Developing a Research-Grade Iowa Work Zone Database

Final Report
December 2020

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16. Abstract

Accurate work zone data are a challenge that all agencies face. Agency staff that want to be proactive in their work zone management are limited by the accuracy of their work zone data and are looking for ways to improve the methods of collecting their data. In Iowa, as well as most other states, work zone data are manually collected using forms or lane closure planning systems. This works well for planned work zone data but is not ideal for collecting actual work zone data from the field where the work zones are actually located and when and where lanes are closed.

Improvements to this process should collect better data without any additional undue burden on field staff or contractors by using connected temporary traffic control devices (cTTCDs) to supplement the planned work zone data with verified location and time data.

The Federal Highway Administration (FHWA) Work Zone Activity Data (WZAD) Framework and Data Dictionary were invaluable resources in identifying and establishing the data elements needed for a research-grade work zone database. The FHWA WZAD Data Dictionary was used to develop the database structure by understanding the relationships between all of the data frames and data elements. An entity relationship diagram was created to show these relationships and identify the similar data elements for the various tables in the work zone database.

With the database established, a process was developed for archiving work zone data by integrating planned 511 work zone data with data from smart arrow boards deployed in Iowa. The smart arrow boards allow for verified coordinates and times to be included in the work zone database for greater confidence in the accuracy of the data.

The archival of the work zone data is a two-fold process that is scheduled to run every five minutes and update the work zone database with any new work zone information. Part 1 of the process cleans the existing 511 field data and formats it to match the fields and data enumerations from the WZAD Data Dictionary. Part 2 takes the output from Part 1 and integrates the cTTCD data from another existing process based on the Iowa DOT's linear referencing system.

This research identified challenges with integrating cTTCD data with planned work zone data and also identified a variety of data elements that the Iowa DOT could begin collecting in the future. The current work zone database should be viewed as a starting point and should be expanded in the future as other data become available or improved methods of collecting data are added.

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DEVELOPING A RESEARCH-GRADE IOWA WORK ZONE DATABASE

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December 2020

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ACRONYMS, ABBREVIATIONS, AND INTIALISMS

ATIS	advanced traveler information system
ATMS	advanced traffic management system
API	application programming interface
CalTrans	California DOT
cTTCD	connected temporary traffic control device
DE	data element
DF	data frame
DOT	department of transportation
FHWA	Federal Highway Administration
HTTP	hypertext transfer protocol
IOO	infrastructure owner and operator
ITIS	International Traveler Information System
ITS	intelligent transportation system
LRS	linear referencing system
MnDOT	Minnesota DOT
PLCS	permitted lane closure system
RAMS	Roadway Asset Management System
RCE	resident construction engineer
SABP	smart arrow board protocol
TCD	traffic control device
TMC	traffic management center
TMDD	Traffic Management Data Dictionary
TPEG	Transport Protocol Experts Group
URL	uniform resource locator
WisDOT	Wisconsin DOT
WZAD	Work Zone Activity Data
WZDB	work zone database
WZED	Work Zone Event Data
WZDI	Work Zone Data Initiative
WZDS	work zone data system
WZDx	Work Zone Data Exchange
XML	extensible markup language

EXECUTIVE SUMMARY

Problem Statement

Accurate work zone data are a challenge that all agencies face. Agency staff that want to be proactive in their work zone management are limited by the accuracy of their work zone data and are looking for ways to improve the methods of collecting their data.

Background

In Iowa, as well as most other states, work zone data are manually collected using forms or lane closure planning systems. This works well for planned work zone data but is not ideal for collecting actual work zone data from the field where the work zones are actually located and when and where lanes are closed. While a variety of standards that include work zone data are available, there is no concurrence among states on the data that should be included in a work zone database (WZDB).

Objectives

This research served to achieve the following objectives:

- Define relationships between a potential work zone activity monitoring system and relevant Iowa Department of Transportation (DOT) business processes. An important aspect of this was how to effectively implement a WZDB without creating an undue burden on Iowa DOT construction engineers and inspectors.
- Identify desired data entry methods, e.g., laptops, smartphones, connected devices.
- Identify any components of this system that can be adapted from existing open-source software platforms.
- Develop a plan for integrating the WZDB with the future Iowa DOT Permitted Lane Closure System (PLCS) and its 511 system.
- Develop a prototypical process for archiving work zone data.

Research Description and Findings

To develop a research-grade WZDB, the current data collection method needed to be understood first to determine what and where data can be collected, in addition to identifying improvements to existing collection methods. The current process of collecting work zone data in Iowa was documented, including the various ways to input work zone data, as well as the systems that are using the data. Additionally, any issues with the process were documented, including accuracy and the need for a research-grade WZDB.

As part of understanding the process and working with the Iowa DOT, it was identified that field staff and contractors are not ideal sources for collecting work zone data, because field staff and contractors are primarily focused on controlling work activities and can introduce human error in collecting data. The agency is also sensitive toward placing additional burden on inspection staff to collect these data.

In lieu of a mobile application to collect work zone data, the Iowa DOT focused on other methods of collecting the most critical elements of a work zone, which are location and time. Connected temporary traffic control devices (cTTCDs), like smart arrow boards, are available in the market today and can be used to collect work zone location and time information. The combination of the planned work zone data that are already input by users and the cTTCD data should be included in the WZDB.

There are currently no reference guides or agreed upon standards available to provide insight toward digitally describing and communicating the dynamic work zone activities that take place on roads and highways. However, multiple standards exist in the area of traffic management, which can be used to gain insights into the critical information that is needed for a research-grade WZDB.

The Federal Highway Administration (FHWA) Work Zone Activity Data (WZAD) Framework and Data Dictionary were ultimately used to identify the data elements that are needed for a WZDB given that they comprehensively cover all aspects of a work zone including the data requirements. Additionally, the Work Zone Data Exchange (WZDx) was used to identify any additional data elements that should also be included in the WZDB. Identifying the data elements in the WZAD Data Dictionary allowed for an entity relationship diagram to be developed showing the relationship between all data elements for the WZDB. Slight modifications were made to adapt the data dictionary to Iowa for better integration with other data sources within the Iowa DOT, including representing mileposts as linear referencing measures and also including the route identifier for the linear referencing system (LRS).

Once the data elements were identified, the structure of the WZDB was established, including the following seven tables:

- SubTask table
- Recurring table
- Restrictions table
- SubTask Activity table (future data collection)
- SubTask Intersection Location table (future data collection)
- SubTask Advanced Warning table (future data collection)
- Detour Path table (future data collection)

All of the tables are related based on the wZ-SubtaskID. Three of the tables include data that is currently collected, while the remaining four tables are for future use, representing the items that are not currently collected by the Iowa DOT.

The SubTask table contains the majority of critical work zone information. The subtask identifier is used instead of the task identifier because the WZDB represents the individual lane closures that occur throughout the state. All of the lane closures can be summarized up to a higher level representing the entire work zone project.

With the database structure established, a process to begin populating the database with work zone data was developed. The archival of the work zone data is a two-fold process that is scheduled to run every five minutes and update the WZDB with any new work zone information.

Part 1 of the process cleans the existing 511 field data and then formats it to match the fields and data enumerations from the WZAD Data Dictionary. The data are also conflated to the Iowa DOT's LRS to extract additional data elements needed for the WZDB that are not currently collected, including the total number of lanes and the facility type.

Part 2 of the process takes the output from Part 1 and integrates the cTTCDs from another existing process based on the LRS. The data from the cTTCDs can then be used to populate the verified location and time data elements.

Given that all of the 511 work zone and cTTCD data are processed every five minutes, not all of the data should be archived in the WZDB since most data are likely redundant. Instead, the process compares the final results with the data in the work zone database to identify if the final data represents a new work zone or includes updates such as verified location and time. These final data can then be used to update the work zone database while the other redundant data are discarded. The process results in a populated work zone database that includes verified coordinates and time, which will provide confidence for users on the accuracy of the work zone data.

Conclusions

The establishment of a WZDB is an initial step in improving the work zone data collected in Iowa. This research identified the current process of collecting work zone data and established the WZDB without any additional undue burden on field staff or contractors by using cTTCD data to supplement the planned work zone data with verified location and time data. This eliminated the need for a data entry screen and instead relied on the smart arrow board protocol developed by the Iowa DOT.

The FHWA WZAD Framework and Data Dictionary were invaluable resources for identifying and establishing the data elements needed for a WZDB. The Work Zone Plan Dissemination to Third Party Data Providers use case identified in the data framework became the foundation for developing the WZDB in Iowa.

The FHWA WZAD Data Dictionary was then used to develop the database structure by understanding the relationships between all of the data frames and data elements. An entity relationship diagram was created to show these relationships and identify the similar data elements for the various tables in the WZDB. Implementation of other use cases can follow a similar methodology of using the FHWA WZAD documents as a guide for the data elements needed for the use case.

Finally, the WZDB was developed and in lieu of a data entry screen, and work zone data were archived by integrating the planned 511 work zone data with smart arrow boards that are currently deployed in Iowa. The smart arrow boards allow for verified coordinates and time to be included in the WZDB to provide confidence for users in the future on the accuracy of the location and time for the data.

Implementation Readiness/Recommendations for the Future

The major challenge with the current implementation is the accuracy of the planned work zone data that are entered into the 511 system. The Iowa DOT is currently developing the requirements for its PLCS that should improve the accuracy of the planned work zone data and remove redundant work zones that are entered into the 511 system. Having redundant work zones causes ambiguity when relating the work zone to the cTTCD data that should be eliminated.

Various data elements are also not collected in the current 511 system that should be included in future systems by the Iowa DOT, if deemed necessary. These include the contract number, the reduced speed limit, worker presence, the work zone separation type, and the temporary traffic control standard that is used (i.e., TC-421, TC-418).

The current WZDB should be viewed as a starting point and should be expanded in the future as other data become available or improved methods of collecting data are added.

INTRODUCTION

Background

The difficulty in obtaining detailed information about current and historical work zone activities limits the ability to proactively manage work zones. Although project plans and daily construction logs provide general information about the locations and timing of planned and completed work activities, actual conditions in the field often change very rapidly—and sometimes several times each day.

A planned lane closure can be advanced or delayed by minutes, hours, or days based on factors such as weather; the availability of specialized personnel, equipment, or materials; or the effects of a traffic incident near the work zone. In many cases, these work schedule changes interact with real-time changes in traffic conditions and with adjustments to the work tasks to be accomplished. For example, if a key piece of equipment, such as a crane or paving machine, breaks down, workers can be redeployed to another work area (or even another project) while the machine is being repaired, resulting in very different traffic impacts compared to those for the work that was scheduled.

The Federal Work Zone Safety and Mobility Rule requires states to "continually pursue improvement of work zone safety and mobility by analyzing work zone crash and operational data from multiple projects to improve State processes and procedures." Nevertheless, important details, such as the location and extent of lane closures, are generally not tracked in real time. As a result, it can be very difficult to quantify relationships between work activities and traffic flow rates, queuing, delay, and road user safety. These difficulties are often evident when comparing existing 511 system data to actual use and when conducting a post construction analysis.

