Best Practices for Managing Work Zone Data

Final Report
August 2017

Sponsored by
Smart Work Zone Deployment Initiative
(TPF-5(295))
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(InTrans Project 15-535)

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Iowa, Kansas, Missouri, and Nebraska created the Midwest States Smart Work Zone Deployment Initiative (SWZDI) in 1999 and Wisconsin joined in 2001. Through this pooled-fund study, researchers investigate better ways of controlling traffic through work zones. Their goal is to improve the safety and efficiency of traffic operations and highway work.

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16. Abstract This work investigated methods and best practices that agencies use to manage work-zone data. Information gathered from the survey includes types of data collected, methods used for data collection, data architecture, methods used for geo-referencing data, how work-zone data is currently being used, and additional data needs. The results of the survey were compiled and analyzed to develop recommendations to help agencies more effectively manage work-zone data, and to leverage that data for operational and safety analysis purposes.			
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BEST PRACTICES FOR MANAGING WORK ZONE DATA

Final Report
August 2017

Principal Investigator
Steven Parker
Deputy Director, Information Technology Program Manager
Wisconsin Traffic Operations and Safety (TOPS) Laboratory
University of Wisconsin-Madison

Co-Principal Investigator
Yang Cheng
Assistant Researcher
Wisconsin Traffic Operations and Safety (TOPS) Laboratory
University of Wisconsin-Madison

Research Assistant
Shuoxuan Dong

Authors
Yang Cheng, Steven Parker, and Shuoxuan Dong

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The Wisconsin Traffic Operations and Safety (TOPS) Laboratory at the University of Wisconsin-Madison would like to acknowledge the Smart Work Zone Deployment Initiative (SWZDI) and Federal Highway Administration (FHWA) Pooled Fund Study TPF-5(295) for sponsoring this project. The team would like to thank the technical advisory committee for their assistance and feedback:

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EXECUTIVE SUMMARY

Background

Effective work zone operations, management, and safety analysis require comprehensive work zone planning and management information that is accessible and easy-to-integrate with related data sets. With the help of modern transportation information systems, we are able to collect, manage, and archive significant amounts of transportation related data. However, these information systems are often oriented towards specific purposes and different application areas; the data pulled from them are usually in different formats and by various standards. In addition, those data sets are often difficult to be spatially and temporally integrated for lacking a common GIS location system and the capabilities to support map-based interfaces and data modeling. Therefore, it is necessary to gather information about the currently used work zone data management methods, the data management needs to improve work zone safety and operations, and develop implementable guidance for agencies.

Project Objectives

The main objective of this project is to investigate methods and best practices that agencies use to manage work zone data, such as types of data collected, methods used for data collection, data architecture, methods used for geo-referencing data, how work zone data is currently being used, and additional data needs. The results will be compiled and analyzed to develop recommendations to help agencies more effectively manage work zone data, and to leverage that data for operational and safety analysis purposes.

Methodology

The project team began by working with the host state and Technical Advisory Committee (TAC) members to identify work zone data management focus areas, and conducted a survey of states agencies (20 recorded responses) in the US. The survey covered questions about work zone data collection, related applications, and work zone data sharing.

Key Findings

- States are at different development levels of work zone data management practices.
- There is no uniform work zone data collection and sharing mechanism.
- There are quite a few best practices in various aspects of work zone data management, which are valuable references for other states and the development of a future data collection strategy.
- The responding states were satisfied with their current work zone data quality in general, but acknowledge shortcomings in current practices.
- States welcome a federal and state collaboration effort to build a uniform work zone data management strategy and develop guidance.
- More resources are needed to support work zone data management.

Recommendations

An effective work zone data management strategy includes a standards-based approach, format and an effective data warehouse, with consideration of various work zone mobility, safety, and data sharing applications. Based on the findings from the survey, we propose the following recommendations:

- States would benefit from a comprehensive work zone data management strategy that would provide a consistent roadmap for development.
- Any such strategy should provide guidance for states at different development stages.
- The strategy should cover a standard definition for work zone data elements to facilitate performance reporting and data sharing.
- It is essential to establish collaboration among all stakeholders, both internal and external.
- Efforts at the federal and national level can speed up the strategy development and support states' implementation.

CHAPTER 1 INTRODUCTION

1.1 Background

Work zones inherently interrupt regular traffic flow patterns, and may cause traffic delays and safety risks. One important strategy to minimize such risks is to develop intelligent systems to more effectively plan for and manage work zone operations. At the federal level, smart work zone initiatives aim to provide tools and assistance to accelerate the adoption of Smarter Work Zone strategies, and states have begun to streamline their work zone practices by implementing business processes following the *Work Zone ITS Implementation Guide* (FHWA2014). Although not specifically targeting work zone data, there are several projects investigating data and information management in general, such as NCHRP Project 20-90: *Improving Management of Transportation Information* (see Cambridge Systematics, Inc. 2013) and NCHRP Project 08-92: *Implementing a Transportation Agency Data Self-Assessment* (see Spy Pond Partners and Iteris, Inc. 2015). There are also studies about work zone assessment and monitoring both at the federal level (Ullman 2010) and state level that have also developed custom solutions to address work zone planning, operations, and monitoring, such as key safety and mobility performance measures (Hallmark et al. 2013, Ullman et al. 2009a, Ullman et al. 2009b), and work zone safety and mobility data collection (Michigan DOT 2010).

All those efforts rely heavily on the availability and accessibility of reliable work zone data to support data needs of various work zone planning, safety, and operations applications. However, the availability and quality of work zone data are often limited. Moreover, work zone data management systems are typically developed within the context of a specific application or business domain and do not support wider integration with other datasets or data reuse to address current and future requirements. Therefore, it is necessary to develop a common work zone data management strategy to provide guidance to collect, manage, and integrate work zone data into agency-wide and regional applications. An important foundational step in that process is to investigate existing capabilities and potential gaps between states' work zone application needs and existing data management methods. Future recommendations should incorporate best practices and the broader context of emerging work zone data requirements.

Figure 1 shows a concept diagram of the role of a work zone data management strategy, listing a few exemplary applications that rely on a well-maintained work zone date warehouse.

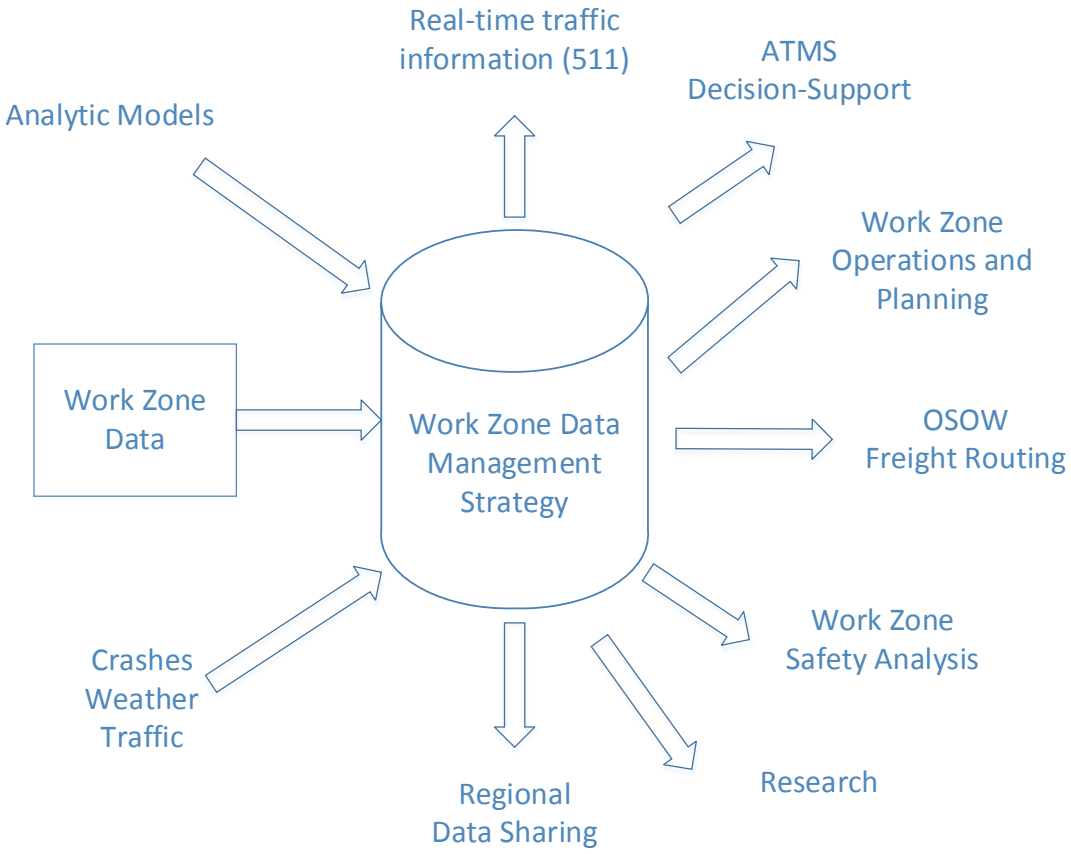

Figure 1. Role of a work zone data management strategy

This study aimed to investigate work zone data management practices aligning with this concept diagram.

1.2 Project Objectives

The project aimed to:

1. Identify the key focus areas for work zone data management that are most important to the states, and develop data management performance measurement criteria,
2. Investigate state of the art / best practices as well as common data management shortcomings among participating states, and identify the gaps between the current work zone data management methods and needs of work zone applications in the identified key focus areas,
3. Summarize project findings for use by state agencies and integrators that face similar questions, and
4. Propose recommendations for work zone data management based on findings from the survey.

1.3 Report Organization

Aside from this introduction, the rest of this report is organized into five other chapters. Chapter 2 presents an overview of the survey design and responses. Chapter 3 presents the findings of work zone data collection from the survey. Chapter 4 shows the results about the work zone related applications, and Chapter 5 shows findings for work zone data sharing. Chapter 6 summarizes the challenges and recommendations from this study.

