed (min) | Mean delay based on reference speed (min) | Minutes of congestion | Percent of time with congestion | Congested mile hours | Mean queue length (mi) | Percent of time with a queue longer than 1 mi | Percent of time with a queue longer than 1 mi |
|-----------|---------------|----------------------------------------------------|-------------------------------------------|-----------------------|---------------------------------|----------------------|------------------------|-----------------------------------------------|-----------------------------------------------|
| unknown   | Group Minimum | 0.03                                               | 0.03                                      | 252.0                 | 0.56                            | 271.20               | 0.01                   | 0.56                                          | 0.56                                          |
| unknown   | Group Median  | 0.29                                               | 0.26                                      | 2603.5                | 5.83                            | 3210.32              | 0.07                   | 5.83                                          | 4.70                                          |
| unknown   | Group Maximum | 0.94                                               | 0.84                                      | 5287.0                | 11.85                           | 11878.40             | 0.27                   | 11.85                                         | 8.38                                          |

Figure A-3. Statewide downloadable report for four Missouri work zones, page 3/4

|     |         |      |      |        |       |          |      |       |      |
|-----|---------|------|------|--------|-------|----------|------|-------|------|
| all | um      |      |      |        |       |          |      |       |      |
|     | Overall | 0.03 | 0.03 | 252.0  | 0.56  | 271.20   | 0.01 | 0.56  | 0.56 |
|     | Minimum |      |      |        |       |          |      |       |      |
| all | Overall | 0.29 | 0.26 | 2603.5 | 5.83  | 3210.3   | 0.07 | 5.83  | 4.70 |
|     | Median  |      |      |        |       | 2        |      |       |      |
| all | Overall | 0.94 | 0.84 | 5287.0 | 11.85 | 11878.40 | 0.27 | 11.85 | 8.38 |
|     | Maximum |      |      |        |       |          |      |       |      |

*Delay, Congestion, and Queue Performance Metrics for Individual Work Zones from HERE Data*

| work_type | id      | Mean delay based on historical average speed (min) | Mean delay based on reference speed (min) | Minutes of congestion | Percent of time with congestion | Congested miles hours | Mean queue length (mi) | Percent of time with a queue longer than 1 mi | Percent of time with a queue longer than 1 mi |
|-----------|---------|----------------------------------------------------|-------------------------------------------|-----------------------|---------------------------------|-----------------------|------------------------|-----------------------------------------------|-----------------------------------------------|
| unknown   | modot-1 | 0.94                                               | 0.84                                      | 5287                  | 11.85                           | 11878.40              | 0.27                   | 11.85                                         | 8.38                                          |
| unknown   | modot-2 | 0.49                                               | 0.35                                      | 2366                  | 5.30                            | 3148.58               | 0.07                   | 5.30                                          | 3.03                                          |
| unknown   | modot-3 | 0.03                                               | 0.03                                      | 252                   | 0.56                            | 271.20                | 0.01                   | 0.56                                          | 0.56                                          |
| unknown   | modot-4 | 0.10                                               | 0.16                                      | 2841                  | 6.37                            | 3272.07               | 0.07                   | 6.37                                          | 6.37                                          |

**Figure A-4. Statewide downloadable report for four Missouri work zones, page 4/4**

## A.2 Report for Selected Work Zone in Missouri

### Work Zone Performance Metrics from the wzperformat App

August 05, 2025

#### Work Zone

This report contains performance metrics computed by the wzperformat app for the modot-1 work zone.