Another complication is that small highway maintenance projects (such as replacing a knocked-down traffic sign) are often tracked through task-order systems separate from those used for major construction activities. This is compounded by the difficulty of identifying projects done by counties, municipalities, and private utilities, which potentially overlap with state highway construction to create concurrent impacts at multiple points along a route, or on multiple routes that serve the same destination.

A few jurisdictions have developed advanced data management systems for tracking lane closures, utility permits, and other work activities. These systems provide extraordinary benefits for performance monitoring, assessment, and inter-agency communication but require a considerable amount of software development.

The Iowa Department of Transportation (DOT) is exploring the development of a permitted lane closure system (PLCS). The PLCS will be an important step toward more proactive work zone management. The concurrent development of a research-grade work zone database (WZDB) can augment the PLCS by providing additional details about work activities and other factors that influence traffic flow in work zones, including accurate locations and time extents of the work zone as compared to the entered planned activities.

Benefits and Future Capabilities

The integrated development of the PLCS and WZDB offers several immediate benefits and sets the stage for a wide range of possible future capabilities. These benefits and capabilities include the following:

- Improved accuracy for post-project evaluation and analysis, by replacing “passive” data sources such as general project schedules with more-specific “active” information gathered in real-time (or near real-time).
- Improved information about concurrent projects and their interactions.
- Potential integration with 511 and other statewide traffic management systems through automated data feeds. This can, for example, provide traffic management center (TMC) operators with advanced notice of planned road work, along with information about the status of current work zones (i.e., active, overrunning, completed, or cancelled).
- Potential automated dissemination of road work status to key stakeholders, such as police, fire, emergency medical services, and TMCs in neighboring states.
- Potential future improvements in communication of work zone status with the public and fleet operators through radio traffic reports, in-vehicle navigation devices, and connected vehicle technologies.

Although related, the PLCS and WZDB address different business needs. As currently envisioned, the PLCS will handle the process of requesting and authorizing a lane or shoulder closure, providing timely notice when the lane or shoulder has reopened, and feeding these data to the 511 system. The WZDB will integrate this information with additional data regarding real time work zone characteristics, such as the beginning and end of work zones, as well as the time the work begins and ends. Thus, it is likely that low-impact work zones (such as mowing) will have an entry in the PLCS but with limited additional information in the WZDB, while high-impact work zones might have a single entry in the PLCS linked to multiple entries in the WZDB that document work configuration and work location changes as the project work progresses.

Project Goals

This project focused on identifying data resources relevant to work zone activity monitoring, determining how the use of such a system relates to existing Iowa business processes, documenting the interactions between the PLCS, the WZDB, and the 511 system from both the business and technical perspectives, and developing a process for monitoring work zone activity.

Objectives

This project included the following objectives:

- Define relationships between a potential work zone activity monitoring system and relevant Iowa DOT business processes. An important aspect of this issue was how to effectively implement a WZDB without creating an undue burden on Iowa DOT construction engineers and inspectors.
- Identify desired data entry methods, e.g., laptops, smartphones, connected devices.
- Identify any components of this system that can be adapted from existing open-source software platforms.
- Develop a plan for integrating the WZDB with the future Iowa DOT PLCS and its 511 system.
- Develop a prototypical process for archiving work zone data.

Since initiation of this project, some of the objectives were adapted to align with improvements in technology and included collaboration with industry and direction from Iowa DOT technical advisory staff. The researchers confirmed that manual entry of work zone data, which introduces human error, is not desirable and that automated systems should be developed to integrate with existing Iowa DOT systems to improve the accuracy of work zone data.

With the goal of having a research-grade WZDB, the consensus was that better methods of collecting active work zone information can be obtained using connected traffic control devices. In addition, the WZDB should align with the Federal Highway Administration (FHWA) Work Zone Data Initiative (WZDI) that was introduced after this project started and incorporated the concept of a WZDB that allows for verified information to be archived into the system.

METHODOLOGY

To develop a research-grade WZDB, the current data collection method needed to be understood first to determine what and where data can be collected, in addition to identifying improvements to existing collection methods. The current process of collecting work zone data in Iowa was documented, including the various ways to input work zone data, as well as the systems that are using the data. Additionally, any issues with the process were documented, including accuracy and the need for a research-grade WZDB.

The process that will be used to improve the accuracy of the work zone data was then identified and aligned with current activities within the Iowa DOT.

Identifying relevant standards is critical to ensure that the correct data are being collected as well as identifying the best standards to communicate this data to others. The WZDI that was developed by the FHWA was a primary focus given the architecture that includes the entire life cycle of a work zone from planning to active work zone to post work zone analysis. This architecture served as a template for developing a research-grade WZDB.

Finally, a process for developing a research-grade WZDB was discussed including how data are currently being archived according the WZDI architecture using connected temporary traffic control devices (cTTCDs) such as smart arrow boards in lieu of a manual data entry screen.

LITERATURE REVIEW

Most agencies have methods, which vary from simple DOT submission forms to a system in which data are electronically input, for collecting planned work zone data. For example, Rhode Island has a report form that is submitted by contractors or DOT maintenance staff to their TMC (Holt and Murthy 2020). The form includes the type(s) of lane(s) closed, direction of travel, location, time, and contact information. Many agencies have similar methods of collecting work zone data that are submitted to their advanced traffic management system (ATMS) or advanced traveler information system (ATIS).

Other agencies also have lane closure systems where planned work zone information must be submitted for approval. For example, the Wisconsin DOT (WisDOT) lane closure system (LCS) is a web-based system where users can create, approve, and track lane closures (WisDOT 2016). This system interfaces with other systems within the DOT such as their 511 system and traffic operations center. The system collects planned information including the number of lanes closed, the location of the closure, the impact times, contact information, and other relevant work zone data for the closure.

The California DOT (CalTrans) has a similar lane closure system, which includes a mobile application that can be used in the field (Caltrans 2017). A training video by CalTrans shows that the mobile application is intended to be used when traffic cones are placed or picked up or if a lane closure is cancelled. Based on the training, it doesn’t appear the location information is collected and only the time when the closure starts, ends, or is cancelled. The mobile application does have time restrictions when each of the statuses can be input, but there is no discussion on the accuracy of the information that is submitted. The Florida DOT District 6 also has a lane closure information system and has plans for a mobile friendly web application, but there is no discussion on what information can be input (Kapitanov et al. 2016).

For all of these systems, basic work zone information is collected, but the data should be considered to be planned information with the exception of the work zone status by CalTrans. Data accuracy is a major issue and is discussed further in the next chapter.

Some agencies have developed mobile applications to improve work zone activity data collection. Azadi et al. (2020) developed a mobile application for real-time work zone data collection in Missouri. The application provides a mobile interface to collect all aspects of the work zone similar to the data collected in other systems including geo-locating the work zone. However, the same challenges exist in the accuracy of the data and the manual input requirement. The current application is a standalone system and the researchers have plans to integrate it with a 511 system.

Location and time are critical elements for any WZDB and are often the most inaccurate. Without knowing the accurate location and time, any analysis using the data may be based on false assumptions that the work zone was active. One of the reasons for the inaccuracies is because the systems are designed for planning purposes and not for operations where the time and location may vary throughout the day.

In addition, the time commitment required to update work zone information is burdensome for field staff that would favor better methods of collecting information like using cTTCDs, which include smart arrow boards, connected pins/panels, connected temporary traffic signals, etc. The market for providing connected location equipment within work zones is growing and is being tested in multiple states including Iowa.

The Minnesota DOT (MnDOT) was the first state agency to begin testing smart arrow boards, in 2018 (Roelofs et al. 2020). A concept of operations was developed that provided details of how these devices would be integrated within the MnDOT traffic management system (Athey Creek Consultants 2018). Some of the details include the vendor providing an application programming interface (API) to access truck-mounted smart arrow board data every two minutes, which the ATMS then uses to create an event. The event created would be a new event and would not be related to any existing events within the ATMS. Although the data were not fully integrated within the ATMS, by associating these data to planned events, the process showed how more accurate work zone location information could be obtained.

Parikh et al. (2019) developed a process of associating traffic control device (TCD) assets in Minnesota to a database of work zones to determine whether the traffic control layout needs to be inspected. The TCD assets are similar in nature to the cTTCDs previously described (reporting their locations and status) but were developed by the researchers and mounted to existing TCDs in the work zone. As part of their processing, assets are associated with projects in what appears to be an automated way but with few available details on how this process was achieved and any limitations in the approach.

The cTTCDs alone do not provide all of the relevant details needed for a research-grade WZDB but have an automated way of collecting the most critical aspects of the work zone, which are the time and location of the closure. The value of these devices is that they should be viewed as sensors/inputs into the overall work zone management system, requiring little to no additional work by field staff to implement. These devices can minimize the amount of human error and the accuracy issues that can be introduced by inputting this information into a mobile application/data entry system.

FINDINGS

Business Process Relationships

Work zone activity monitoring has a wide range of impacts across the Iowa DOT. Activity logging impacts DOT district staff, DOT maintenance staff, inspectors, contractors, statewide TMC operators, and DOT central staff. This chapter describes the current process of collecting active work zone information. It also discusses limitations in the proposed system and areas that can be improved to collect better work zone data in the future.

The Iowa DOT’s 511 website database has become the central repository of active work zone information. Given the 511 website has become a central location for active work zone information on a statewide basis, this section focuses on the flow of work zone data into it and potential issues that can occur.

To be clear, the 511 website is not the only source for work zone data at the Iowa DOT. For example, the Traffic Critical Project Program collects work zone information on selected high-impact projects, but this is not comprehensive and doesn’t align with the concept of having a research-grade WZDB. Because of issues like these, the other work zone data sources were not considered as part of the research-grade WZDB.

Figure 1 provides a summary of the current process of collecting active work zone data within the Iowa DOT.