CHAPTER 2 SURVEY DESIGN AND RESPONSES

This chapter provides an overview of the survey questions, distribution and recorded responses.

1.1 Overview of the Survey Questions

Questions of this survey were organized into three sections: (1) Work Zone Data Collection, (2) Work Zone Data Related Applications, and (3) Work Zone Data Sharing. Many of the elements of this survey are narrative in nature. The goal is to provide an opportunity to describe work zone data management in those agencies with as much detail as appropriate.

The section of Work Zone Data Collection is to identify best practices, as well as current challenges about work zone data collection, regarding data elements, data sources, data quality, and data standards. The section of Work Zone Data Related Applications is about the value of work zone data, how work zone data is used, and how work zone data supports various business requirements and research needs. The section of Work Zone Data Sharing is to investigate how work zone data is and can be shared with other stakeholders, including researchers, analysts, and other state agencies.

2.2 Survey Distribution and Response Collection

This survey was sent to all 50 state agencies, the District of Columbia (DC), and the I-95 Corridor Coalition. Twenty-two states responded to the survey: Arkansas, California Connecticut, Florida, Georgia, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, North Carolina, North Dakota, Ohio, Oregon, South Carolina, Texas, Utah, Virginia, and Wisconsin. Although some of the responses are incomplete and some of the questions are not fully answered, this survey still provided a geographically balanced coverage of states from most regions in the US, from east to west, from north to south. The states are shown in Figure 2.

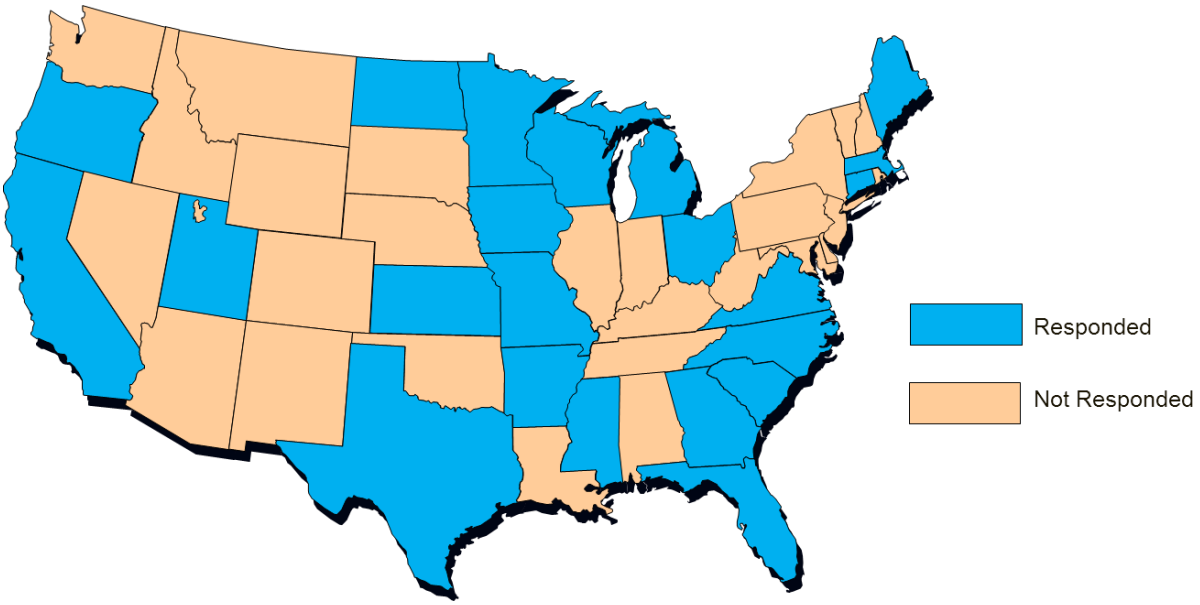

Figure 2. State map for responses

2.3 Survey Summarization

The survey questions included a large number of free-text areas alongside predefined single and multiple selection choices, since our goal was to obtain as much information as possible from the states, without the limits bounded by the predetermined choices. Although the free-text spaces greatly increased the efforts to fully respond to the questions and to summarize the responses, we found the information gathered to be of great value compared to simple choice selection questions.

CHAPTER 3 WORK ZONE DATA COLLECTION

This chapter summarizes the findings from the questions in the section about work zone data collection from the survey.

3.1 Work Zone Data Sources

This question asked about the number of work zone data sources. From all the responses, most of the states rely on one major work zone data source, with the exception of Iowa and Virginia. In Iowa, two data sources are mentioned: (1) the 511 traveler information portal archives and (2) the crash database MMUCC4. Their 511 traveler information portal archives provide "location and various information regarding work zones as posted on the public portal" (http://511ia.org/), and the crash database, MMUCC 4, "compliant and contains fields suggested by MMUCC 4". These data, with personal data removed, are widely available through various resources, analytical tools, and downloads. The data are shared with university partners, as well as others, in raw form. The online crash analysis resource (web-SAVER) currently under development (https://saver.iowadot.gov/) is available to anyone with internet access and work zone data can be queried. As the application is under development, not all information can be accessed/reported on (e.g., not all particular aspects of the data).

In Virginia, there are several ways of collecting work zone data. Three of the five Regions (Northern Virginia, Hampton Roads, and Northwest), and have implemented a lane closure system (LCS) while the other two Regions plan to do so soon. Information is also available through the 511 traveler information system. On the other hand, Wisconsin has a centralized LCS system covering all the five regions.

3.2 Data Elements

This survey also looked at the data elements collected from those data sources by the agencies. Note that responses have been examined and manually corrected based on the additional information provided as free texts; the original responses are shown in the Appendix.

3.2.1 Work Zone Location

Figure 3 shows the work zone location data that agencies collect; this was a multiple selection survey question since location data can be collected in more than one format; hence several states selected more than one category.

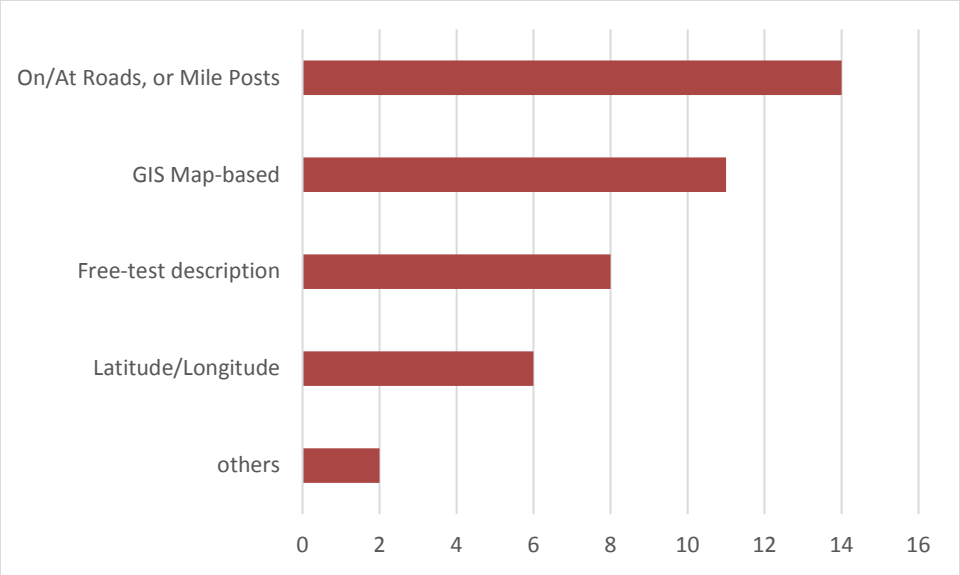

Figure 3**. Formats for work zone location data (modified responses)**

3.2.2 Work Zone Time

Work Zone Time represents the data elements available to describe the period and repeating intervals (Scheduling) of the work zone. A summary of the raw responses is shown in Figure 4.

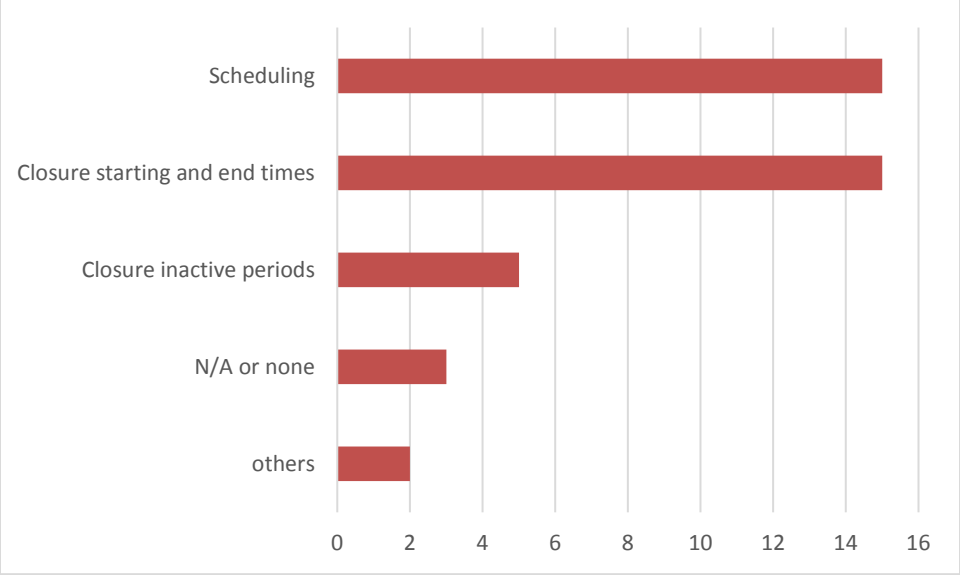

Figure 4. Work zone time data collected (modified responses)

Others responses were:

- Closures actual start/end time on continuous basis.