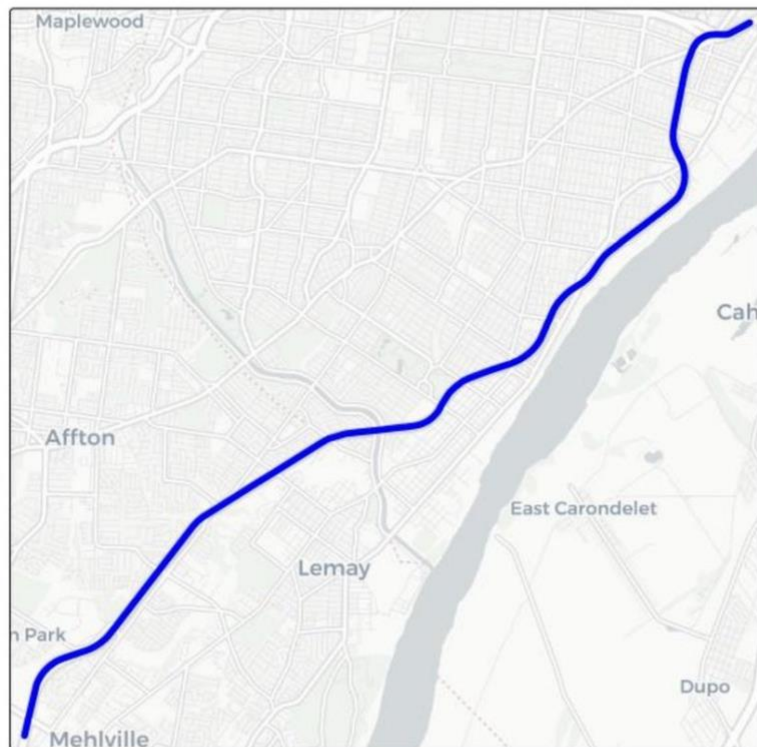


Figure A-5. Selected work zone in Missouri, page 1/6

### Core Details

#### Core Details

##### property details

|                |                       |
|----------------|-----------------------|
| event_type     | placeholder_event     |
| road_names     | placeholder_road      |
| direction      | placeholder_direction |
| update_date    | 2023-12-27 15:39:14   |
| data_source_id | unknown               |
| description    | unknown               |

##### Lanes

|      |             |         |
|------|-------------|---------|
| lane | type        | status  |
| 1    | unspecified | unknown |

##### Work Types

|           |
|-----------|
| work_type |
| unknown   |

### Crash Data

There are no performance metrics from crash data to report.

### INRIX Probe Data

There are no performance metrics from INRIX data to report.

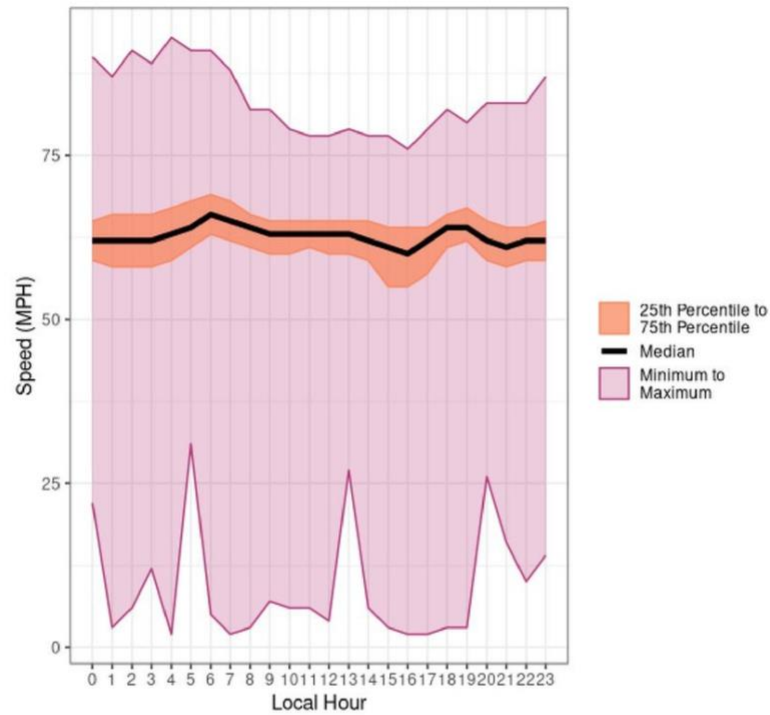
### HERE Data

#### Work Zone Speed Adherence Based on HERE Data

|                 |                                  |                      |
|-----------------|----------------------------------|----------------------|
| OSM speed limit | Percent 15 mph below speed limit | Percent below 15 mph |
| 60              | 2.74                             | 0.54                 |

Figure A-6. Selected work zone in Missouri, page 2/6

Hourly Summaries of Work Zone Speeds (MPH)  
from INRIX Probe Data



Summaries of Work Zone Speeds (MPH) during Peak Periods from HERE Data

| period       | minimum | 25th percentile | median | 75th percentile | maximum |
|--------------|---------|-----------------|--------|-----------------|---------|
| Morning peak | 2       | 61              | 64     | 67              | 91      |
| Evening peak | 2       | 57              | 62     | 64              | 82      |
| Off-peak     | 2       | 59              | 63     | 66              | 93      |

