

A Guide for Work Zone Crash Data Collection, Reporting, and Analysis



Prepared For:

United States Department of Transportation
Federal Highway Administration
Washington, D.C.



U.S. Department of Transportation
Federal Highway Administration

Prepared By:

Contractor:
Wayne State University
Transportation Research Group
Detroit, Michigan



College of Engineering

Subcontractor:
University of Missouri
Columbia, Missouri



A Guide for Work Zone Crash Data Collection, Reporting, and Analysis
FHWA Contract No. DTFH61-13-RA-00019

Submitted:

United States Department of Transportation
Federal Highway Administration
HSA Room #E71-324
1200 New Jersey Ave. SE
Washington, DC 20590

Contractor:

Wayne State University
Transportation Research Group
Civil & Environmental Engineering
5050 Anthony Wayne Drive
Engineering Development Center, Room #0504
Detroit, MI 48202

Subcontractor:

University of Missouri
Civil & Environmental Engineering
3502 Lafferre Hall
Columbia, MO 65211

Date:

March 2017

The opinions, findings, and conclusions expressed in this publication are those of the contractor(s) and not necessarily those of the U.S. Department of Transportation or the Federal Highway Administration. This report was prepared in cooperation with the U.S. Department of Transportation and the Federal Highway Administration.

1. Report No.	2. Government Accession No.	3. Recipient Catalog No.	
4 Title and Subtitle A Guide for Work Zone Crash Data Collection, Reporting, and Analysis		5 Report Date March 2017	
		6 Performing Organization Code	
7. Author(s) Tapan Datta, Nicholas Nicita, Timothy Gates, Praveen Edara, Sahadev Parajuli		8 Performing Organization Report No.	
9 Performing Organization Name and Address Wayne State University – Transportation Research Group 5050 Anthony Wayne Drive, EDC 0504 Detroit, Michigan 48202		10 Work Unit No. (TRAIS)	
		11 Contract or Grant No. DTFH61-13-RA-00019	
12 Sponsoring Agency Name and Address Federal Highway Administration – United States Department of Transportation		13 Type of Report and Period Covered	
		14 Sponsoring Agency Code	
15 Supplementary Notes			
16 Abstract This guide describes the work zone crash data collection and reporting process, as well as the benefits and challenges in developing a unified system across the states. The quality and consistency of work zone crash data suffers from the variation in crash data elements collected by states and individual record keeping. This guide focuses on which work zone related attributes should be included on all state crash report forms, the justification for inclusion of work zone crash data elements, best practices among the 50 states, and how to overcome various challenges when implementing uniform work zone crash data elements. Recommendations are also provided in achieving the work zone related data element inclusion at the state level.			
17 Key Words Attribute Subfield, Attribute Value, Countermeasure, Crash Modification Factor, Data Element, Fatal Crash, Safety Performance Function, Work Zone Crash		18 Distribution Statement	
19 Security Classification (of this report)	20 Security Classification (of this page)	21 No. of pages 32	22 Price

Table of Contents

1.0 BACKGROUND 1

2.0 WORK ZONE CRASH DATA COLLECTION AND REPORTING 3

3.0 BEST PRACTICES - WORK ZONE CRASH DATA COLLECTION 15

4.0 CRASH DATA REPORTING..... 18

5.0 CHALLENGES TO IMPLEMENTING UNIFORM WORK ZONE CRASH DATA
ELEMENTS..... 20

6.0 WORK ZONE CRASH DATA ANALYSIS 21

7.0 CONCLUSIONS AND RECOMMENDATIONS 28

8.0 ADDITIONAL RESOURCES..... 29

9.0 REFERENCES 30

10.0 GLOSSARY 31

List of Figures

Figure 1: Connecticut Uniform Police Crash Report Form (PR-1 REV June 2014.01)..... 4

Figure 2: North Carolina Crash Report Form (DMV-349)..... 4

Figure 3: State of Louisiana Uniform Motor Vehicle Traffic Crash Report (DPSSP 3105 REV.
MAR, 2005) 4

Figure 4: Component Parts of a Temporary Traffic Control Zone (Adapted from 6C-1)..... 8