- Project's acceptable hours for lane closures, tracked by individual construction offices and not centrally available.

3.2.3 Work Zone Lane Configuration

Work zone lane configuration represents the lane details of a work zone. A summary of the raw responses is shown in Figure 5.

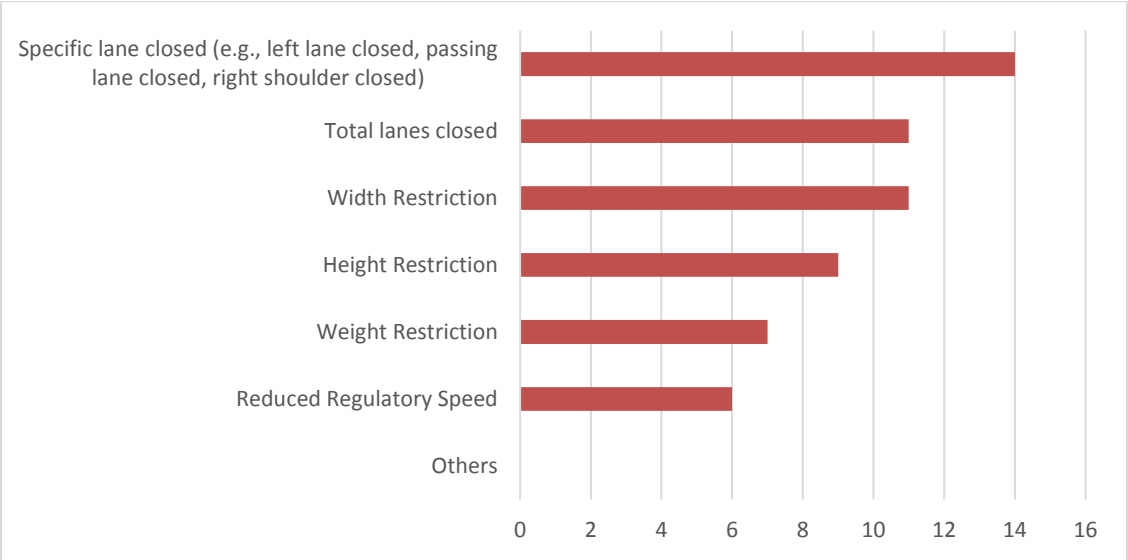

Figure 5. Lane configuration data (modified responses)

3.2.4 Work Zone Traffic Control

Work zone traffic control is about traffic control methods that can be recorded in those data sources from those states, as shown in Figure 6.

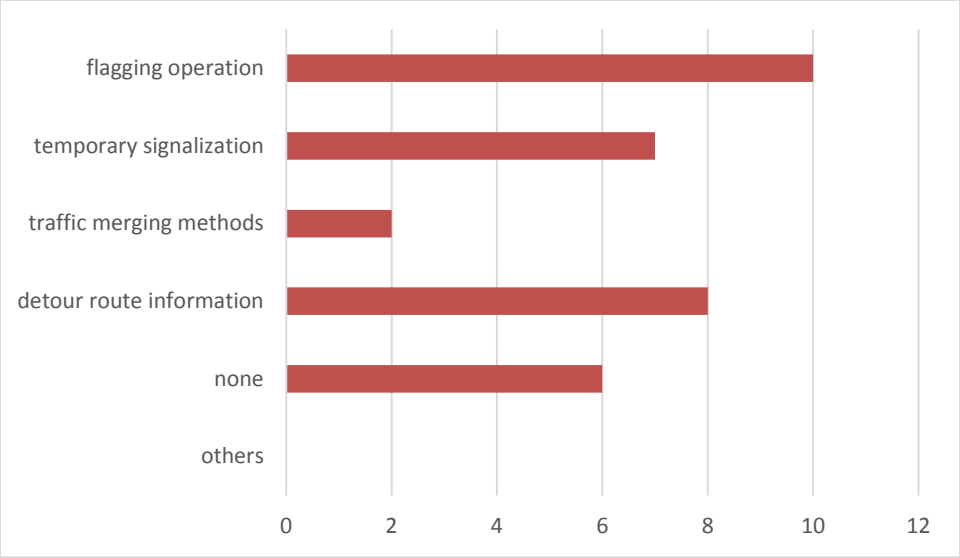

Figure 6. Traffic control types (modified responses)

3.2.5 Other Data Elements

This survey also asked about other data elements that were not covered explicitly in the provided questions. The raw responses were:

- Relative speeds crashes
- Moving lane closure
- We do not collect any specific data elements about the actual work zone from the Road Notification Form outside of how many lanes the existing roadway has and what is being closed to do the work.
- Moving lane closure
- Also included are the estimated completion dates (ECD), the RE Office responsible, the contractor/job cost information, and of course the location information.
- No other data is available in our system.
- For long term work, an expected ending date.
- OHGO tracks whether the road is open, restricted or closed.
- Dates closed but not particularly precise or informative.
- Oregon DOT is a partner agency with Portland State University's big data project, known as PORTAL. This project collects data from roadside sensors throughout the Portland Metro area. ODOT has developed a work zone ITS platform that connects to this data warehouse. Work zones that incorporate roadside sensors will have available data, as well as from permanent sensors near project locations. A sample of work zones is chosen each year for inspection by the engineering standards office. These work zones are rated for adherence to standards for temporary traffic control quality, as well as for traffic delay. The delay measure in this inspection is judged qualitatively. Work zone delay is generally unavailable for the majority of projects.

In those responses, those additional elements can be categorized into some main types: (1) additional data collected for work zone safety and mobility analysis, such as crashes, traffic detection, and delay (2) project information such as completion date and cost, (3) additional lane configuration types that are not explicitly listed in the previous questions, and (4) work zone ITS and traffic control deployments.

It is worth mention that the Oregon DOT provided a great example for work zone data collection and mobility analysis, as it has developed a work zone ITS platform connecting traffic data warehouse (the PORTAL system) and work zone records. Although the delay is qualitatively judged and unavailable for most of the projects, it can serve as a best practice for such application and collaboration between state DOTs and research institutes.

3.3 Work Zone Data Archiving

This section summarizes the methods and applications for work zone data archiving.

3.3.1 Database Type

Figure 7 shows the database systems used to archive work zone data in those states.

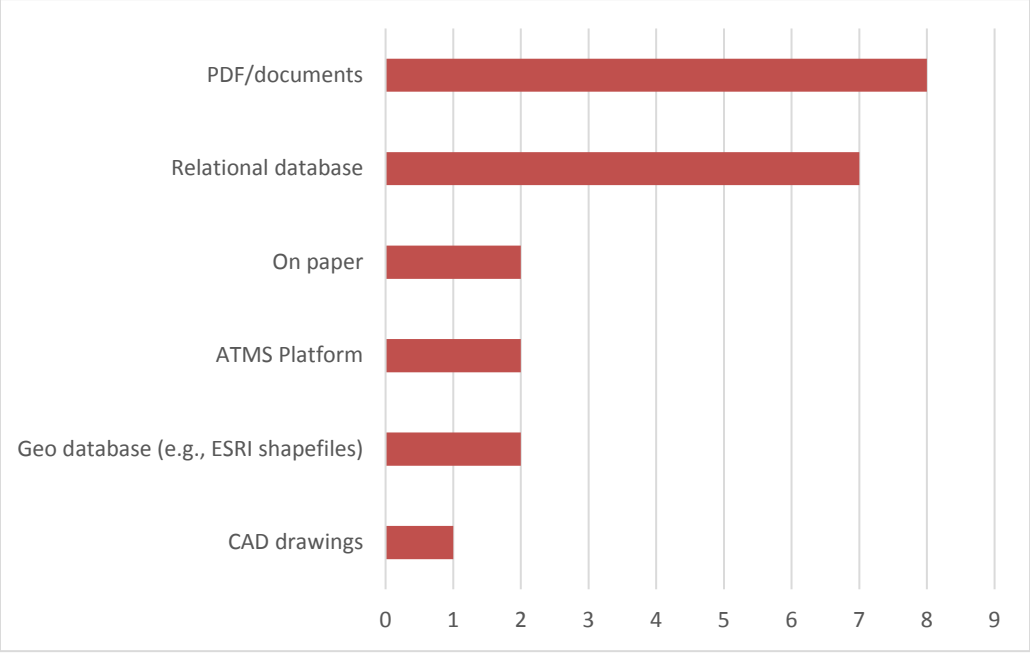

Figure 7. Database used for work zone data storage (modified responses)

3.3.2 Data Update Frequency

Another important factor is the frequency at which work zone data is updated. The collected raw responses from the agencies were:

- Updated every two minutes.
- Supposed to be daily inputs but can cover a long period if the project is not changing.
- Data is updated in real time and must be confirmed by the Contractor through the LCIS system at least once every two weeks for accuracy.
- The contractor reported data should be close to real time. The other is weekly during construction season
- WisLCS data is automatically transferred from WisLCS to WisDOT's Superload OSOW routing system twice per day.
- We have the ability to fill out and send the form electronically, but many Resident Engineers and Maintenance Foreman will fill out a paper version and scan/email or fax it in.
- Real-time
- Data collected in real-time and is updated/refreshed every 5 minutes.
- The data is updated daily. It is updated through AWS using PGAdmin.
- The data is updated quarterly and is downloaded from the vendor's system (JamLogic) into a spreadsheet.
- Updated by crews as situation changes
- Monthly
- Hourly lane closure prohibition restrictions are updated every two years.
- In Real-Time
- Real time - OHGO is our ATMS
- Maintained real-time but no idea how often archived/saved. Congestion Information is relatively real time where cameras and speed information is available.
- Data that is collected from roadside hardware is available in real-time and reports are available in multiple formats, such as spreadsheet export or text. The work zone ITS pilot does post to our public-facing 511 website (TripCheck.com); at present this is only for a single project. Weekly reports from the construction offices are managed by our Public Information Officers who aggregate information and post for public view.
- Weekly meetings are held in the three regions to determine lane closure priorities, then contractors or VDOT personnel are required to call the Traffic Operations Centers when travel or shoulder lanes are closed and opened back to traffic.
- Near real-time. The data is updated via interactive maps, printable maps, json, text versions, and xml.