Figure A-7. Selected work zone in Missouri, page 3/6



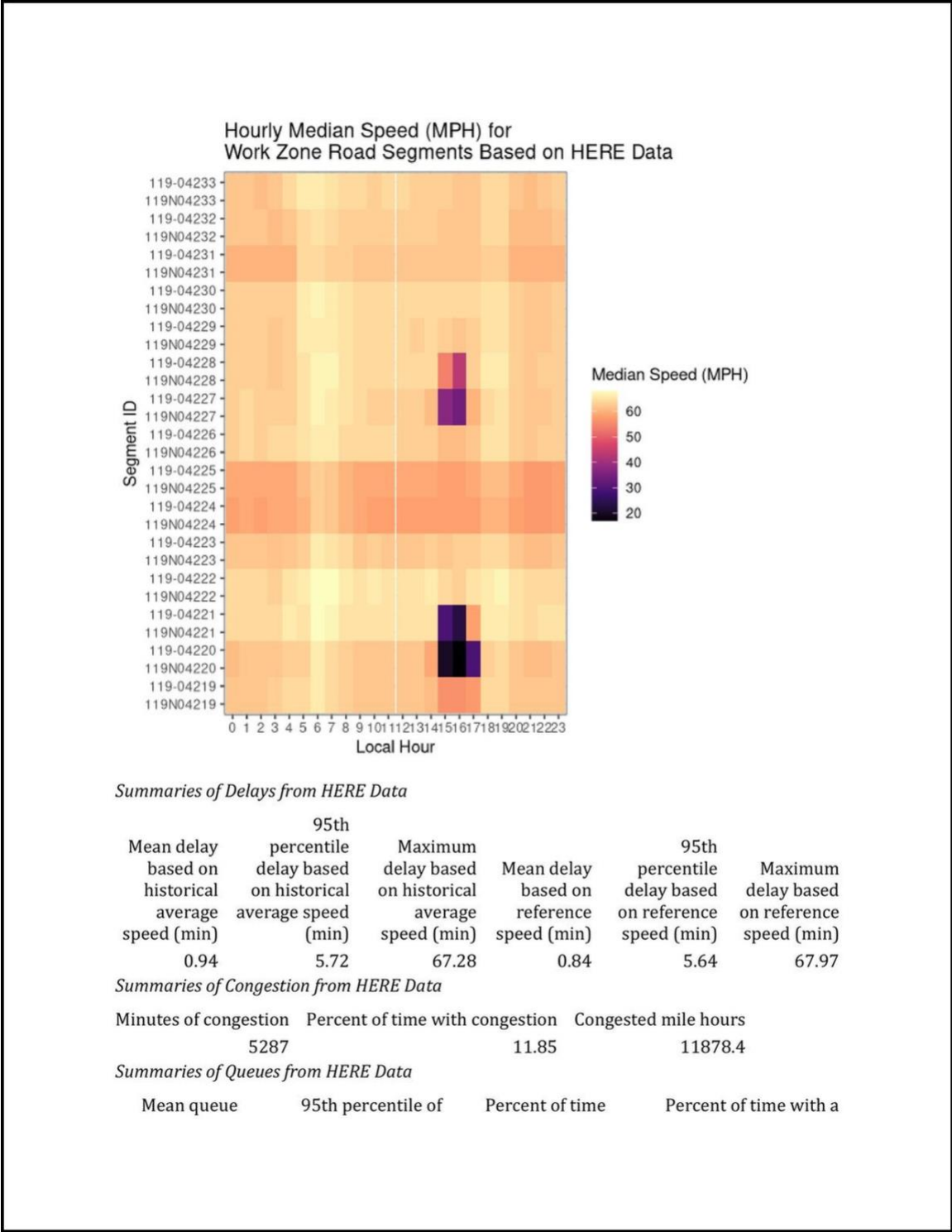


Figure A-9. Selected work zone in Missouri, page 5/6

|             |                   |              |                        |
|-------------|-------------------|--------------|------------------------|
| length (mi) | queue length (mi) | with a queue | queue longer than 1 mi |
| 0.27        | 2.57              | 11.85        | 8.38                   |

#### Connected Vehicle Data

There are no performance metrics from connected vehicle data to report.