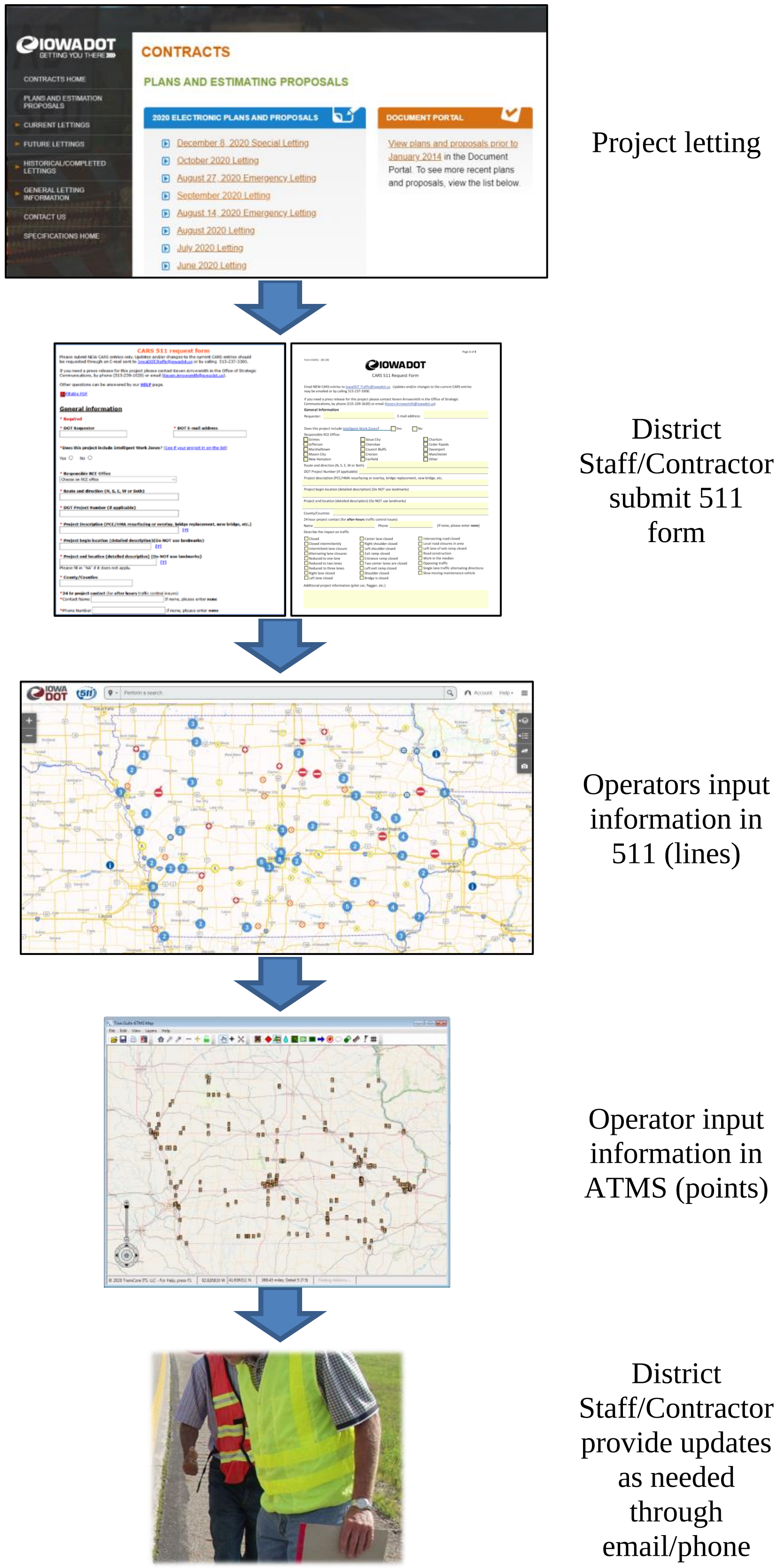


Figure 1. Current active work zone data collection process

The primary method of providing active/planned work zone information after a project is let is through a 511 request form. The 511 work zone request form is shown in Figure 2 and is available here: https://iowadot.seamlessdocs.com/f/Cars511RequestForm.

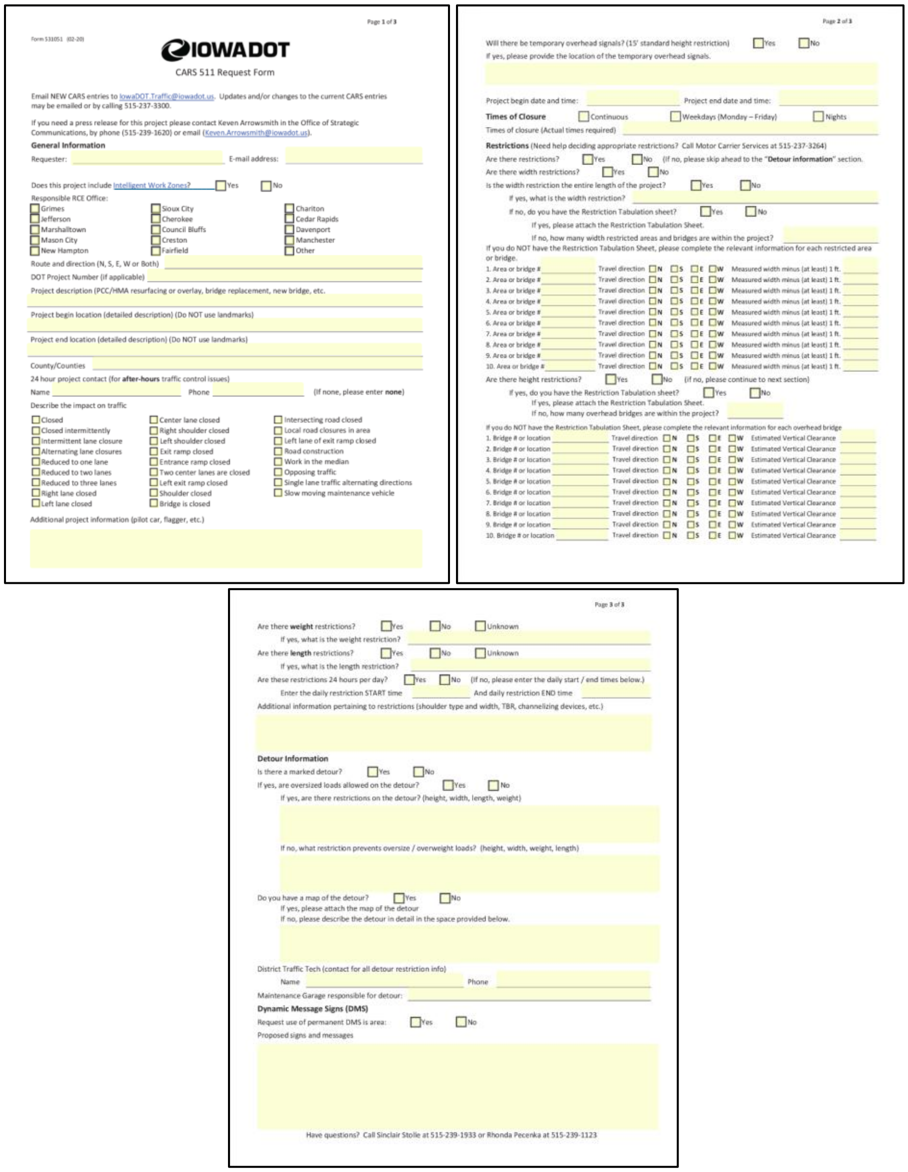


Figure 2. 511 Work zone request form

This request contains information about the work zone including the responsible resident construction engineer's (RCE's) office, the route and direction impacted, a written description of the begin/end locations, impact on traffic, and other details related to the work zone. The Iowa DOT has discussed the development of a lane closure permitting/planning system that would replace the existing form and provide a streamlined method of data entry into the 511 system. The data collected either from the form or from the planning system can be viewed as static data associated to a given planned work zone.

Once received by the TMC operators, the information is entered into 511 and also into the ATMS system. These systems do not currently communicate, and this requires the operator to input the information multiple times. The Iowa DOT is currently implementing a new ATMS/ATIS system planned for December 2020 that will allow the operators to only enter the data once but follow the same procedure for getting work zone information.

After the work zone data are entered by the operators, they rely on communications from field staff on any changes to the work zone or when the work zone has ended. The TMC operators have a procedure to follow up on when work zones are ending to verify that the event should not be extended. The primary issues with this process are the facts that this information requires manual entry and it is not uncommon to have an active work zone on 511 yet no work underway (Figure 3).

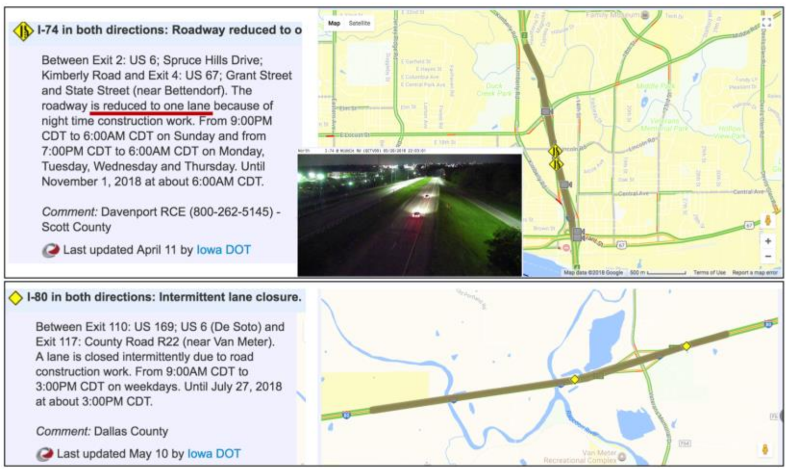


Figure 3. Inaccurate work zone information in Iowa 511

The reasons for not working as entered into the 511 system could be because of weather, equipment delay, or that field staff forgot to update or notify the TMC that the work is completed.

The other challenge with relying on input from the field is the location of the work zone activity. The form for providing work zone information only allows for a description of the begin and end location, which often results in cross streets or mile markers being used that may not be the actual location of where the closure occurs. This location of the work zone may not align with the location in the traffic control plans given slight modification are allowed by traffic control contractors and can result in inaccurate locations provided to the public. Feedback from users has also shown that crews often report the total project work limits or a longer duration than necessary to avoid having to update the data repeatedly.

Field staff, contractors, and inspectors are already overworked and have little desire to require additional information using another form or application. Additionally, issues exist when information is manually input by users even if an application is developed to assist in the process. Because of this feedback, and to align with other projects being completed by the Iowa

DOT, the process to collect active work zone data was focused on connected location equipment within work zones (cTTCDs).

Today’s cTTCDs include smart arrow boards, connected pins, which are placed within traffic cones, and connected vertical panels, which are all common in their function to report both location and status (on/off, arrow pattern, etc.). Additional devices under development include connected flagger poles and temporary traffic signals, and, as capabilities continue to expand, additional efforts are required in consideration of devices that can be connected. The Iowa DOT has already begun this effort by developing a smart arrow board protocol (SABP) and will be requiring projects on interstates to have smart arrow boards starting in 2021.

The collection of active work zone data through these cTTCDs better aligns with the concept of a research-grade WZDB as the location and information can be collected in a timely and accurate fashion rather than by manual entry. The cTTCDs do not provide all of the details about the active work zone but supplement the data that are entered into 511 to provide accurate begin/end locations, accurate start/stop times, and, in limited cases, the actual lanes that are closed (i.e., smart arrow boards provide lane closures while connected pins only provide location).

The method of integrating cTTCD data with 511 data is an ongoing effort that is also being conducted at the Institute for Transportation for the Iowa DOT and will ideally automatically associate a cTTCD to a work zone based on proximity, requiring no effort by field staff. The remaining sections of this chapter focus on archiving active work zone data using cTTCDs and how the data are structured.