It was nice to see that more than half of the state DOTs update their work zone data in real-time (11 of 20 answers), and 75% (15 of 20) update at least once a day. Figure 8 summarizes the responses.

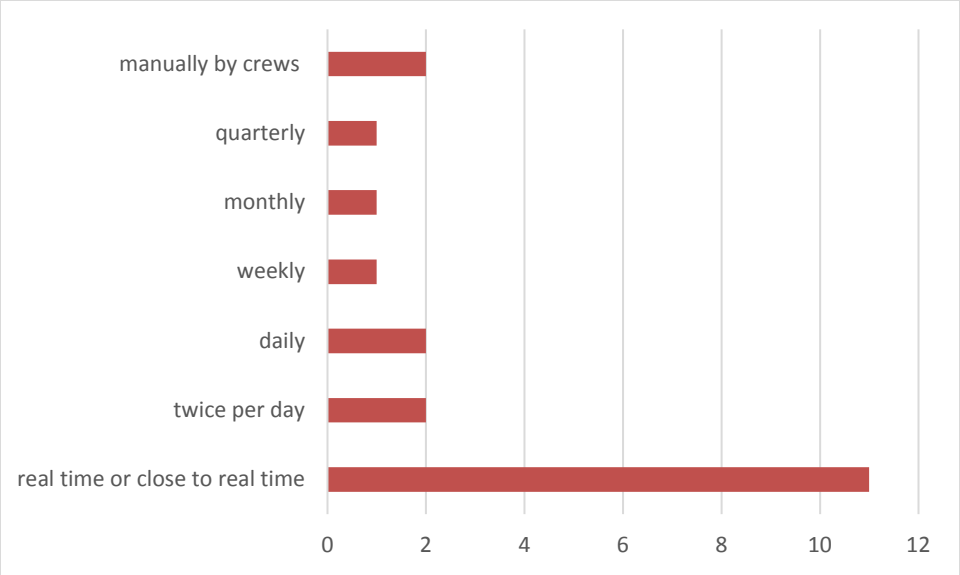

Figure 8. Work zone data update frequency

3.3.3 Data Mapping and Visualization

Work zone location data is critical for most work zone assessment and monitoring applications, and it is important to be able to put work zones on a map. Figure 9 shows the breakdown of responding agencies that have a current work zone mapping capability versus those agencies that do not.

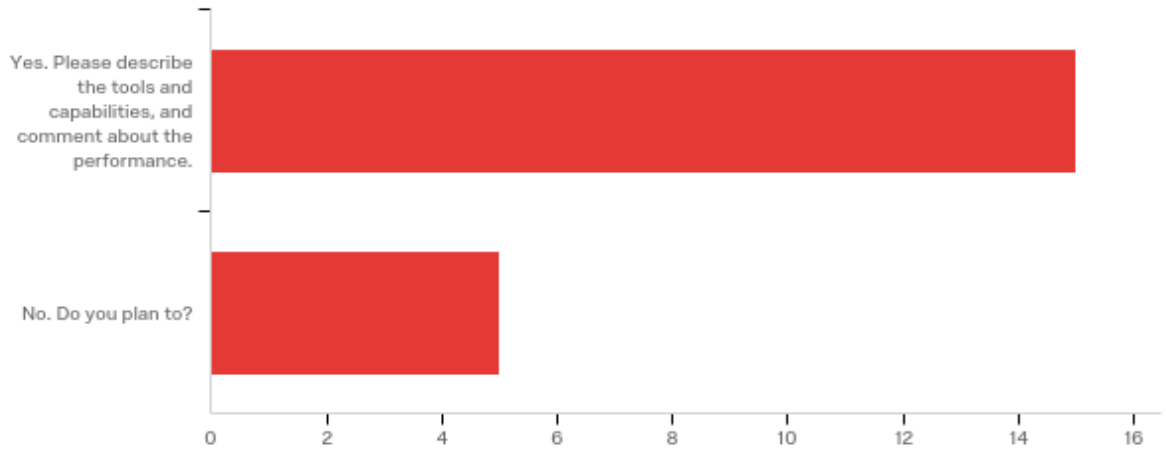

Figure 9. Mapping tool availability

15 out of 20 of the agencies have mapping capability, and two of those who do not currently have the mapping capability, have planned to implement one. A quite popular (10 of the 15) mapping solution is mapping through other systems, such as the state 511 systems and ATMSs, in which Google Maps and ERSI maps are often used. The rest (5 of 15) uses internal linear reference systems (LRS).

3.4 Data Standards

Currently, agencies use a few standards to guide their practices of work zone data collection, including Model Minimum Uniform Crash Criteria (MMUCC), Model Inventory of Roadway Elements (MIRE), and Purdue Signal Metrics. Agencies use MMUCC for crash reporting, which includes appropriate fields for work zones; MIRE is for the roadway inventory, which can help work zone location data and mapping capability; Purdue Signal Metrics, which is primarily for traffic signal performance, includes expected utility in analyzing corridor performance, including for work zone analysis. The problem is that those standards are designed for other applications not specifically for work zone data, and only cover a portion of data needs for work zone applications.

3.5 Data Coverage

The work zone data set coverage regarding roadway types is shown in Table 1.

Table 1. Work zone data coverage

	All		Mostly		Some		Other		
Road Type	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**Total**
Highway system	61.90%	13	19.05%	4	9.52%	2	9.52%	2	21
Local roads	0.00%	0	7.69%	1	61.54%	8	30.77%	4	13
Tollways	9.09%	1	9.09%	1	9.09%	1	72.73%	8	11
Tribal roads	0.00%	0	0.00%	0	0.00%	0	100.00%	8	8
Private roads	0.00%	0	0.00%	0	0.00%	0	100.00%	8	8
Park roads	0.00%	0	12.50%	1	0.00%	0	87.50%	7	8

For Highway Systems, the raw Other cases were:

- Not all state system has all the data
- State Highway Locations
- Project-specific
- Interstate system

For Local Roads, the raw Other cases were:

- Not covered by DOT
- None on Local roads
- Primary and state routes

- We report what we are informed about
- Non-DOT-administered roads are not included in 511 currently.

For Tollways, the raw Other cases were:

- Not covered by DOT
- N/A - no tollways in Utah
- Not applicable in Mississippi
- Oregon does not have tollways.

3.6 Data Satisfaction

Figure 10 shows how agencies evaluate their work zone data meeting their needs.

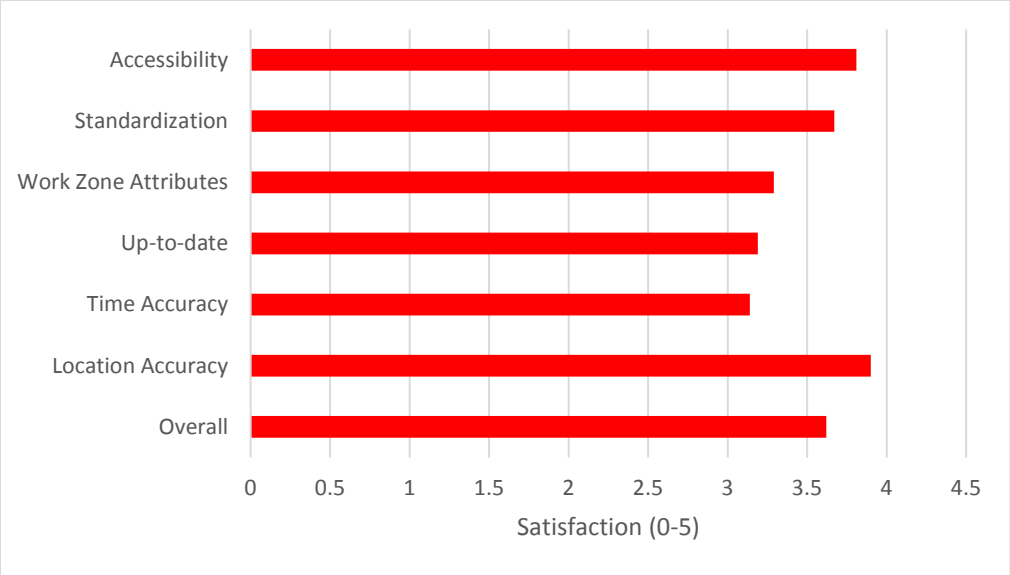

Figure 10. Satisfaction for work zone data

It is good to see that the work zone data collected is generally satisfactory for state agencies for daily tasks, with an overall satisfactory score of 3.62/5. Among all the aspects, location accuracy has the highest score of 3.9/5, and time accuracy and up-to-date are the aspects that responding agencies are most unsatisfied with (3.14 and 3.19).

3.7 Best Practices for Data Collection

There are some best practice cases about work zone data collection mentioned by agencies:

Data Collection Integrated with Applications
In Iowa, work zone data is collected through the 511 traveler information portal archives and

the crash database MMUCC4. Their 511 traveler information portal archives provide "location and various information regarding work zones as posted on the public portal" (http://511ia.org/), and the crash database, MMUCC 4, "compliant and contains fields suggested by MMUCC 4". The MUCC 4 includes work zone related activity, location, type, workers present as well as other MMUCC 4 crash data elements that would be collected for any crash such as location, weather conditions, and time of day. These data are widely available through various resources, analytical tools, and downloads. The online crash analysis resource (web-SAVER) currently under development (https://saver.iowadot.gov/) is available to anyone with internet access and work zone data can be queried. There is very little challenge in maintaining the data. The process is "essentially smooth," with planned further enhancements to speed up the data update.