**Figure A-10. Selected work zone in Missouri, page 6/6**

## **APPENDIX B. REPORT WITH CRASH, INRIX, AND CONNECTED VEHICLE DATA**

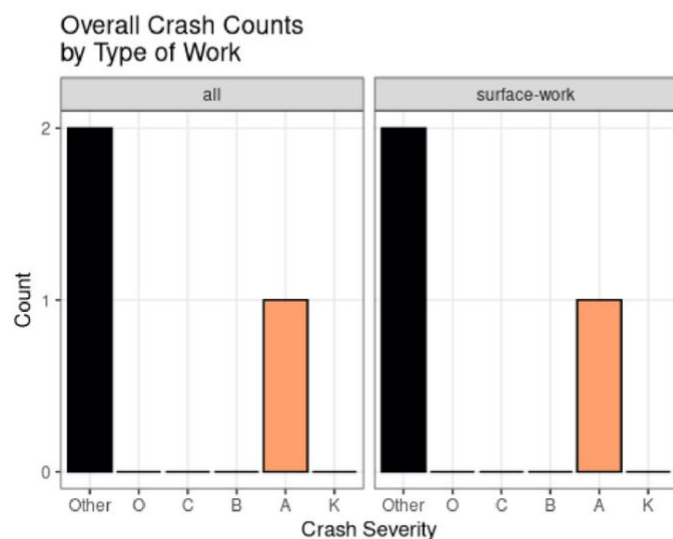
This appendix includes both statewide and individual downloadable reports from WZPERFORMAT. These reports are based on the WZDx work zone locations, with crash data, INRIX data, and connected vehicle data also available. HERE data were not provided, and this is noted in the reports. The probe data provided cover four days in June 2024.

## B.1 Statewide Report for Iowa

### Overall Work Zone Performance Metrics from the wzperformat App

August 06, 2025

#### Overall Safety Performance Metrics



#### Crash-Related Safety Performance Metrics for Individual Work Zones

| work_type    | id                            | No Apparent Injury (O) | Possible Injury (C) | Suspected Minor Injury (B) | Suspected Serious Injury (A) | Fatal Injury (K) | Other |
|--------------|-------------------------------|------------------------|---------------------|----------------------------|------------------------------|------------------|-------|
| surface-work | OpenTMS-Event10028696774-EB   | 0                      | 0                   | 0                          | 1                            | 0                | 2     |
| surface-work | OpenTMS-Event11683704897-4-WB | 0                      | 0                   | 0                          | 0                            | 0                | 0     |
| surface-     | OpenTMS-                      | 0                      | 0                   | 0                          | 0                            | 0                | 0     |

Figure B-1. Statewide downloadable report for four Iowa work zones, page 1/6

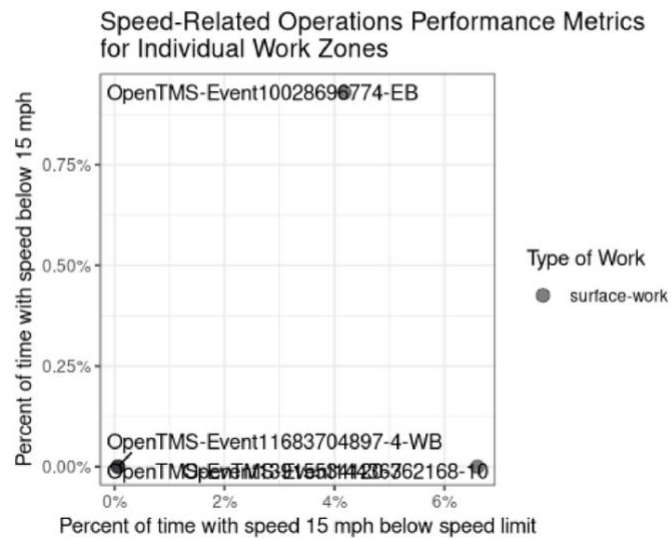
|          |                 |   |   |   |   |   |   |
|----------|-----------------|---|---|---|---|---|---|
| work     | Event1443636216 |   |   |   |   |   |   |
|          | 8-10            |   |   |   |   |   |   |
| surface- | OpenTMS-        | 0 | 0 | 0 | 0 | 0 | 0 |
| work     | Event1391553412 |   |   |   |   |   |   |
|          | 0-7             |   |   |   |   |   |   |

### Overall Operations Performance Metrics from INRIX Data (if Applicable)

*Overall Speed-Related Operations Performance Metrics by Type of Work*

| work_type    | statistic       | Percent 15 mph below speed limit | Percent below 15 mph |
|--------------|-----------------|----------------------------------|----------------------|
| surface-work | Group Minimum   | 0.06                             | 0.00                 |
| surface-work | Group Median    | 2.12                             | 0.00                 |
| surface-work | Group Maximum   | 6.60                             | 0.93                 |
| all          | Overall Minimum | 0.06                             | 0.00                 |
| all          | Overall Median  | 2.12                             | 0.00                 |
| all          | Overall Maximum | 6.60                             | 0.93                 |