It should also be noted that inspectors in the field do collect additional information within their work zone logs, but access to this information is limited and not easily shared. This information may provide some additional details but would again be limited in the accuracy of active work zone information. Inspectors cover multiple work zones and may rely on information from the contractor that is imprecise as far as when and where lane closures occur.

Relevant Standards and Open-Source Components

There are currently no reference guides or agreed upon standards available to provide insight toward digitally describing and communicating the dynamic work zone activities that take place on roads and highways. However, multiple standards exist in the area of traffic management, which can be used to gain insights into the critical information that is needed for a research-grade WZDB.

The following explores the various standards available but focuses on the WZDI, which performed a similar analysis nationwide on work zone data over the entire lifecycle of a work zone from planning to active construction to post work zone analysis. The WZDx is also discussed and the capabilities it has to provide active work zone information to third parties.

The research team began by first exploring the available standards used in the transportation industry and the data provided related to work zones. The DATEX II, Transport Protocol Experts Group (TPEG), Traffic Management Data Dictionary (TMDD), and International Traveler Information System (ITIS) data protocols are the most common standards that are used to provide traffic incident information, which includes work zone data.

In the European Union, DATEX II is the standard that is implemented to disseminate traffic incident information. TPEG provides an associated standard that also allows for alternative routes or modes to be recommended. Within DATEX II, each work zone is treated as an individual event and includes the following data elements related to work zones: duration, location, under traffic, mobility (mobile versus stationary), type of work, and maintenance vehicle actions.

In the United States, TMDD is most commonly used to exchange intelligent transportation system (ITS) related information between traffic management centers. Similar to DATEX II, each work zone is treated as an event and includes work zone related data elements such as category (planned, construction, or current), effective period, status, severity, time, and location. Additionally, ITIS provides lists of standard phrases that include work activity categories. These standards contain the basic information needed for a work zone but are limited by being intended to contain all traffic related events. The FHWA WZDI identifies other essential work zone data elements in detail.

Recently, the U.S. DOT has actually led two coordinated efforts for improving work zone data, and these were ultimately selected as the basis for developing the WZDB for the Iowa DOT.

The FHWA launched the WZDI with the goals to develop a recommended practice for managing work zone data and create a consistent language for communicating information on work zone activity across jurisdictional and organizational boundaries. The Initiative’s mission is broad and forward-looking, and it has significant implications beyond the traditional stakeholders of highway construction.

The Intelligent Transportation Systems Joint Program Office is leading the WZDx, which is developing a standard way of communicating work zone information between infrastructure owners and operators (IOOs) and third party data consumers.

Although these efforts are coordinated, some differences do exist and must be considered when developing the WZDB.

The most significant benefit of the WZDI is the expectation that it will lead to a nationally consistent data dictionary and framework for communicating and storing WZAD that also provides references to external databases containing related work zone data, e.g., mobility and crash data. WZAD will support enhanced work zone management operations within transportation agencies along with advancing development of WZAD applications that will enable stakeholder use of the data. The resulting national dictionary content and structure will facilitate better harmonization of WZAD for current and future uses, resulting in real-time, accurate, and comprehensive data in a standard format that allows for seamless data communications across jurisdictional boundaries.

Two important deliverables from the WZDI include the following:

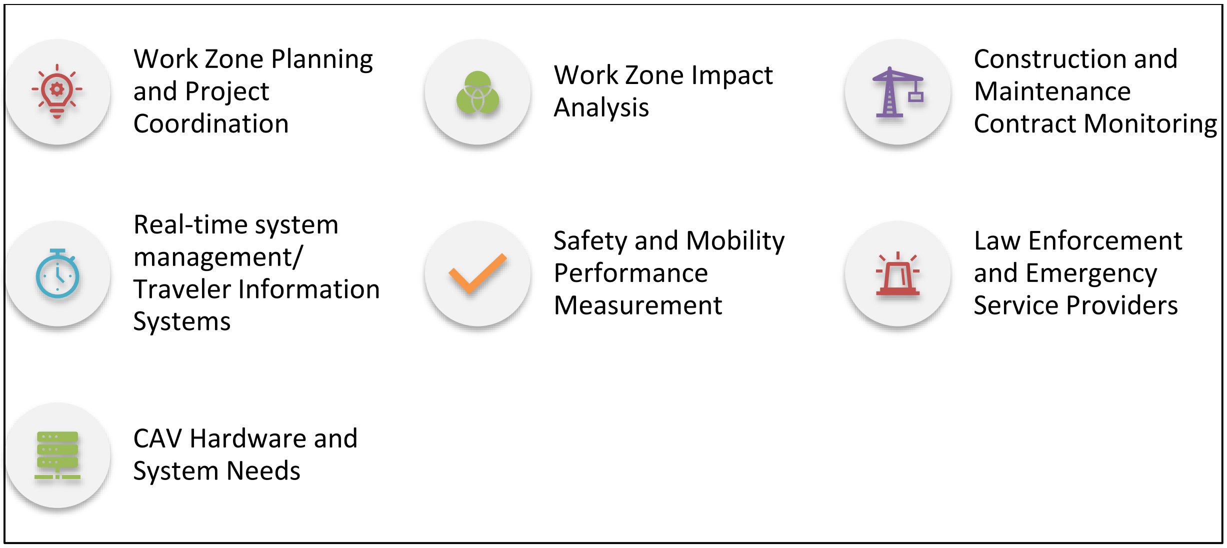
WZAD Framework (Stephens et al.2020): Framework for Work Zone Event Data Collection and Management. The framework establishes a standard and consistent approach for collecting, organizing and communicating work zone information to contractors, neighbor agencies, third party data consumers, and other key stakeholders. The framework describes the stakeholders, their needs and use cases, and the relevant data content needed to fulfill these needs.

WZAD Data Dictionary (Okunieff et al. 2020): Data Dictionary Report. The Data Dictionary attempts to specify consistent data with respect to meaning and enumerated values such as assignment of locations (e.g., begin/end locations), temporal states, and impacts.

User needs refers to the functions and features of a system desired by its users and stakeholders. A use case is a system engineering term for a user's interaction with a system that technically describes the user needs for a work zone data system developer. User needs and use cases are fundamental and complementary building blocks for development of system requirements and tests that verify user needs are satisfied.

The WZDI conducted a series of stakeholder interviews and meetings to identify stakeholder needs for the WZAD data dictionary. From that investigation, the team members identified 27 key user needs for WZAD and 50 candidate use cases. When considering implementation and development of a work zone data system (WZDS), agencies may use these user needs and use cases as a starting place for creating their own user needs and use cases.

The FHWA WZDI lists seven user categories with numerous use cases under each category. The framework adopts a holistic approach including use cases from the planning and design stage of work to active operations and post-work performance analysis. Figure 4 shows the seven categories of user needs focused on in the FHWA WZDI framework.



CAV=connected and automated vehicle; image based on
https://ops.fhwa.dot.gov/publications/fhwahop18083/index.htm

Figure 4. Categories of use cases for work zone data

As suggested, the WZAD architecture was the starting place for the research team to identify the user needs for the Iowa DOT WZDB. Additional details are provided in the next section, and Use Case 4.2.1 – Work Zone Plan Dissemination to Third Party Data Providers was selected as the basis for the research-grade WZDB because it contains the critical information that was identified by the Iowa DOT as data needed for identifying work zones. The following lists the work zone event data content needed for this use case and is incorporated into the WZDB:

- Project ID
- Event ID
- Sub-event ID
- Location – Name of roadway where event/subevent is located
- Location – Roadway classification of roadway where event/subevent is located
- Location – Facility type of roadway where event/subevent is located
- Location – Direction of travel of event/subevent
- Location – Planned begin location of event/subevent
- Location – Planned end location of event/subevent
- Location – Actual begin location of event/subevent
- Location – Actual end location of event/subevent
- Time – Planned start date/time of event/subevent
- Time – Planned end date/time of event/subevent
- Time – Recurring flag
- Time – Actual start date/time of event/subevent
- Time – Actual end date/time of event/subevent
- Time – Status
- Event – Planned number of lanes to be closed
- Event – Description of planned lanes to be closed

- Event – Actual number of lanes to be closed
- Event – Description of actual lanes to be closed
- Event – Expected effect on travel time/delay/queuing
- Event – Detour Route information
- Metadata – Indicator that a change to an event/subevent entry has been made

This should be viewed as a starting point in the work zone event database and can be expanded in the future to include other work zone data elements as they become available.

The identified data needs were used as a basis for establishing the structure of the WZDB described in the next section, but the WZDx data content must also be considered. The WZDx was currently in version 3.0 and available on github here.

Again, although these efforts are coordinated, the WZDx is continuously being refined through open collaboration between IOOs and third party data consumers. Because of this, some data elements that are included are not shown in Use Case 4.2.1 – Work Zone Plan Dissemination to Third Party Data Providers. The current version of the WZDx was reviewed and the relevant data contents were identified and related back to the WZAD data dictionary to include the following data content needed as part of the WZDB.

- Event – Temporary restrictions in place Event ID
- Event – Warning notifications

Based on the review of the WZAD and WZDx, the necessary data content that should be included in the WZDB has been identified.

Work Zone Activity Monitoring Data

As previously stated, a data entry screen to collect active work zone information is not ideal given data entry will contain similar errors in the location and time, which are critical for a research-grade WZDB.

A method was developed at Iowa State University’s Institute for Transportation, through a separate project for the Iowa DOT, to automate the process of associating a cTTCD, such as a smart arrow board, with a 511 work zone. Use of this method will help in improving the location and time data for a work zone.

Given the method of collecting active work zone data will be through the use of cTTCDs, a prototype data entry screen was not developed. Instead, a process was developed that uses the automation of assigning a cTTCD with the 511 work zone to archive the data into the WZDB.

Not all data elements identified in the previous section are available in the 511 work zone data, so the process will extract data from other sources when they are available. Any data elements not collected were identified and are included in the recommendations for future data collection by the Iowa DOT.

Work Zone Database Structure

Before developing the process, the database structure was established. As described in the previous section, Use Case 4.2.1 – Work Zone Plan Dissemination to Third Party Data Providers was used as the basis for the minimum data elements needed for a research-grade WZDB. This use case most aligns with the objective of obtaining work zone data and contains the critical data elements necessary for post work zone analysis identified in the WZAD use cases under 5.1 and 5.2.

The data elements described in the previous section were then explored in the data dictionary to identify all of the relevant data schemas and elements. A summary of the schemas associated to each data element and the corresponding date frames and data elements are shown in Table 1.