For each Smart Work Zone System, MassDOT requires some of the sensors used to support the collection of Speed, Volume and Occupancy Data on a lane-by-lane basis. This data is required to be provided to them in 5-minute increments for their eventual storage into a Data Warehouse. The Data Warehouse will allow for them to calculate work zone capacity and produce performance measures to meet the FHWA WZS&M Rule requirements.

The Oregon DOT has developed a work zone ITS platform connecting traffic data warehouse (the PORTAL system) and work zone records. Although the delay is qualitatively judged and unavailable for most of the projects, it can serve as a best practice for such application, and collaboration between state DOTs and research institutes.

Centralized Lane/Highway Closure System

Wisconsin Lane Closure System (WisLCS, http://transportal.cee.wisc.edu/closures/) serves as a comprehensive management and reporting system for all highway (State, US, and Interstate) lane closures and restrictions statewide. Operational since April 2008, the WisLCS facilitates work zone acceptance and monitoring at the WisDOT Statewide Traffic Operation Center (STOC) and regional transportation offices, provides real-time lane closure information to the Wisconsin 511 traveler information system, and supports WisDOT Oversize / Overweight permitting activities for approximately 10,000 work zones per year.

Work Zone Traffic Control

NCDOT is collecting "wait time" information at random work zones where flaggers are controlling the traffic. They will begin "connecting" some of our Interstate/Freeway work zones in 2017. This involves instrumenting the flashing arrow boards to transmit information about location, direction and which lane is closed. This information will be collected by data aggregators such as HERE, WAZE and Google Maps to provide this real-time information to motorists via Navigation systems and cell phone.

Oregon DOT has established policies that require highway projects to minimize disruption to free-flow traffic. Expected delays are mitigated where possible by changing working hours or building temporary capacity. Where delays are unavoidable, extensive coordination with freight stakeholders is required by agency policies.

3.8 Challenges for Work Zone Data Collection

Although the agencies are generally satisfied with the current work zone data collection practices (Figure 10), there are lots of improvements needed and challenges to overcome towards better work zone data collection.

Lack of a uniform data collection mechanism
A standard approach, format and a central data warehouse to store the information and report from are something needed. Currently, agencies use a few standards to guide their practices of work zone data collection, including Model Minimum Uniform Crash Criteria (MMUCC), Model Inventory of Roadway Elements (MIRE), and Purdue Signal Metrics. Agencies use MMUCC for crash reporting which includes appropriate fields for work zones; MIRE is for the roadway inventory which can help work zone location data and mapping capability; Purdue Signal Metrics, which is primarily for traffic signal performance, includes expected utility in analyzing corridor performance, including for work zone analysis. The problem is that those standards are designed for other applications not specifically for work zone data, and only cover a portion of data needs for work zone applications.

There is a lack of understanding of most effective way to collect, visualize, and assess work zone data. One suggestion from the agencies is that the most successful pathway to work zone data collection and reporting will be developed by FHWA. Having a clear target that is based on best practices will make efforts to standardize and expand work zone data collection far easier.

Institutional barriers
There are usually different sources for work zone data across different sections and agency branches. Overcoming the institutional inertia and bringing construction offices into a new standard for data collection is not very difficult and reasonably achievable. However, construction contracts only account for roughly half of the work on highways. Between maintenance operations, local agencies, and utility companies, significant work is performed on highways. For most states, there are many working units involved, and often the goals and duties of these units do not overlap. Work zone data can be tricky to collect and timely updated. The effort required to develop and enforce policies that require those parties to participate in data collection and sharing can be “daunting”. A designated unit to collect and distribute all relevant data would be desirable.

Lack of Resources
It is noted by agencies that there is lack of available storage, lack of resources to collect data on a state-wide basis, and lack of personnel to analyze all the data collected, and to maintain consistency of reported information and timeliness.

CHAPTER 4 WORK ZONE DATA RELATED APPLICATIONS

This chapter is about the value of work zone data, how work zone data is used, and how work zone data supports various applications.

4.1 Types of Applications

Among applications using work zone data, 511/Traveler Information, Traffic Operations/Traffic Management Center, and Lane Closure System are most popular, as shown in Table 2.

Table 2. Applications using work zone data

Application Type	Counts
511/Traveler Information	14
Oversize/Overweight Freight Permitting	8
Traffic Operations/Traffic Management Center	11
Social Media Feed	9
Planning/Project Delivery	5
Lane Closure System	10
Transportation Management Plan (TMP)	8

Regarding work zone data elements used in those applications, a summary from the narratives is shown in Table 3 and Table 4.

Table 3. Work zone data elements used

Data Type	Counts
Lane closure/Detours	14
Height/weight/width restrictions	5
Project information	9

Table 4. Work zone data elements used

Data Type	Counts
Twitter/Facebook/website information	3
Incidents/Crashes	5
Road Status/Congestion information	5
Weather	2
Special Events	2

In addition to the basic lane closure/detour information, it is clear that work zone restrictions have been used for freight permitting. Project information is also frequently used.

Although it is somewhat unrelated to what has been asked, it is interesting to see that there are additional "data elements" mentioned by agencies, as shown in Table 4. Those "data elements" in Table 4, which are not work zone data but only related, indicate additional data sources used in those work zone applications.

4.2 Performance Measures

Work zone performance measures are essential for work zone assessment and monitoring, and the building blocks for most work zone related applications. In this survey, how and what performance measures agencies generate about work zone mobility/operations, safety, and project management were investigated.

For performance measures about mobility/operations, agencies typically generate work zone associated delay, queue length, and speed drop. One example is work zone mobility reports, the volcanogram, used by Ohio DOT. The Ohio volcanogram report includes graphs representing the number of hours in which the traffic speeds dropped below 35 mph in a work zone, or on either side of it. There are also efforts to extend the reports a few miles on either side of the work zone to provide an overall review by including work zone impacts propagated to upstream and downstream, outside of the normal work zone length. There are also monthly views to compare across different months and compare the same month across different years for the 2 years prior to construction beginning. The volcanogram provides a good indication for traffic speed before and after work zones are in place, and also gives a general idea of a delay "pattern" of the work zones. If there is a sudden change in one month, the work zone Traffic Managers can look into it more closely to determine if there is any issue or shift in configuration. In this way, informed decisions can be made.

Another example is about using new traffic data sources, such as probe data, for work zone assessment. A probe based national data set of average travel times has been acquired by FHWA and made available to States and Metropolitan Planning Organizations (MPOs) to facilitate their

performance measurement, which is named National Performance Management Research Data Set (NPMRDS, https://ops.fhwa.dot.gov/freight/freight_analysis/perform_meas/index.htm). Some states are using or investigating this data sources for work zone mobility assessment.

For safety performance measures, the majority is about crash data collection and statistics, which is based entirely or mostly on police crash reports. One agency reported to be at the beginning stages about safety performance, utilizing Tableau and researching other products. It is also worth noting that crash data could be particularly difficult to secure due to strict data privacy laws in some states. For performance measures regarding project management, construction on-time and on-budget are generally used. Some agencies are currently establishing performance measures in this category.

Additional and more comprehensive performance measures and assessment are being conducted by agencies too, such as the speed comparison "before/during" studies once a work zone speed limit is enacted. However, it is still quite common that not a lot is being done after the stage of plan letting, and for some agencies most analysis is only in the scoping process. In addition, very little aggregation of work zone performance throughout some agencies are generated. Fortunately, agencies have acknowledged this shortcoming, and there are efforts towards department-wide performance measures.

Table 5 and Table 6 show the level of efforts to generate those performance measures, and the reporting frequency, respectively.

Table 5. Level of effort of pm generation

PM Data Type	Low (a few hours)	Medium (one day or two)	High (three days to a week)	Very High (more than a week)	Total
Mobility	0	1	0	1	2
Safety	0	2	0	2	4
Project Management	1	0	1	0	2

Table 6. Reporting frequency of pm

PM Data Type	Real-time	Monthly	Quarterly	Annually	Other	Total
Mobility	1	1	0	0	1	3
Safety	1	1	0	3	0	5
Project Management	0	1	1	1	0	3

Although there are a limited number of responses, the results echo with the previous findings with the high level of effort.

The level of effort to generate safety and mobility performance measures appear to be high, due to both the higher reporting frequency and higher data collection effort. Project management performance measures is relatively easier to obtain since they are already covered by the project management personnel as a long history practice.

4.3 Data Integration

Data integration is a critical step for further work zone analysis. Table 7 and Table 8 shows the status of work zone data integration methods and the level of effort with different types of data.

Table 7. Data integration status

Data Type	Case by case or manual	Established process	Automated process	Total
Crash	4	1	1	6
Traffic	3	0	1	4
Pavement condition / weather	3	0	1	4
Transportation Management Plans (TMPs)	2	2	1	5

Table 8. Level of effort for data integration

Question	Low (a few hours)	Medium (one day or two)	Very High (more than a week)	Total
Crash	2	1	1	4
Traffic	0	2	0	2
Pavement condition and weather	0	1	1	2
Transportation Management Plans (TMPs)	0	1	2	3

It is clear that those data integration practices are generally done case by case or manually, and therefore the level of effort for data gathering generally needs a few days of work or more, not to mention large-scale studies across several years and long stretches of roadway.

4.4 Best Practices for Work Zone Data Applications

Comprehensive analysis to show work zone delay patterns
The Ohio work zone mobility reports, the volcanogram, includes graphs representing the number of hours in which the traffic speeds dropped below 35 mph in a work zone, or on either side of it. There are also efforts to extend the reports a few miles on either side of the work zone to provide an overall review by including work zone impacts propagated to upstream and downstream, outside of the normal work zone length. There are also monthly views to compare across different months and compare the same month across different years for the two years prior to construction beginning. The volcanogram provides a good indication of traffic speed before and after work zones are in place, and also gives a general idea of a delay "pattern" of the work zones. If there is a sudden change in one month, the work zone Traffic Managers can look into it more closely to determine if there is any issue or shift in configuration, etc. In this way, informed decisions can be made.