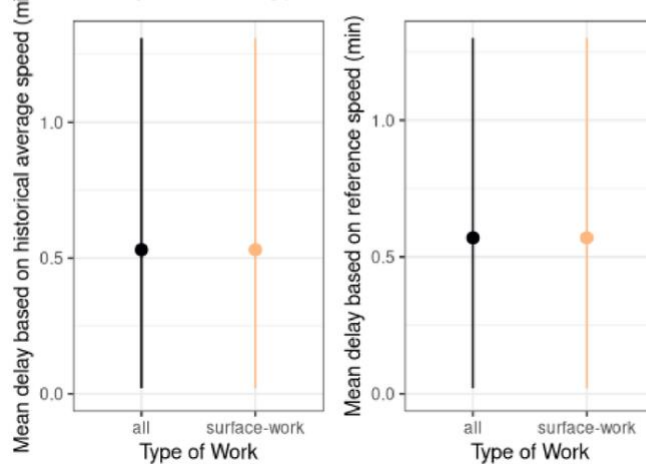
**Figure B-2. Statewide downloadable report for four Iowa work zones, page 2/6**



**Figure B-3. Statewide downloadable report for four Iowa work zones, page 3/6**

### Overall Delay, Congestion, and Queue Performance Metrics from INRIX Data (if Applicable)

Minimum, Median, and Maximum of the Mean Delay for Each Type of Work



Overall Delay, Congestion, and Queue Performance Metrics by Type of Work from INRIX Data

| work_type    | statistic     | Mean delay based on historical average speed (min) | Mean delay based on reference speed (min) | Minutes of congestion | Percent of time with congestion | Congested mile hours | Mean queue length (mi) | Percent of time with a queue longer than 1 mi | Percent of time with a queue longer than 1 mi |
|--------------|---------------|----------------------------------------------------|-------------------------------------------|-----------------------|---------------------------------|----------------------|------------------------|-----------------------------------------------|-----------------------------------------------|
| surface-work | Group Minimum | 0.02                                               | 0.02                                      | 0                     | 0.00                            | 0.00                 | 0.00                   | 0.00                                          | 0.00                                          |
| surface-work | Group Median  | 0.53                                               | 0.57                                      | 17                    | 1.18                            | 2.73                 | 0.00                   | 1.18                                          | 0.00                                          |
| surface-work | Group Maxim   | 1.31                                               | 1.30                                      | 99                    | 6.88                            | 113.06               | 0.08                   | 6.88                                          | 1.32                                          |

Figure B-4. Statewide downloadable report for four Iowa work zones, page 4/6

|     |         |      |      |    |      |        |      |      |      |
|-----|---------|------|------|----|------|--------|------|------|------|
| all | um      |      |      |    |      |        |      |      |      |
|     | Overall | 0.02 | 0.02 | 0  | 0.00 | 0.00   | 0.00 | 0.00 | 0.00 |
|     | Minimum |      |      |    |      |        |      |      |      |
| all | Overall | 0.53 | 0.57 | 17 | 1.18 | 2.73   | 0.00 | 1.18 | 0.00 |
|     | Median  |      |      |    |      |        |      |      |      |
| all | Overall | 1.31 | 1.30 | 99 | 6.88 | 113.06 | 0.08 | 6.88 | 1.32 |
|     | Maximum |      |      |    |      |        |      |      |      |

*Delay, Congestion, and Queue Performance Metrics for Individual Work Zones from INRIX Data*

| work_type    | id                            | Mean delay based on historical average speed (min) | Mean delay based on reference speed (min) | Minutes of congestion | Percent of time with congestion | Congested mile hours | Mean queue length (mi) | Percent of time with queue | Percent of time with a queue longer than 1 mi |
|--------------|-------------------------------|----------------------------------------------------|-------------------------------------------|-----------------------|---------------------------------|----------------------|------------------------|----------------------------|-----------------------------------------------|
| surface-work | OpenTMS-Event10028696774-EB   | 0.34                                               | 0.34                                      | 99                    | 6.88                            | 113.06               | 0.08                   | 6.88                       | 1.32                                          |
| surface-work | OpenTMS-Event11683704897-4-WB | 1.31                                               | 1.30                                      | 5                     | 0.35                            | 1.51                 | 0.00                   | 0.35                       | 0.00                                          |
| surface-work | OpenTMS-Event14436362168-10   | 0.02                                               | 0.02                                      | 29                    | 2.01                            | 3.94                 | 0.00                   | 2.01                       | 0.00                                          |
| surface-work | OpenTMS-Event13915534120-7    | 0.72                                               | 0.79                                      | 0                     | 0.00                            | 0.00                 | 0.00                   | 0.00                       | 0.00                                          |

#### Overall Operations Performance Metrics from HERE Data (if Applicable)

There are no overall operations performance metrics from HERE data to report.