Table 1. Summary of data elements and relevant schemas

Data Element	Schema	Data Frame (DF)/Data Element (DE)
Project ID	Phase Work Zone Project WZ-Subtask WZ-Task	ProjectEventID (DF)
Event ID	WZ-Task	wz-TaskID (DE)
Sub-event ID	WZ-Subtask	wZ-SubtaskID (DE)
Location - Name of roadway where event/subevent is located	Phase WZ-Subtask WZ-Task	BeginLocation (DF) roadName (DE) WZ-Geometry (DF)
Location - Roadway classification of roadway where event/subevent is located	Phase WZ-Subtask WZ-Task	RoadType (DF) WZ-Geometry (DF)
Location - Facility type of roadway where event/subevent is located	Phase WZ-Subtask WZ-Task	RoadType (DF) facilityType (DE)
Location - Direction of travel of event/subevent	Phase WZ-Subtask WZ-Task	BeginActivityLocation (DF) BeginLocation (DF) roadDirection (DE) WZ-Geometry (DF)
Location - Planned begin location of event/subevent	Phase WZ-Subtask WZ-Task	BeginActivityLocation (DF) BeginLocation (DF)
Location - Planned end location of event/subevent	–	EndActivityLocation (DF) EndLocation (DF)
Location - Actual being location of event/subevent	Phase WZ-Subtask WZ-Task	BeginActivityLocation (DF) BeginLocation (DF)
Location - Actual end location of event/subevent	–	EndActivityLocation (DF) EndLocation (DF)
Time - Planned start date/time of event/subevent	Phase WZ-Subtask WZ-Task	StartDateTime (DF) EndDateTime (DF)

Data Element	Schema	Data Frame (DF)/Data Element (DE)
Time - Planned end date/time of event/subevent	Phase WZ-Subtask WZ-Task	EndDateTime (DF)
Time - Recurring flag	WZ-Subtask WZ-Task	dayOfWeek (DE) endPeriod (DE) Recurring (DF) startPeriod (DE)
Time - Actual start date/time of event/subevent	Phase WZ-Subtask WZ-Task	StartDateTime (DF)
Time - Actual end date/time of event/subevent	Phase WZ-Subtask WZ-Task	EndDateTime (DF) endDateTime-cancelled (DE) endDateTime-complete (DE) endDateTime-ver (DE) timeConfidence (DE)
Time - Status	Phase WZ-Subtask WZ-Task	wz-Status (DE)
Event - Planned number of lanes to be closed	Phase WZ-Subtask WZ-Task	lanesClosed (DE) WZ-Geometry (DF)
Event - Description of planned lanes to be closed	WZ-LaneActivity	laneDescription (DE)
Event - Actual number of lanes to be closed	WZ-Subtask WZ-Task	lanesClosed (DE) lanesOpen (DE) shouldersClosed (DE) totalLanes (DE) WZ-Geometry (DF)
Event - Description of actual lanes to be closed	WZ-LaneActivity	laneDescription (DE)
Event - Expected effect on travel time/delay/queuing	OperationalLog	–
Event - Temporary restrictions in place	WZ-Subtask WZ-Task	laneRestriction (DE) wz-SeperationType (DE)
Metadata	–	WZ-ProjectSchedule
Event - Detour Route information	–	DetourPath (DF)
Event - Warning notifications	Phase WZ-Subtask WZ-Task	AdvancedWarning (DE) WZ-Geometry (DF)

Appendix A lists all of the data frames identified and the relevant data element and data frame for each.

To develop a WZDB, relationships must be understood between all of the various data frames and data elements shown above. An entity relationship diagram was created (Figure 5) that shows each of the relationships between the various data elements and how the data frames relate to each other.

An interactive entity relationship diagram for the WZDB is also available here. Through the process, some data frames, which are highlighted in Figure 6, were identified as not being collected or unnecessary in the current deployment of the WZDB.

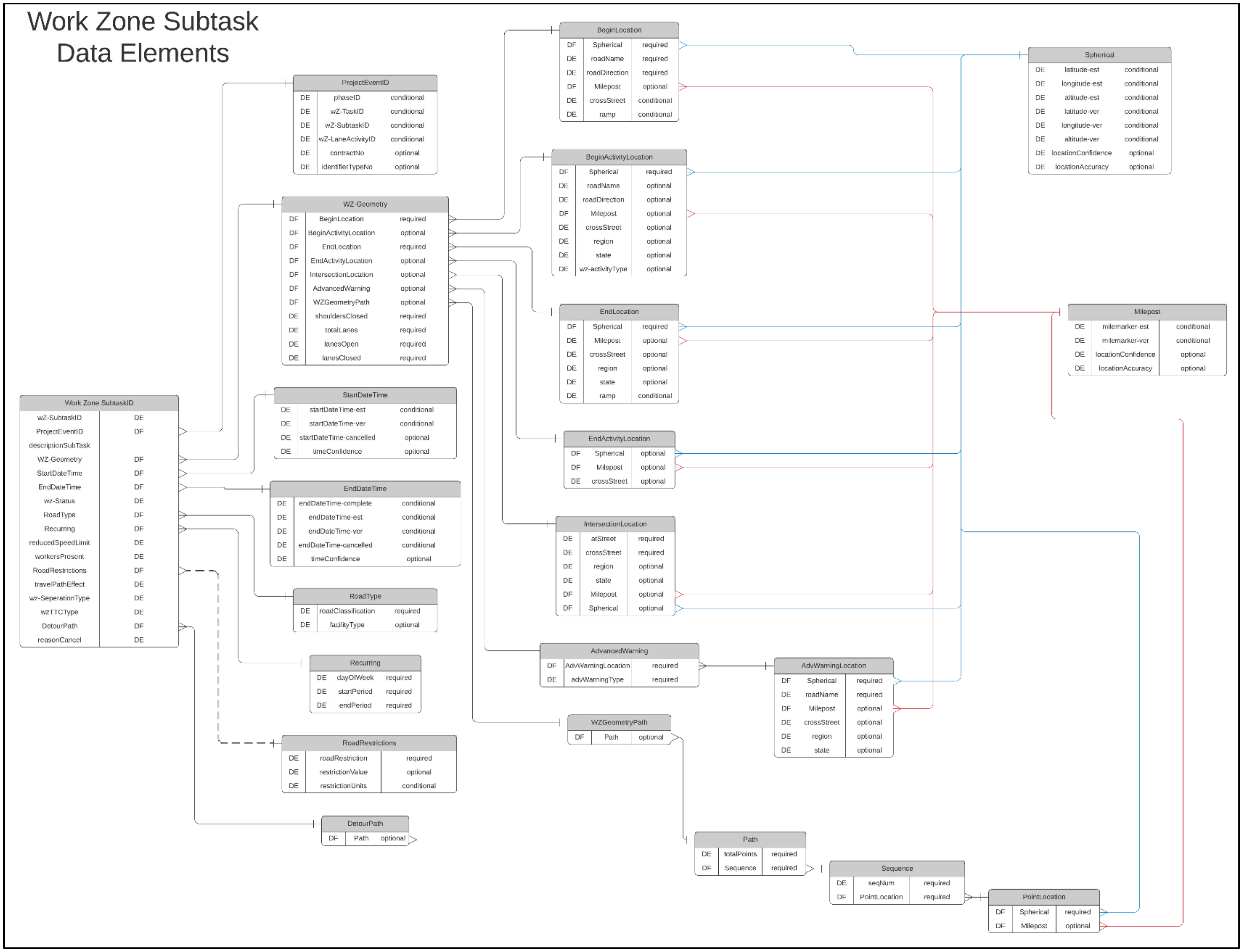


Figure 5. Entity relationship diagram of data elements for active work zone from WZDI

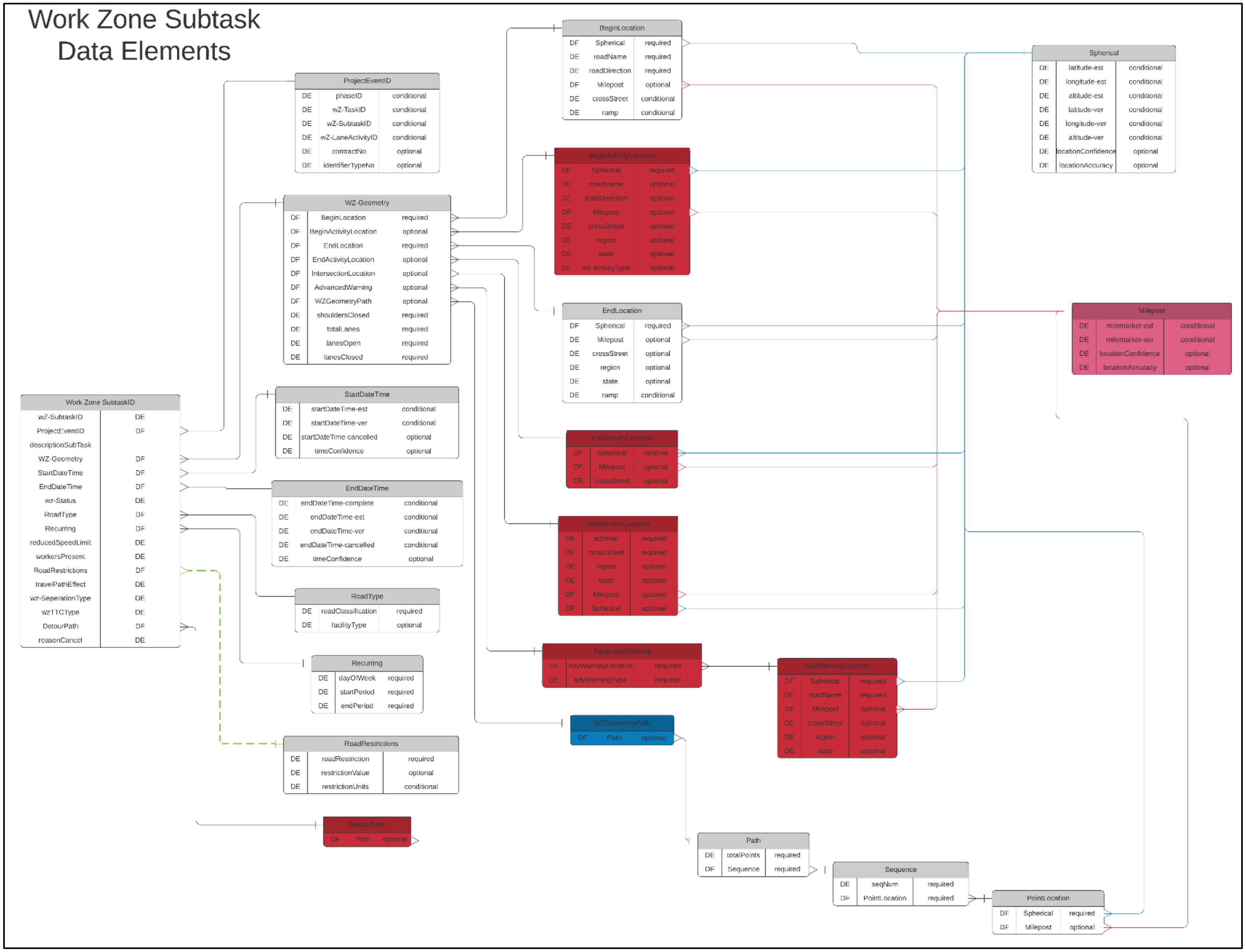


Figure 6. Entity relationship diagram highlighting data elements not currently collected or maintained

In Figure 6, the items highlighted in red include the begin activity location, end activity location, intersection location, advanced warning, advanced warning location, and detour path. All of the data from these tables are not currently available in the existing data collection and are not critical for the WZDB at this point. For reference, all of the location information for the work zone is stored in the begin and end location data frame because the data collected is more representative of this data frame than the others listed above. Future iterations should identify methods of collecting this data if needed.