Leverage emerging data sources
New data sources are becoming available and accessible for work zone applications. A probe based national data set of average travel times has been acquired by FHWA and made available to States and Metropolitan Planning Organizations (MPOs) to facilitate their performance measurement, which is named National Performance Management Research Data Set (NPMRDS, https://ops.fhwa.dot.gov/freight/freight_analysis/perform_meas/index.htm). Some states are using or investigating this data sources for work zone mobility assessment.

Traffic Impact Mitigation
MassDOT have just recently completed their Smart Work Zone Concept of Operations that will help planners and designers determine if the use of Work Zone ITS can be leveraged to mitigate the traffic impacts associated with construction/maintenance projects.

WisDOT has been utilizing a statewide Transportation Management Planning System. CTDOT is working on developing Regional TMPs (Projects Coordination) to help mitigate major traffic impacts from project to project within one geographical area.

For Oregon DOT, the most successful processes require those working at the work zone locations to report all desired information, since currently attempting to pursue project-specific information from a central office is nearly impossible. They also acknowledge that robust policies that require the data to be centralized are critical.

4.5 Challenges for Work Zone Related Applications

The discussion regarding challenges collected from the survey is summarized as below. It is interesting to see that some of the challenges echo with the ones regarding work zone data collection from the previous chapter. Obviously, there are some universal challenges for work zone data management as a whole.

Lack of resources

It is clear that how to fully leverage the collected work zone data for various mobility and safety applications requires a huge amount of workforce, time and funds, but some states do not have sufficient resources to pursue all the goals they have envisioned.

Difficulties in collecting and managing related data

There are quite a few types of data related to work zones that require collection for various applications, such as traffic detection and crashes. For example, one response mentioned, “it is difficult to collect reliable crash data in work zones as to whether it was work zone related or not.” A centralized data warehouse could be greatly helpful. However, it could also be challenging to break the intra- and inter-institutional barriers, for example, “getting approval for the work zone data warehouse needed to support real-time performance measure reporting (dashboard) and the creation of a public-facing map interface.”

Work zone data scattered in various entities

There are many different working units involved, and they collect different portions of work zone data since the goals and duties of these units do not overlap. Such application causes difficulties in data management for work zones and related data sets. As one of the states suggests, “Ideally, there would be a designated unit to collect and distribute all relevant data.”

CHAPTER 5 WORK ZONE DATA SHARING

This chapter is to investigate how work zone data is and can be shared with other stakeholders, including researchers, analysts, and other state agencies.

5.1 Data Requests

As an important data set used for different purposes, agencies are receiving data requests for work zone data by different entities, from divisions within the agency, to federal agencies and external research institutes. The requests are mostly from within the agencies, followed by the state and research institutes/universities. Most state DOTs receive requests from their agencies quarterly or annually.

Table 9 and Table 10 show the request frequency and the sources, respectively.

Table 9. Request frequency

Requests From	Daily	Weekly	Monthly	Quarterly	Annually	Total
Within your agency	0	1	1	4	3	9
Within the state	1	0	1	1	1	4
Federal government	0	0	0	0	3	3
Research institutes/universities	0	1	0	1	2	4
Others	1	0	0	0	1	2

Table 10. Level of effort to meet the requests

Requests From	Low (a few hours)	Medium (a day or two)	High (three days to a week)	Very High (more than a week)	Total
Within your agency	3	3	2	1	9
Within the state	3	1	0	0	4
Federal government	2	0	0	1	3
Research institutes/universities	2	0	0	2	4
Others	2	0	0	0	2

Most of the requests can be met in the timeframe, and there is no discrepancy in terms of types of requestors. Table 11 shows how quickly agencies can respond to work zone data requests.

Table 11. Timeliness to meet the requests

Requests From	Always	Most of the time	Slightly delayed	We don't have all the data they ask for	Total
Within your agency	2	4	2	1	9
Within the state	2	2	0	0	4
Federal government	2	0	0	0	2
Research institutes/universities	2	1	1	0	4
Others	2	0	0	0	2

Table 12 shows the status of policies to address work zone data requests.

Table 12. Agency policy to address work zone data requests?

Answer	%	Count
Yes, and it works very well.	7.14%	1
Yes, but it needs some improvement.	14.29%	2
No, but we are developing one.	0.00%	0
No, but we plan to develop one	7.14%	1
No.	71.43%	10
Total	100%	14

Most of the agencies (10/14) do not have a policy and do not plan to develop one. Two agencies have a policy but need to improve it. Only one of them have a policy that works well and don't need any immediate improvements.

It is worth noting that the agencies may not have any specific policy for work zone data requests, but there is usually some general "policy" to guide the practice, and some agencies are taking an effort to develop a Data Governance Policy that can be applied to work zone data requests.

5.2 Automated Work Zone Data Sharing

Automated work zone data sharing between systems is one of the building blocks for real-time applications, such as for advanced traveler information systems (ATIS), advanced traffic management systems (ATMS), and Integrated Corridor Management (ICM) systems. Figure 11 shows such use instances among agencies.

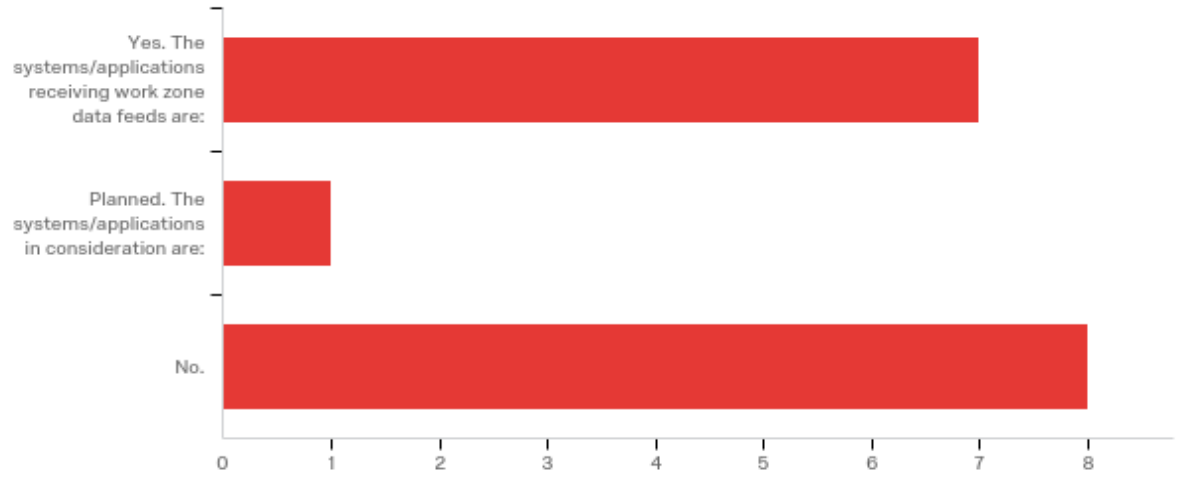

Figure 11. Automated work zone data transmission applications

Almost half of the agencies have implemented automated work zone data sharing with external systems. Those external systems include 511 traveler information systems, freight permitting, ATMS, HERE Map and ICAMS. In Wisconsin, the work zone data is shared through a centralized work zone management system with statewide 511 system and used for freight permitting in almost real-time. MassDOT has evaluated this capability but have put this on hold until their new Statewide Integrated Transportation Management System (ITMS) is operational in two years.

5.3 Best Practices for Work Zone Data Sharing

For Caltrans, their Lane Closure System disseminates construction information to QuickMap, Commercial Wholesale Web Portal (CWWP), Performance Monitoring System (PeMS) and Caltrans Highway Information Network. The Commercial Wholesale Web Portal (CWWP) is designed to assist commercial and media Information Service Providers (ISPs) requesting and receiving traveler information generated by the California Department of Transportation. The data exchange is based on the Traffic Management Data Dictionary (TMDD), which works well for data sharing with third parties.

Wisconsin Lane Closure System (WisLCS, http://transportal.cee.wisc.edu/closures/) serves as a comprehensive management and reporting system for all highway (State, US, and Interstate) lane closures and restrictions statewide. The WisLCS provides real-time lane closure information to the Wisconsin 511 traveler information system, and supports WisDOT Oversize/Overweight permitting activities.

5.4 Challenges for Work Zone Data Sharing

Based on the survey, the main difficulty for work zone data sharing is about limited resources: the lack of staffing, time, and funding. Work zone data sharing needs to build on top of a robust and effective work zone data collection process, which validates the building of a centralized

work zone database and provides a strong reason for statewide customers to utilize the database. However, work zone data collection needs to be a priority before work zone data sharing is a concern.

CHAPTER 6 CHALLENGES AND RECOMMENDATIONS

This survey shows the achievements agencies have made in quite a lot of aspects of work zone data management; it also shows the challenges existing regarding work zone collection, application, and sharing. There are states leading in building and implementing advanced and modern work zone applications. States want to excel in this area but have other priority issues to address first. Nevertheless, some of the states enthusiastically welcome the efforts in establishing a standard and uniform process to facilitate and streamline their work zone data management, especially at the federal or a state coalition level, and eager to learn from the successful practices of the national community.

6.1 Overall Challenges for Work Zone Data Management

There are several challenges agencies repeatedly mentioned in the survey.

Lack of a uniform data collection mechanism
There is a lack of understanding of an effective way to collect, visualize, and assess work zone data. One suggestion from the agencies is that the most successful pathway to work zone data collection and reporting would be developed by FHWA. Having a clear target that is based on best practices will make efforts to standardize and expand work zone data collection far easier.

Such data collection mechanism should cover both work zone and related data sources, since it is acknowledged that collecting related data sets is not straightforward either. There are quite a few types of data related to work zones that also need to be collected for various applications, but they are usually distributed in different applications, in various formats, updated in different time frames. All those can affect the data completeness and therefore affect timeliness of the essential work zone applications.