**Figure B-5. Statewide downloadable report for four Iowa work zones, page 5/6**

**Overall Delay, Congestion, and Queue Performance Metrics from  
HERE Data (if Applicable)**

There are no overall delay, congestion, and queue performance metrics from HERE data to report.

**Figure B-6. Statewide downloadable report for four Iowa work zones, page 6/6**

## B.2 Report for Selected Work Zone in Iowa

### Work Zone Performance Metrics from the wzperformat App

August 06, 2025

#### Work Zone

This report contains performance metrics computed by the wzperformat app for the OpenTMS-Event10028696774-EB work zone.

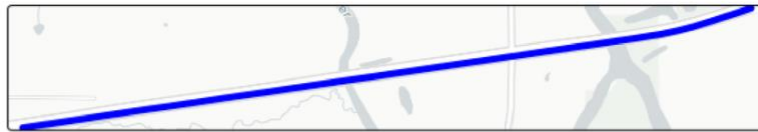


Figure B-7. Selected work zone in Iowa, page 1/7

## Core Details

### Core Details

| property       | details                                                                                                                                                                                                                                                                                                                          |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| event_type     | work-zone                                                                                                                                                                                                                                                                                                                        |
| data_source_id | IowaDOT-WZDx                                                                                                                                                                                                                                                                                                                     |
| road_names     | I-80                                                                                                                                                                                                                                                                                                                             |
| direction      | eastbound                                                                                                                                                                                                                                                                                                                        |
| description    | Between US 6 (near De Soto) and Exit 113: County Road R16 (near Van Meter). The left shoulder is closed due to road construction work. Expect changing traffic patterns. Until June 3, 2024 at about 5:00PM CST. Full schedule below: • May 3, 7:00AM - June 3, 2024, 5:00PM Comment: Creston RCE (877-226-8109) - Dallas County |
| update_date    | 2023-12-27 15:39:14                                                                                                                                                                                                                                                                                                              |

### Lanes

| lane | type     | status |
|------|----------|--------|
| 1    | shoulder | closed |
| 2    | general  | open   |
| 3    | general  | open   |
| 4    | general  | open   |
| 5    | shoulder | open   |

### Work Types

| work_type    |
|--------------|
| surface-work |

**Figure B-8. Selected work zone in Iowa, page 2/7**

## Crash Data



### Work Zone Crashes

| id                          | start_date          | end_date            | casenum     | crash_datetime      | fatalities | injuries | severity                     |
|-----------------------------|---------------------|---------------------|-------------|---------------------|------------|----------|------------------------------|
| OpenTMS-Event10028696774-EB | 2023-05-03 12:00:00 | 2024-06-03 22:00:00 | 20241409598 | 2024-02-16 11:14:00 | 0          | 1        | Suspected Serious Injury (A) |
| OpenTMS-Event10028696774-EB | 2023-05-03 12:00:00 | 2024-06-03 22:00:00 | 20241413201 | 2024-03-13 17:05:00 | 0          | 0        | Other                        |

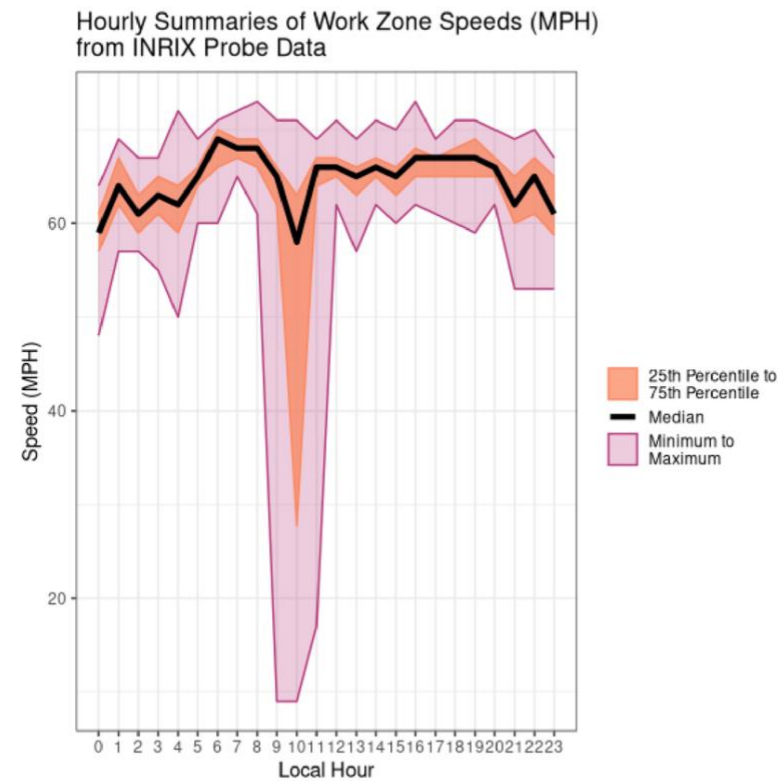
**Figure B-9. Selected work zone in Iowa, page 3/7**