The items highlighted in pink were slightly altered in their definitions to align with the Iowa linear referencing system (LRS), which allows for integration of data across various data sources within the Iowa DOT. The mile marker values are instead used as the measures along the route, which to identify the mile marker if needed. In addition, a RouteID field is added to identify the route used for the measures in the LRS. A combination of the route identifier and measure allows the work zone to easily be integrated with other data sources.

The item highlighted in blue contains the work zone geometry path and is also not included in the database given this can be obtain by using the RouteID and measure values to identify the geometry of the work zone. It is unnecessary to store this data in the database given it can be easily obtained using the LRS.

With the data element relationships established, the tables for storing the data were then developed. If the data elements within the entity relationship diagram are all related and collected at a similar frequency, those elements were placed in the same table. Other tables were created if there was a one-to-many relationship between data elements, such as restrictions. Some work zones may have multiple restrictions causing this one-to-many relationship. Seven tables were created, as follows:

- SubTask table
- Recurring table
- Restrictions table
- SubTask Activity table (future data collection)
- SubTask Intersection Location table (future data collection)
- SubTask Advanced Warning table (future data collection)
- Detour Path table (future data collection)

All of the tables are related based on the wZ-SubtaskID. Three of the tables include data that are currently collected, while the remaining four tables are for future use, representing the items highlighted in red in the entity relationship diagram (Figure 6). A summary of all of the data elements in each table is provided in Appendix B. The tables were put into a MySQL database for data archival.

The SubTask table contains the majority of critical work zone information. The subtask identifier is used instead of the task identifier because the WZDB represents the individual lane closures that occur throughout the state. All of the lane closures can be summarized up to a higher level representing the entirety of a work zone project.

Work Zone Archival Process

With the database established, the process to begin archiving the work zone data was developed. As previously mentioned, the method of integrating cTTCD data was developed through a separate project and will only be discussed at a high level in this report.

The archival of the work zone data is a two-fold process. The process runs as a Python script every five minutes. The input for Part 1 is the 511 feed, and the input for Part 2 is the processed output from Part 1 and the archived output of the cTTCDs from another process. After the process is completed, the results are compared to the existing WZDB to determine whether any of the events are new and should be archived or updated.

The first part of the process works on processing all 511 events. The 511 event uniform resource locator (URL) is sent a hypertext transfer protocol (HTTP) request, and the encoded response object is obtained as an extensible markup language (XML) file. The XML file is parsed and hierarchically accessed for each of its child elements and their attributes. These correspond to 511 events and their member fields.

Processing the 511 work zone begins by filtering only the work zones that should be active at the time of processing the data. This is because only active work zones should be archived in the WZDB, and any future work zones are ignored until they become active. The 511 field data are processed, cleaned, and formatted to match the fields and data enumerations from the WZAD Data Dictionary. The tables in Appendix B describe the source of each of the data elements in the WZDB and also reference lookup tables in Appendix C that convert the existing enumerations from the 511 data to the enumerations from the WZAD Data Dictionary. The tables also identify data elements, such as number of lanes, road classification, and facility type, that are extracted from the Iowa DOT Roadway Asset Management System (RAMS). These data elements are needed for the WZDB but are not available in the 511 work zone data. The data are extracted from RAMS based on where the work zone is located in the Iowa DOT LRS.

The 511 work zones are conflated to the Iowa DOT LRS to obtain the necessary RouteID and measure values. The original location data for the work zone (primary and secondary location) is conflated to the LRS and ran through a route dominance algorithm to fetch the most dominant route for the locations. The work zones are located on the LRS because it allows for easier data integration across the agency. This includes extracting the number of lanes, facility type, and road classification. The LRS also allows for the direction of the work zone to be established and to identify the opposite direction of travel. Finally, the LRS is the basis for associating a cTTCD with the work zone in Part 2.

The work zones in 511 do not have a start and end location, because they are based on how the TMC operator draws the work zone on the map, but also because a 511 work zone may represent both directions of travel. The WZDB, on the other hand, will individually represent each lane closure to provide the highest level of accuracy.

To identify the start and end location, the location with the lower measure value is used as the start location and the one with the higher measure value is used as the end location. The left image in Figure 7 shows how the primary and secondary location of the work zone, represented as points, are conflated to the LRS, and the point with the lower measure value is identified as the start of the work zone.

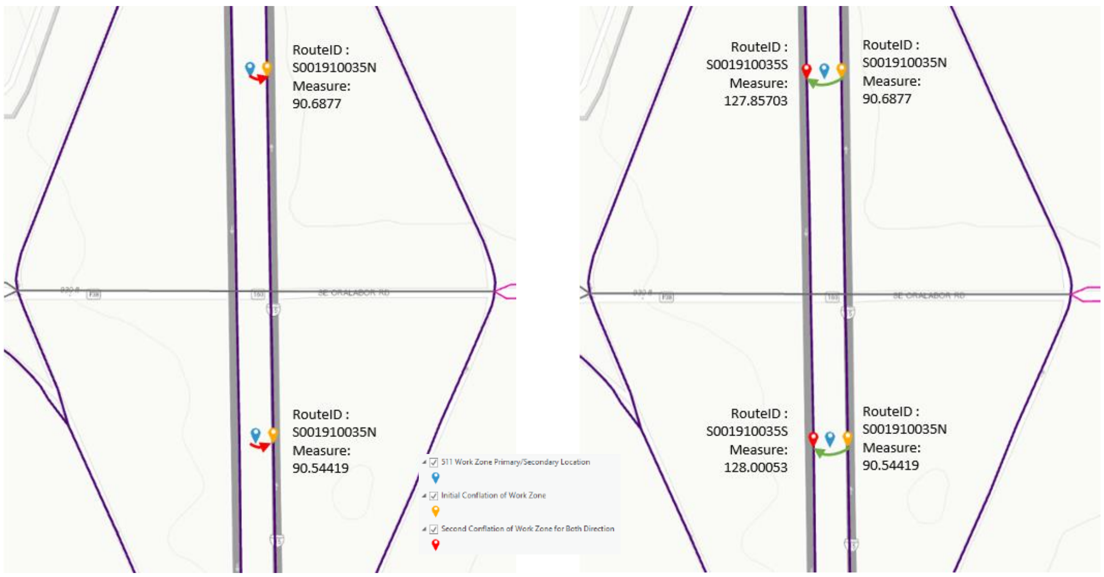


Figure 7. Sample conflation of work zone start/end to LRS (left) and conflation of data to opposite direction for both direction records (right)

The LRS always increases mileage in the direction of travel of the roadway. One point to note is that the coordinates obtained from the LRS are used in the archive and not the ones from the 511 feed. This helps in aligning the coordinates to the RAMS network and visually displaying the data.

The 511 system data represent work zones as in the positive, negative, or both directions. For positive or negative directions of work zones, there is no extra step to process the data given each event represents a single direction of travel. For events that are in both directions, a second event is created for the opposite direction of travel by modifying the direction in the RouteID, and then re-conflating the data to the LRS to get the correct measure values. For example, in the image on the right in Figure 7, the RouteID was changed from S001910035N to S001910035S to force the record to the opposite direction; then, the re-conflation using the RouteID returns the correct measure values for the opposite direction of travel.

The final step in Part 1 is to identify redundant closures/work zones at the same location, based on the route and measure values, and maintain an individual record for each location.

The second part of the process integrates the cTTCD data, such as that from smart arrow boards, with the processed 511 event data from Part 1. A parallel process conflates all of the cTTCD data to the LRS data that will be the basis of integrating the cTTCD data with the 511 work zone data.

An inner join is first performed between the cTTCD and processed 511 work zone data using the Route ID as the key. If the join exists, the cTTCD information is compared to the begin and end measure values of the processed 511 work zone. If the cTTCD is near either the begin or end location, the information from the cTTCD is used as the verified coordinates for the work zone. If there are multiple cTTCDs, the devices are sorted based on their measure values, and the device with the lowest value is used as the verified begin location and the device with the highest measure value is used as the verified end location. Figure 8 shows an example of how cTTCDs are associated with the processed 511 work zones.

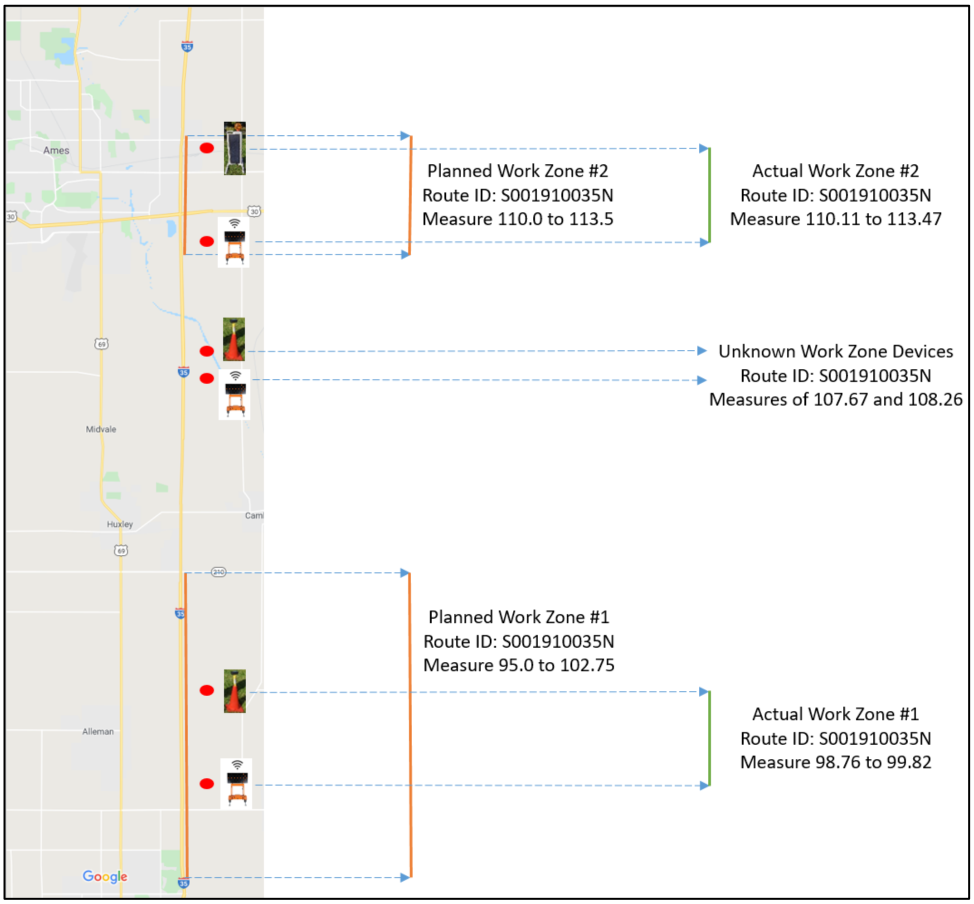


Figure 8. Example of integrating cTTCD data with processed 511 data

The actual work zone information is then used as the verified coordinates and measures used in the WZDB. Additionally, the timestamp of when the cTTCD is first associated with the work zone is used as the verified start time of the work zone. The time when a cTTCD is last associated with the work zone is also used as the verified end time of the work zone.