Lack of a Uniform Definition for Work Zone Data Elements
Currently, agencies use a few standards to guide their practices of work zone data collection, which are designed for other applications not specifically for work zone, and only cover a portion of data needs for work zone applications. Furthermore, different agencies may use different work zone data format and definition, which leads to difficulties in system interoperability or data sharing between agencies. Take the work zone scheduling type for example. The Michigan DOT defines road maintenance activities into five categories in its *Maintenance Work Zone Traffic Control Guidelines* (Michigan DOT 2007):

A. Long-term stationary: work that occupies a location more than three days.
B. Intermediate-term stationary: work that occupies a location more than one daylight period up to three days, or nighttime work lasting more than 1 hour.
C. Short-term stationary: daytime work that occupies a location for more than one hour within a single daylight period.

D. Short duration: work that occupies a location up to 1 hour.

E. Mobile: work that moves intermittently or continuously.

For the same data element, WisDOT uses a different definition in their WisLCS system:

A. Daily/Nightly: the time of operation occurs on a daily or nightly basis as specified by the starting and ending times per each day within the start and end range.

B. Weekly: the time of operation occurs on a weekly basis as specified by the day of the week.

C. Continuous: continuous operation lasting less than two weeks

D. Long-Term: continuous operation but lasting longer than two weeks.

At the same time, the FHWA has a different definition from their *Manual on Uniform Traffic Control Devices* (FHWA 2009).

Institutional barriers

There are usually various sources for work zone data across different sections and agency branches. For most states, there are many working units involved which are in charge of different elements of work zone data, and therefore it can be difficult to collect and update all the data elements in a timely manner. The effort required to develop and enforce policies that require those parties to participate in data collection and sharing can be "daunting." One of the states suggested creating "a designated unit" within the agency in charge of all work zone relevant data collection and serve as the one-stop-shop for all work zone related data needs.

It is also suggested that agencies should make all data gathered publically available to developers to use and develop private applications to best serve the public. Work zone data sharing requires collaboration with public agencies, contractors, and third-party vendors.

Lack of Resources

Some agencies also feel their resources available for work zone data management are insufficient; more personnel, time and funding would be needed to collect, update, analyze and report work zone data and information. In addition to collect the work zone data, how to fully leverage the data to support various mobility and safety applications also requires an enormous amount of resources. However, states sometimes do not have sufficient resources to pursue all the goals they have envisioned.

6.2 Recommendations for Work Zone Data Management

An effective work zone data management strategy includes a standard approach, format and an effective data warehouse, with consideration of various work zone mobility, safety, and data sharing applications. Regarding the challenges and best practices learned from the survey, we would make the following recommendations for work zone data management:

A work zone data management roadmap
Work zone management practices in different states usually have focus areas and are at different development stages. A comprehensive roadmap with guidnance on minimal requirements for various development stages can significantly help all states in building and enhancing their work zone data management capabilities and effectiveness.

A standard for work zone data element definition
A uniform work zone data element definition would ensure data collection completeness and facilitate data sharing among different agencies within and across state borders.

Collaboration of all stakeholders
Different division within the agency, contractors, and vendors are the direct user and first-hand collector of a different portion of work zone data. It is necessary to break institutional barriers and bring all participants together.

Federal and national community support
The resources are limited in individual states, and states have different focus areas and can be on the leading edge of some applications but fall behind in others. Based on the survey, all the states enthusiastically welcome the efforts at the federal or a state coalition level in establishing a standard and uniform process, and eager to learn from the successful practices of the national community.

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APPENDIX: RAW RESPONSES

Figure 12 shows about work zone location data that agencies collect; location data can be collected in more than one format.

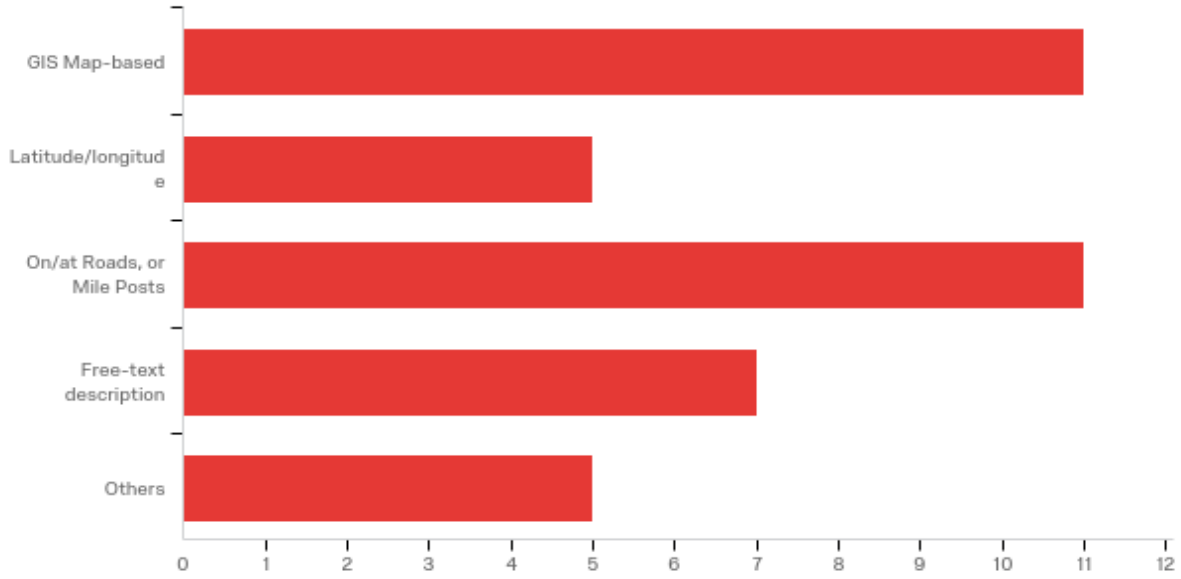

Figure 12. Formats for work zone location data (raw responses)

It is clear that most work zone location data are collected in terms of "GIS Map-Based," or "On/at Roads or Mile Posts." Please note that more than one selection is possible, and most states use more than one location description. Two most widely used supplemental location description are "Latitude/longitude," and "Free-text description."

In the Others category, the raw responses were:

- I collect all of the data above from WisLCS except for GIS map-based data.
- District, Route, Post Mile, Direction, Facility type, # of lanes, County, City
- Work Zone Location information is identified on Google Maps and free text descriptions identify the project and general conditions
- Generally, work zones are only tracked by the highway mileposts associated with the construction contract.

Work Zone Time represents the period and repeating intervals of the work zone. A summary of the raw responses is shown in Figure 13.

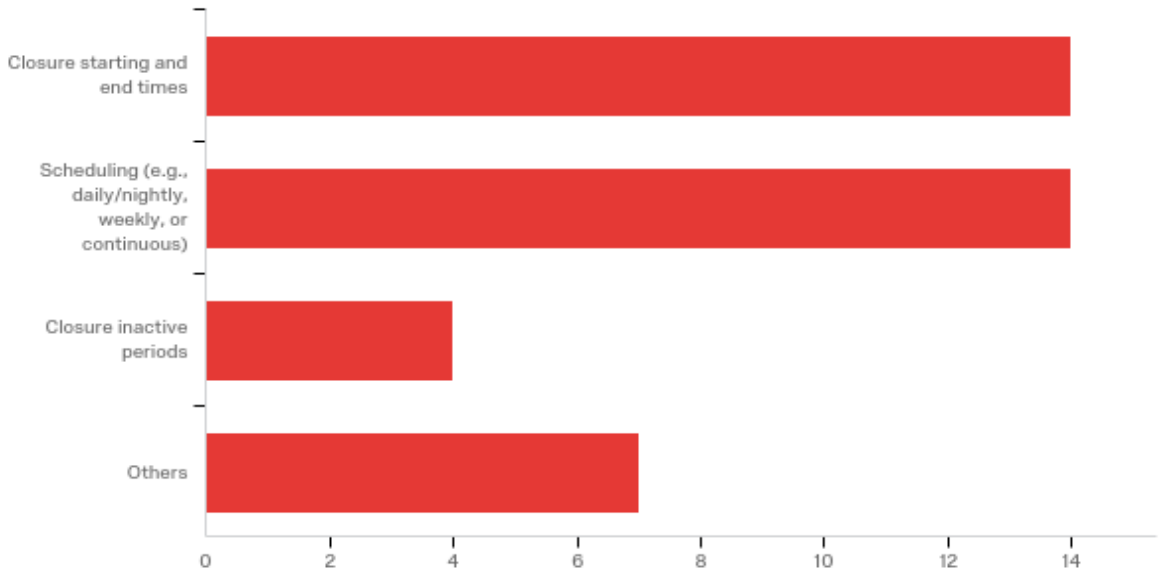

Figure 13. Work zone time data collected (raw responses)

For the Others cases, the raw responses were:

- All of the above.
- All of the above.
- Closures requested by, approved by, statused by, actual start/end time on continuous basis.
- Not applicable
- None
- Scheduling data is not available on the Traveler Information System
- Each construction project's specifications indicate acceptable hours for lane closures. Tracking actual closures are tracked by individual construction offices and not centrally available.

Work zone lane configuration represents the lane details of a work zone. A summary of the raw responses is shown in Figure 14.