|                                     |                                |                                |                 |                        |   |   |       |
|-------------------------------------|--------------------------------|--------------------------------|-----------------|------------------------|---|---|-------|
| OpenTMS-<br>Event10028696<br>774-EB | 2023-<br>05-03<br>12:00:0<br>0 | 2024-<br>06-03<br>22:00:<br>00 | 20241419<br>706 | 2024-04-24<br>12:46:00 | 0 | 0 | Other |
|-------------------------------------|--------------------------------|--------------------------------|-----------------|------------------------|---|---|-------|

### INRIX Probe Data

Work Zone Speed Adherence Based on INRIX Probe Data

| OSM speed limit | Percent 15 mph below speed limit | Percent below 15 mph |
|-----------------|----------------------------------|----------------------|
| 70              | 4.18                             | 0.93                 |



Summaries of Work Zone Speeds (MPH) during Peak Periods from INRIX Probe Data

| period | minimum | 25th percentile | median | 75th percentile | maximum |
|--------|---------|-----------------|--------|-----------------|---------|
|--------|---------|-----------------|--------|-----------------|---------|

Figure B-10. Selected work zone in Iowa, page 4/7

|              |    |    |    |    |    |
|--------------|----|----|----|----|----|
| Morning peak | 9  | 65 | 67 | 69 | 73 |
| Evening peak | 60 | 65 | 67 | 68 | 73 |
| Off-peak     | 9  | 61 | 64 | 66 | 72 |

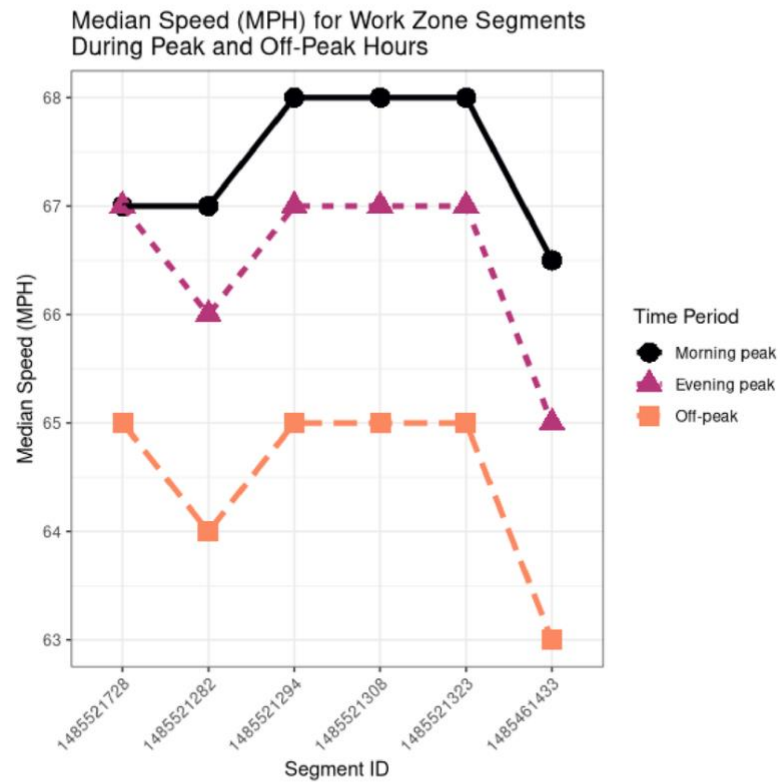
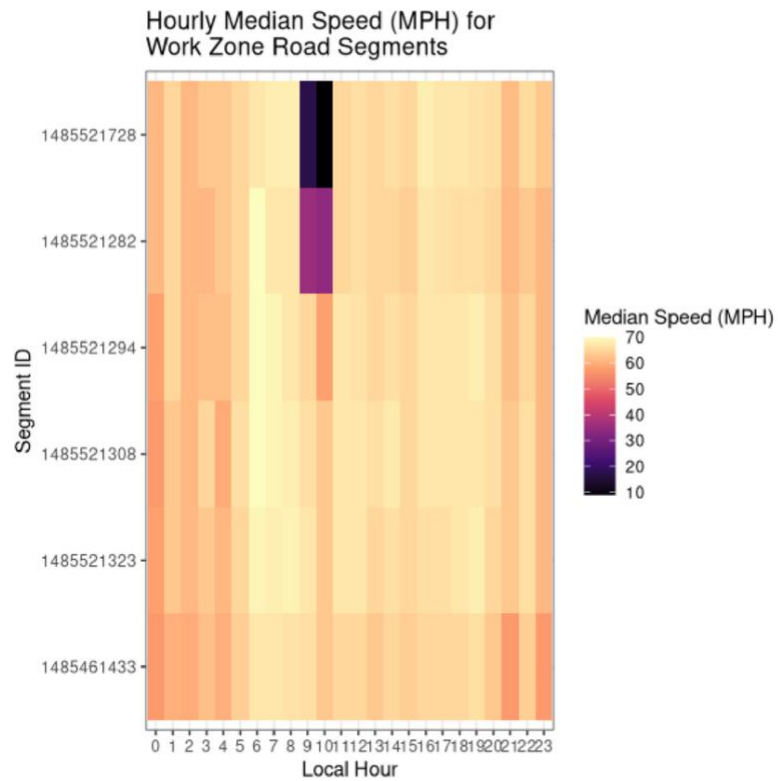