Since all of the 511 work zone and cTTCD data are processed every five minutes, not all of the data should be archived in the WZDB given redundant data. Instead, the process compares the processed results with the data in the WZDB to identify if the processed data represent a new work zone or include updates such as verified location and time. These data are then used to update the WZDB, while the other redundant data are discarded.

SUMMARY AND CONCLUSIONS

Accurate work zone data are a challenge that all agencies face. Agency staff that want to be proactive in their work zone management are limited by the accuracy of their work zone data and are looking for ways to improve the methods of collecting their data.

In Iowa, as well as most other states, work zone data are manually collected using forms or lane closure planning systems. This works well for planned work zone data but is not ideal for collecting actual work zone data from the field.

Field staff and contractors are not suitable sources for collecting work zone data given they are focused on other activities, and additional undue burden should not be placed on them. In lieu of a mobile application to collect work zone data, the Iowa DOT focused on other methods of collecting the location and time a work zone is active through the use of cTTCDs, such as smart arrow boards. The combination of the planned work zone data that are already input by users and the cTTCD data should be included for the WZDB.

Before creating the WZDB, the contents and data elements needed for work zones needed to be understood. The FHWA WZAD Framework provided a valuable resource to identify the use cases of work zone data and the data elements that are needed to achieve these use cases. The Work Zone Plan Dissemination to Third Party Data Providers use case identified in the data framework provided the foundation for developing the Iowa WZDB.

The FHWA WZAD Dictionary was then used to develop the database structure by understanding the relationships between all of the data frames and data elements. An entity relationship diagram was created to show these relationships and identify the similar data elements for the various tables in the WZDB.

Finally, the WZDB was developed where work zone data were archived by integrating the planned 511 work zone data with data from smart arrow boards currently deployed in Iowa. The smart arrow boards allow for verified coordinates and time to be included in the WZDB to provide confidence for users on the accuracy of the locations and times for the data.

The major challenge with the current implementation is the accuracy of the planned work zone data that are entered into the 511 system. The Iowa DOT is currently developing the requirements for a PLCS that should improve the accuracy of the planned work zone data and remove redundant work zones that are currently entered into the 511 system. Having redundant work zones causes ambiguity when relating the work zone to the cTTCDs that should be eliminated.

Various data elements are also not collected in the current 511 system that could be collected in future systems by the Iowa DOT, if deemed necessary. These include the contract number, the reduced speed limit, worker presence, the work zone separation type, and the temporary traffic control standard that is used (i.e., TC-421, TC-418). The current WZDB should be viewed as a starting point and should be expanded in the future as other data become available or improved methods of collecting data are added.

Finally, the Iowa DOT should continue the deployment of cTTCDs, such as connected pins/panels, smart flaggers, and smart temporary signals. The current use of smart arrow boards provides accurate begin points of the work zone but does not include any end points of the work zone. The smart arrow boards were an easy starting point for the Iowa DOT given they did not require any changes to worker activity in the field. The continued deployment of other cTTCDs will further improve the accuracy of work zone data, which in turn improves both safety and mobility.

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APPENDIX A: WORK ZONE DATABASE DATA FRAME DESCRIPTIONS

This appendix summarizes all of the data frames identified for the WZDB based on the FHWA WZDI Data Dictionary. For each data frame, all of the relevant data elements (DEs) or data frames (DFs) are listed along with whether they are required or conditional. These can be seen in relation to each other in the previous Figure 5.

Table 2. Data frame descriptions

ProjectEventID

phaseID	conditional	DE
wZ-TaskID	conditional	DE
wZ-SubtaskID	conditional	DE
wZ-LaneActivityID	conditional	DE
contractNo	Optional	DE
identifierTypeNo	Optional	DE

BeginLocation

Spherical	required	DF
roadName	required	DE
roadDirection	required	DE
Milepost	optional	DF
crossStreet	conditional	DE
ramp	conditional	DE

EndLocation

Spherical	required	DF
Milepost	optional	DE
crossStreet	optional	DE
region	optional	DE
state	optional	DE
ramp	conditional	DE

WZ-Geometry

BeginLocation	required	DF
BeginActivityLocation	optional	DF
EndLocation	required	DF
EndActivityLocation	optional	DF
InterstationLocation	optional	DF
AdvancedWarning	optional	DF
WZGeometryPath	optional	DF
shouldersClosed	required	DE

Spherical

latitude-est	conditional	DE
longitude-est	conditional	DE
altitude-est	conditional	DE
latitude-ver	conditional	DE
longitude-ver	conditional	DE
altitude-ver	conditional	DE
locationConfidence	optional	DE
locationAccuracy	optional	DE

Milepost

milemarker-est	conditional	DE
milemarker-ver	conditional	DE
locationConfidence	optional	DE
locationAccuracy	optional	DE

IntersectionLocation

atStreet	required	DE
crossStreet	required	DE
region	optional	DE
state	optional	DE
Milepost	optional	DF
Spherical	optional	DF

AdvancedWarning

AdvWarningLocation	required	DF
advWarningType	required	DE

AdvWarningLocation

Spherical	required	DF
roadName	required	DE
Milepost	optional	DF
crossStreet	optional	DE

totalLanes	required	DE
lanesOpen	required	DE
lanesClosed	required	DE

RoadType

roadClassification	required	DE
facilityType	optional	DE

BeginActivityLocation

Spherical	required	DF
roadName	optional	DE
roadDirection	optional	DE
Milepost	optional	DF
crossStreet	optional	DE
region	optional	DE
state	optional	DE
wz-activityType	optional	DE

EndActivityLocation

Spherical	optional	DF
Milepost	optional	DF
crossStreet	optional	DE

Recurring

dayOfWeek	required	DE
startPeriod	required	DE
endPeriod	required	DE

StartDateTime

startDateTime-est	conditional	DE
startDateTime-ver	conditional	DE
startDateTime-cancelled	conditional	DE
timeConfidence	optional	DE

EndDateTime

endDateTime-complete	conditional	DE
endDateTime-est	conditional	DE
endDateTime-ver	conditional	DE
endDateTime-cancelled	conditional	DE
timeConfidence	optional	DE

region	optional	DE
state	optional	DE

WZGeometryPath

Path	optional	DF

Path

totalPoints	required	DE
Sequence	required	DF

Sequence

seqNum	required	DE
PointLocation	required	DF

PointLocation

Spherical	required	DF
Milepost	optional	DF

ProjectCoordination

projectName	required	DE
IssuingOrganization	required	DE
WZ-Geometry	required	DF
StartDateTime	required	DF
EndDateTime	required	DF
WorkType	optional	DF
RoadType	optional	DF
roleContact	optional	DE
ProjectEventID	optional	DF
coordinationStatus	optional	DE
coordinationType	required	DE

WorkType

workClassificationType	required	DE
workClassificationDetail	optional	DE

DetourPath

Path	optional	DF

APPENDIX B: WORK ZONE DATABASE TABLES AND DATA ELEMENTS

This appendix provides a list of all the tables and data elements that are included in the WZDB as well as the sources of those data elements.

Table 3. Subtask table

Field Name	Source
wZ-SubtaskID	Based on event-id the update number and the direction
PhaseID	Future data collection
wz-TaskID	Based on event-id and the update number
wz-LaneActivityID	Future data collection
contractNo	Future data collection
identifierTypeNo	Not applicable at this point
descriptionSubTask	Description from 511
ROUTE_ID	Route identifier based on the Iowa DOT LRS
BeginLocation-latitude-est	Based on the coordinates submitted to ATMS/511, returned coordinates are based on Iowa DOT LRS and the direction of the roadway
BeginLocation-longitude-est	Based on the coordinates submitted to ATMS/511, returned coordinates are based on Iowa DOT LRS and the direction of the roadway
BeginLocation-altitude-est	Future data collection
BeginLocation-latitude-ver	Based on coordinates collected from temporary traffic control devices (smart arrow boards, connected pins, etc.), returned coordinates are based on the Iowa DOT LRS
BeginLocation-longitude-ver	Based on coordinates collected from temporary traffic control devices (smart arrow boards, connected pins, etc.), returned coordinates are based on the Iowa DOT LRS
BeginLocation-altitude-ver	Future data collection
BeginLocation-locationConfidence	Future data collection
BeginLocation-locationAccuracy	Future data collection - need to determine the accuracy of connected temporary traffic control devices
BeginLocation-roadName	Based on road name submitted to ATMS/511
BeginLocation-roadDirection	Road direction based on information submitted to ATMS/511 and returned from Iowa DOT LRS
BeginLocation-milemarker-est	Measure value returned from RAMS based on estimated begin coordinates - this does not represent the actual mile marker
BeginLocation-milemarker-ver	Measure value returned from RAMS based on verified begin coordinates - this does not represent the actual mile marker
BeginLocation-crossStreet	Future data collection
BeginLocation-ramp	Future data collection

EndLocation-latitude-est	Based on the coordinates submitted to ATMS/511, returned coordinates are based on Iowa DOT LRS and the direction of the roadway
EndLocation-longitude-est	Based on the coordinates submitted to ATMS/511, returned coordinates are based on Iowa DOT LRS and the direction of the roadway
EndLocation-altitude-est	Future data collection
EndLocation-latitude-ver	Based on coordinates collected from temporary traffic control devices (smart arrow boards, connected pins, etc.), returned coordinates are based on the Iowa DOT LRS
EndLocation-longitude-ver	Based on coordinates collected from temporary traffic control devices (smart arrow boards, connected pins, etc.), returned coordinates are based on the Iowa DOT LRS
EndLocation-altitude-ver	Future data collection
EndLocation-locationConfidence	Future data collection
EndLocation-locationAccuracy	Future data collection - need to determine the accuracy of connected temporary traffic control devices
EndLocation-milemarker-est	Measure value returned from RAMS based on estimated end coordinates - this does not represent the actual mile marker
EndLocation-milemarker-ver	Measure value returned from RAMS based on verified end coordinates - this does not represent the actual mile marker
EndLocation-crossStreet	Future data collection
EndLocation-region	The Iowa DOT District the work zone is located based on the Maintenance District in RAMS
EndLocation-state	Currently will only be Iowa
EndLocation-ramp	Future data collection
shouldersClosed	Based on the accepted phrases in 511 as shown in the Lanes Lookup table in Appendix C
totalLanes	Total lanes based on location in RAMS
lanesOpen	Based on the accepted phrases in 511 as shown in the Lanes Lookup table in Appendix C and the number of lanes from RAMS
lanesClosed	Based on the accepted phrases in 511 as shown in the Lanes Lookup table in Appendix C and the number of lanes from RAMS
startDateTime-est	Date is based on the start time or the recurring start time in 511
startDateTime-ver	Date is based on when connected temporary traffic control device was activated
startDateTime-cancelled	Future data collection
startDateTime-timeConfidence	Future data collection
endDateTime-complete	Future data collection
endDateTime-est	Date is based on the end time or the recurring end time in 511
endDateTime-ver	Future data collection but will be based on when connected temporary traffic control device was deactivated
endDateTime-cancelled	Future data collection
endDateTime-timeConfidence	Future data collection
wz-Status	Archived will only be of active work zones

roadClassification	Based on the Federal Functional Classification in RAMS with modification to meet enumerated values as shown in the Road Classification Lookup table in Appendix C
facilityType	Based on the Facility Type in RAMS with modification to meet enumerated values as shown in the Facility Type Lookup table in Appendix C
reducedSpeedLimit	Future data collection
workersPresent	Future data collection
travelPathEffect	Based on the accepted phrases in 511 as shown in Lanes Lookup table in Appendix C
wz-SeperationType	Future data collection
wzTTCType	Based on the accepted phrases in 511 as shown in Lanes Lookup table in Appendix C
reasonCancel	Future data collection