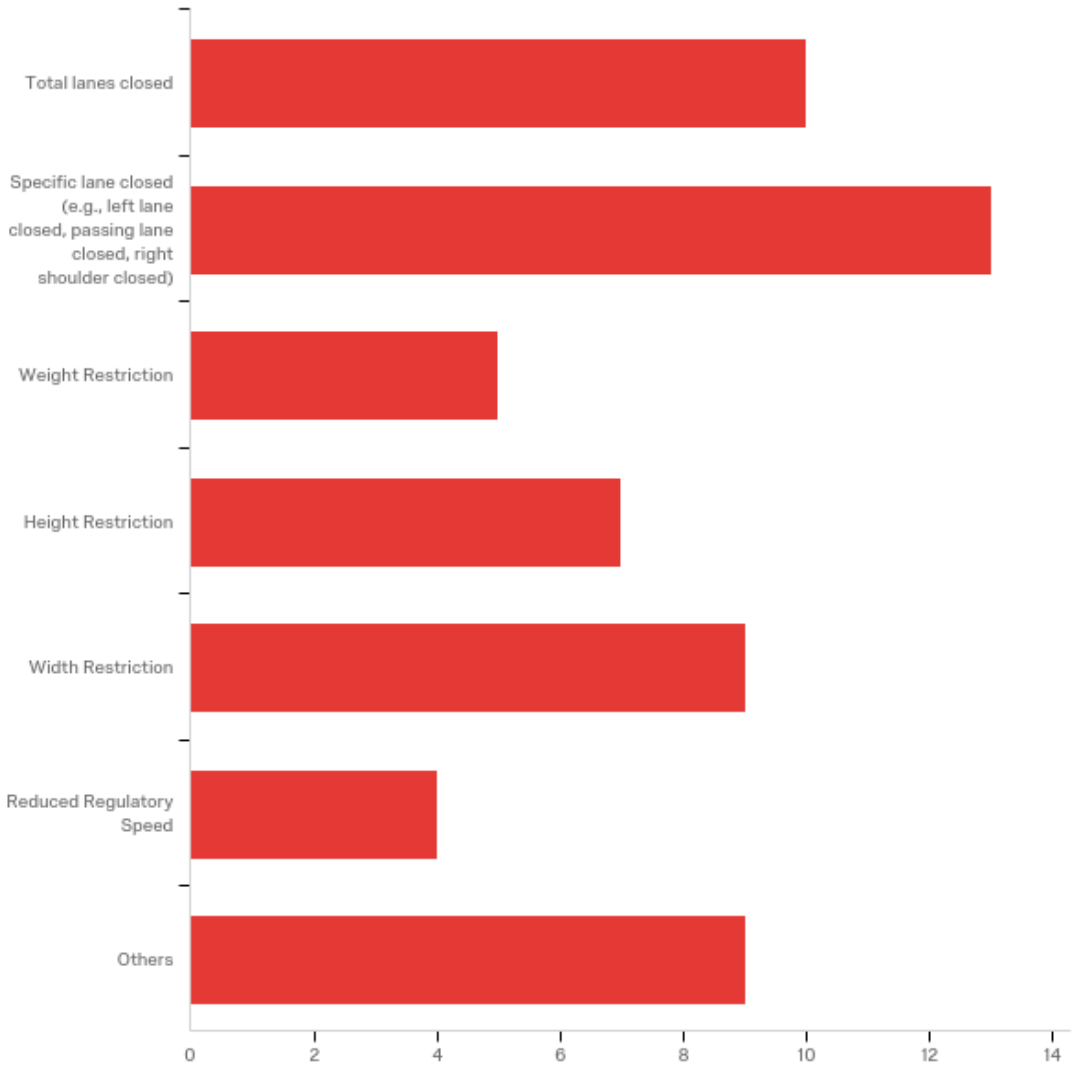

Figure 14. Lane configuration data (raw responses)

For the Others cases, the raw responses were:

- We are looking at adding Height and Width restrictions to the reporting
- All of the above except for reduced regulatory speed.
- All of the above except for reduced regulatory speed.
- The information includes the purpose of the project and what type of work will be performed.
- Not applicable
- Road Closure information is available on the Traveler Information Management Site, but real time lane closure information is not.
- Oregon has a robust process for communicating restrictions for freight permitting. Regulatory speed reductions are processed centrally and managed in a searchable database.
- Travel Speeds

Work zone traffic control is about traffic control methods that can be recorded in those data sources from those states, as shown in Figure 15.

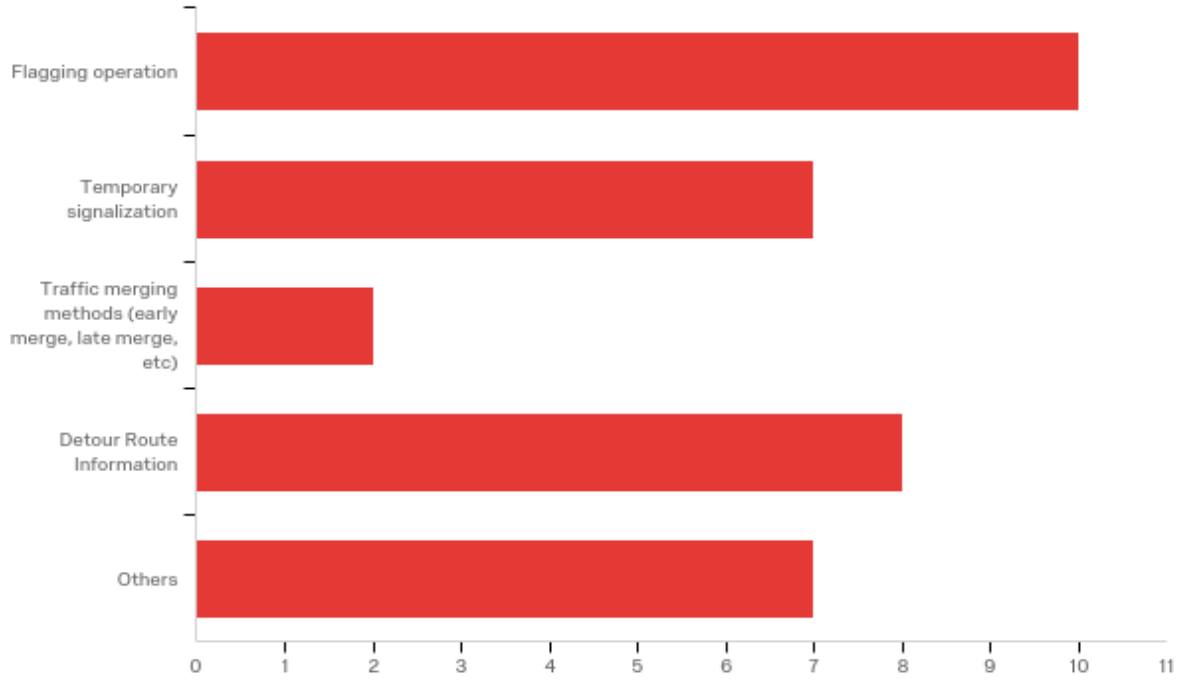

Figure 15. Traffic control types (raw responses)

In the Others category, the raw responses were (note that not all of them provided narrative):

- The information includes the purpose of the project and what type of work will be performed.
- Traffic control and safety information is not collected with our systems.
- None of the above detail.
- Traffic Control/Safety Method information isn't available on the Traveler Information System

Figure 16 shows the database systems used to archive how work zone data in those states.

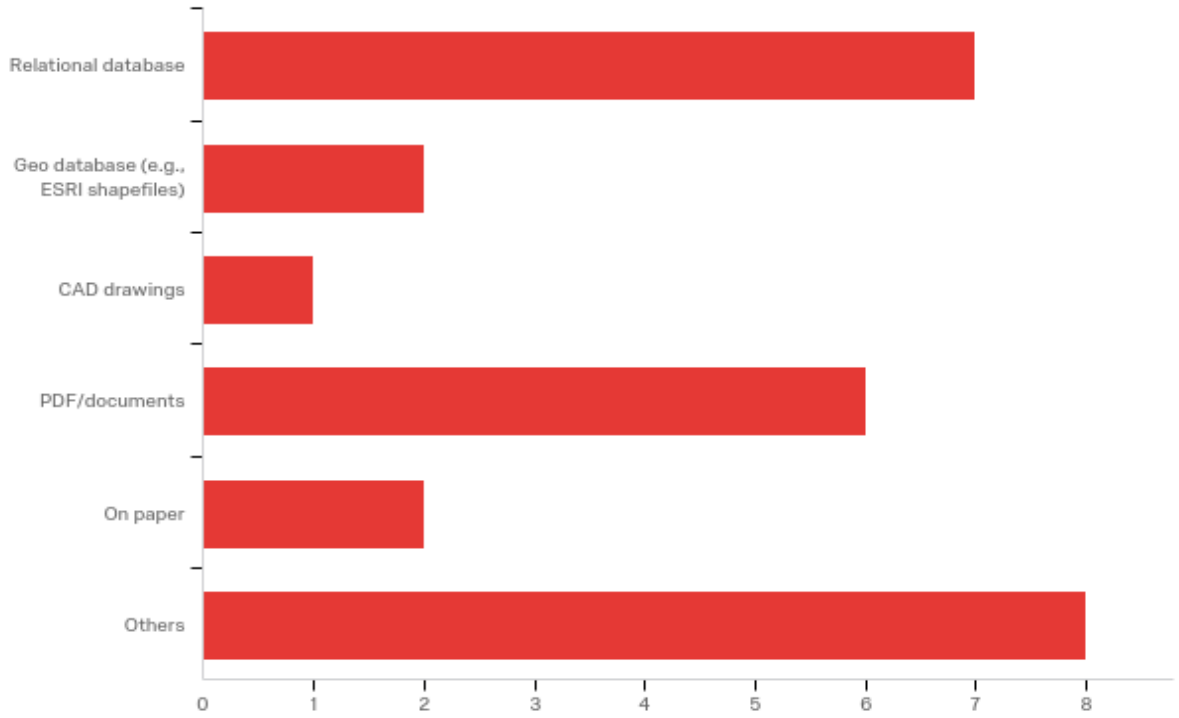

Figure 16. Database used for work zone data storage (raw responses)

For the Others cases, the raw responses were (note that not all of them provided narratives):

- WisLCS data is automatically transferred from WisLCS to WisDOT's Superload OSOW routing system.
- In our ATMS for publication on our website
- Spreadsheets
- ATMS Platform
- The work zone reviews are summarized in a formal report. Remaining data is available on an ad-hoc basis