Figure B-11. Selected work zone in Iowa, page 5/7



*Summaries of Delays from INRIX Probe Data*

| Mean delay<br>based on<br>historical<br>average<br>speed (min) | 95th<br>percentile<br>delay based<br>on historical<br>average speed<br>(min) | Maximum<br>delay based<br>on historical<br>average<br>speed (min) | Mean delay<br>based on<br>reference<br>speed (min) | 95th<br>percentile<br>delay based<br>on reference<br>speed (min) | Maximum<br>delay based<br>on reference<br>speed (min) |
|----------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------|
| 0.34                                                           | 3.08                                                                         | 6.26                                                              | 0.34                                               | 3.08                                                             | 6.25                                                  |

*Summaries of Congestion from INRIX Probe Data*

| Minutes of congestion | Percent of time with congestion | Congested mile hours |
|-----------------------|---------------------------------|----------------------|
| 99                    | 6.88                            | 113.06               |

*Summaries of Queues from INRIX Probe Data*

| Mean queue | 95th percentile of | Percent of time | Percent of time with a |
|------------|--------------------|-----------------|------------------------|
|------------|--------------------|-----------------|------------------------|

**Figure B-12. Selected work zone in Iowa, page 6/7**

| length (mi) | queue length (mi) | with a queue | queue longer than 1 mi |
|-------------|-------------------|--------------|------------------------|
| 0.08        | 0.97              | 6.88         | 1.32                   |

### HERE Data

There are no performance metrics from HERE data to report.

### Connected Vehicle Data

| hour | speed_mph_mean | speed_mph85 |
|------|----------------|-------------|
| 0    | 62.32          | 70.0        |
| 1    | 71.48          | 74.0        |
| 2    | 67.67          | 70.0        |
| 4    | 69.69          | 74.8        |
| 5    | 73.24          | 80.0        |
| 6    | 70.47          | 76.0        |
| 7    | 69.82          | 74.0        |
| 8    | 46.94          | 72.0        |
| 9    | 69.27          | 74.0        |
| 10   | 69.29          | 75.0        |
| 11   | 66.52          | 73.0        |
| 12   | 44.21          | 73.0        |
| 13   | 67.76          | 72.0        |
| 14   | 66.71          | 72.0        |
| 15   | 56.27          | 72.0        |
| 16   | 70.11          | 76.0        |
| 17   | 67.55          | 73.0        |
| 18   | 65.16          | 74.0        |
| 19   | 65.45          | 73.0        |
| 20   | 67.22          | 74.0        |
| 21   | 69.26          | 74.0        |
| 22   | 68.31          | 72.0        |
| 23   | 63.04          | 64.0        |

**Figure B-13. Selected work zone in Iowa, page 7/7**