Table 4. Recurring table

Field Name	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
dayOfWeek	Based on day of week from 511 data
startPeriod	Based on schedule time start
endPeriod	Based on schedule time end

Table 5. Restrictions table

Field Name	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
roadRestriction	Road restrictions entered into 511 system and based on the enumerated conversion in Road Restriction Lookup table in Appendix C
restrictionValue	Road restrictions values entered into 511 system (restriction-width, restriction-length, etc.)
restrictionUnits	Road restriction values based on the enumerated conversion in the Road Restriction Lookup table in Appendix C

Table 6. SubTask Activity table

Field Names	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
BeginActivityLocation-latitude-est	Future data collection
BeginActivityLocation-longitude-est	Future data collection
BeginActivityLocation-altitude-est	Future data collection
BeginActivityLocation-latitude-ver	Future data collection

Field Names	Source
BeginActivityLocation-longitude-ver	Future data collection
BeginActivityLocation-altitude-ver	Future data collection
BeginActivityLocation-locationConfidence	Future data collection
BeginActivityLocation-locationAccuracy	Future data collection
BeginActivityLocation-roadName	Future data collection
BeginActivityLocation-roadDirection	Future data collection
BeginActivityLocation-milmarker-est	Future data collection
BeginActivityLocation-milemarker-ver	Future data collection
BeginActivityLocation-crossStreet	Future data collection
BeginActivityLocation-region	Future data collection
BeginActivityLocation-state	Future data collection
BeginActivityLocation-wz-activityType	Future data collection
EndActivityLocation-latitude-est	Future data collection
EndActivityLocation-longitude-est	Future data collection
EndActivityLocation-altitude-est	Future data collection
EndActivityLocation-latitude-ver	Future data collection
EndActivityLocation-longitude-ver	Future data collection
EndActivityLocation-altitude-ver	Future data collection
EndActivityLocation-locationConfidence	Future data collection
EndActivityLocation-locationAccuracy	Future data collection
EndActivityLocation-milemarker-est	Future data collection
EndActivityLocation-milemarker-ver	Future data collection
EndActivityLocation-crossStreet	Future data collection

Table 7. SubTask Intersection Location table

Field Names	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
atStreet	Future data collection
crossStreet	Future data collection
region	Future data collection
state	Future data collection
milemarker-est	Future data collection
milemarker-ver	Future data collection
latitude-est	Future data collection
longitude-est	Future data collection
altitude-est	Future data collection
latitude-ver	Future data collection
longitude-ver	Future data collection
altitude-ver	Future data collection

Field Names	Source
locationConfidence	Future data collection
locationAccuracy	Future data collection

Table 8. SubTask Advanced Warning table

Field Name	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
advWarningType	Future data collection
latitude-est	Future data collection
longitude-est	Future data collection
altitude-est	Future data collection
latitude-ver	Future data collection
longitude-ver	Future data collection
altitude-ver	Future data collection
locationConfidence	Future data collection
locationAccuracy	Future data collection
roadName	Future data collection
crossStreet	Future data collection
region	Future data collection
state	Future data collection

Table 9. Detour Path table

Field Name	Source
wZ-SubtaskID	Primary Key to relate back to SubTask table
DetourID	Future data collection
seqNum	Future data collection
ROUTE_ID	Future data collection
FROM_MEASURe	Future data collection
TO_MEASURE	Future data collection
TIM_ID	Future data collection

APPENDIX C: 511 WORK ZONE DATA LOOKUP TABLES

This appendix includes all of the lookup tables that are used to convert the 511 work zone data to the enumerations in the FHWA Work Zone Event Data (WZED) Data Dictionary.

Table 10. Lane Lookup table

511 Values	closed Lanes	open Lanes	# of Closed Lanes for Calculation	closedShoulder	travelPathEffect	wzTTCType
Blocked	all	none		both	closed	road-closure
Center lane blocked	middle-lane	left-lane, right-lane		none	merge	lane-closure
Five center lanes blocked	middle-five-lanes	left-lane, right-lane		none	merge	lane-closure
Five left lanes blocked	left-5-lanes	right-*-lane	5	inside	merge-rt	lane-closure
Five right lanes blocked	right-5-lanes	left-*-lanes	5	outside	merge-lt	lane-closure
Four center lanes blocked	middle-four-lanes	left-lane, right-lane		none	merge	lane-closure
Four left lanes blocked	left-4-lanes	right-*-lanes	4	inside	merge-rt	lane-closure
Four right lanes blocked	right-4-lanes	left-*-lanes	4	outside	merge-lt	lane-closure
Lane blocked	unknown	unknown		unknown	unknown	road-closure
Left center lane blocked	middle-lane	left-lane, right-2-lanes		none	merge	lane-closure
Left lane blocked	left-lane	right-*-lanes	1	inside	merge-rt	lane-closure
Left lane of exit ramp blocked	left-lane	right-*-lanes	1	inside	merge-rt	lane-closure
Ramp blocked	all	none		both	closed	ramp-closure
Ramp partially blocked	unknown	unknown		unknown	unknown	lane-closure
Right center lane blocked	middle-lane	left-2-lanes, right-lane		none	merge	lane-closure
Right lane blocked	right-lane	left-*-lanes	1	outside	merge-lt	lane-closure
Right lane of exit ramp blocked	right-lane	left-*-lanes	1	outside	merge-lt	lane-closure
Three center lanes blocked	middle-three-lanes	left-lane, right-lane		none	merge	lane-closure
Three left lanes blocked	left-3-lanes	right-*-lanes	3	inside	merge-rt	lane-closure
Three right lanes blocked	right-3-lanes	left-*-lanes	3	outside	merge-lt	lane-closure
Two center lanes blocked	middle-two-lanes	left-lane, right-lane		none	merge	lane-closure
Two left lanes blocked	left-2-lanes	right-*-lanes	2	inside	merge-rt	lane-closure

511 Values	closed Lanes	open Lanes	# of Closed Lanes for Calculation	closedShoulder	travelPathEffect	wzTTCType
Two left lanes of exit ramp blocked	left-2-lanes	right-*-lanes	2	inside	merge-rt	lane-closure
Two right lanes blocked	right-2-lanes	left-*-lanes	2	outside	merge-lt	lane-closure
Two right lanes of exit ramp blocked	right-2-lanes	left-*-lanes	2	outside	merge-lt	lane-closure
Alternating lane closures	unknown	unknown		unknown	alternating-one-way	alternating-one-way
Bridge closed	all	none		both	closed	road-closure
Center lane closed	middle-lane	left-lane, right-lane		none	merge	lane-closure
Closed (Closures)	all	none		both	closed	road-closure
Closed intermittently	unknown	unknown		unknown	closed	lane-closure
Entrance ramp closed	all	none		both	closed	ramp-closure
Exit ramp closed	all	none		both	closed	ramp-closure
Intermittent lane closure	unknown	unknown		unknown	unknown	lane-closure
Lane closed	unknown	unknown		unknown	unknown	lane-closure
Left exit ramp closed	left-lane	right-*-lanes	1	inside	merge-rt	lane-closure
Left lane closed	left-lane	right-*-lanes	1	inside	merge-rt	lane-closure
Left lane of exit ramp closed	left-lane	right-*-lanes	1	inside	merge-rt	lane-closure
Left shoulder closed	none	all		inside	none	shoulder-closure
Reduced to one lane	unknown	unknown		unknown	unknown	lane-closure
Reduced to three lanes	unknown	unknown		unknown	unknown	lane-closure
Reduced to two lanes	unknown	unknown		unknown	unknown	lane-closure
Reopended to traffic	none	all		none	none	lane-closure
Right lane closed	right-lane	left-*-lanes	1	outside	merge-lt	lane-closure
Right lane of exit ramp closed	right-lane	left-*-lanes	1	outside	merge-lt	lane-closure
Right shoulder closed	none	all		outside	none	shoulder-closure
Shoulder closed	none	all		unknown	none	shoulder-closure
Single line traffic: alternating directions	alternating-flow-lane	alternating-flow-lane		unknown	alternating-one-way	alternating-one-way
Two center lanes are closed	middle-two-lanes	left-lane, right-lane		none	merge	lane-closure

Table 11. Road Classification Lookup table

RAMS Value	RAMS Label	roadClassification
1	INTERSTATE	highway
2	PRINCIPAL ARTERIAL - OTHER FREEWAYS AND EXPRESSWAYS	arterial
3	PRINCIPAL ARTERIAL - OTHER	arterial
4	MINOR ARTERIAL	arterial
5	MAJOR COLLECTOR	connector
6	MINOR COLLECTOR	connector
7	LOCAL	connector

Table 12. Facility Type Lookup table

RAMS Value	RAMS Label	facilityType
1	ONE-WAY ROADWAY	mainline
2	TWO-WAY ROADWAY	mainline
4	RAMP	ramp
5	NON MAINLINE	unknown
6	NON INVENTORY DIRECTION	unknown
7	PLANNED UNBUILT	unknown

Table 13. Restrictions Lookup table

511 Category	511 Label	roadRestriction	511 tag used to get restrictionValue	restrictionUnits
restrictions	Ramp Restrictions	ramp	None	
restrictions	Towing services prohibited	towing-prohibited	None	
restrictions	Axle load limit	axle-load-limit	restriction-weight-axle	kilograms
restrictions	Gross weight limit	gross-weight-limit	restriction-weight-vehicle	kilograms
restrictions	Height limit	reduced-height	restriction-height	cm
restrictions	Length limit	reduced-length	restriction-length	cm
restrictions	Permitted oversize loads prohibited	permitted-oversize-loads-prohibited	None	
restrictions	Width limit	reduced-width	restriction-width	cm

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