Figure 5: States Capturing Work Zone Attribute Subfields (Status as of September 2016) 16

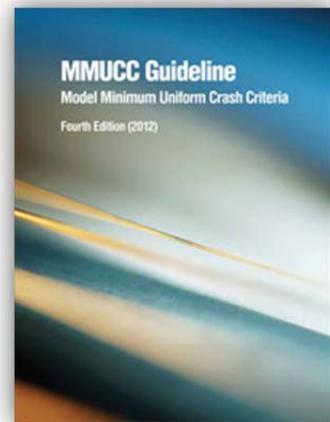
List of Tables

Table 1: Work Zone Traffic Control Safety Countermeasures..... 23

1.0 BACKGROUND

The availability of accurate work zone crash data is important for the identification and analysis of crash trends, to determine the contributing factors of work zone crashes, to develop countermeasures and strategies, and to assist in the development of crash modification factors (CMFs) in work zones. Unfortunately, the quality and consistency of work zone crash data suffers from the variation in procedures required by law enforcement, state departments of transportation (DOTs), and other agencies involved with crash data collection and recordkeeping. Developing a unified system of work zone crash data collection and reporting would result in more accurate crash data, efficiency in crash reporting, and greater uniformity across states.

The Model Minimum Uniform Crash Criteria (MMUCC) Guideline Fourth Edition 2012 (1) recommends the voluntary implementation of a “minimum set” of standardized data elements that can be used to describe a motor vehicle crash on any state crash report form. The *MMUCC Guideline* is based on the American National Standards Institute (ANSI) Standard D16.1-2007 Manual on Classification of Motor Vehicle Traffic Accidents and the ANSI Standard D20.1 Data Element Dictionary for Traffic Records Systems and in close association with the National Highway Traffic Safety Administration’s (NHTSA) Fatality Analysis Reporting System (FARS), National Automotive Sampling System, and Federal Motor Carrier Safety Administration. The *MMUCC Guideline* was developed by an expert panel with members from the United States Department of Transportation (USDOT), Federal Highway Administration, NHTSA, Governors Highway Safety Association, multiple law enforcement agencies, and various public health and safety departments. The general public was also given the opportunity to provide comments.



Many states were interested in standardizing the data elements on their crash report forms in order to share and compare crash data with other states. However, each state having different data element types, along with varying definitions, made this process difficult. As a result, the

MMUCC Guideline was first created in 1998 to help mitigate inconsistencies among states for the crash data that was being collected.

The purpose of the *MMUCC Guideline* is to address uniformity in all areas of crash data collection and reporting, to generate data that can be used to promote comparability, and improve safety at the national, state, and local levels. The USDOT recognizes the *MMUCC Guideline* in having a minimum model set of data elements and offered funding under the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) to states that have adopted or are working towards standardizing their data elements.

The *MMUCC Guideline* contains 110 data elements, 77 of which are recommended to be collected by law enforcement at the scene of the crash. The data elements are divided into four different categories that provide specific details: crash type, vehicle type, person(s), and roadway. States are encouraged to include as many MMUCC data elements as possible when they update their crash report forms. Of the 110 data elements, the *MMUCC Guideline* includes one work zone related crash data element and four work zone related attribute values associated with other crash and vehicle data elements to further describe how the work zone factored into the crash. Some states even include additional work zone related attribute subfields not included in the *MMUCC Guideline* to improve their crash data. These practices are further described in Section 3.

The purpose of this guide is to supplement the *MMUCC Guideline* and describe the work zone crash data collection and reporting process, the benefits and challenges in developing a unified system, including which work zone related attributes should be included on each state's form, justification for inclusion of work zone crash data elements, best practices among the 50 states, and how to overcome various challenges when implementing uniform work zone crash data elements. This guide also includes recommendations on how to perform some typical work zone crash data analyses, how to build a query using various data analysis tools, and how to achieve work zone related data element inclusion at the state level.

2.0 WORK ZONE CRASH DATA COLLECTION AND REPORTING

Crash data is collected by local, county, and state law enforcement agencies and/or statewide highway patrols, depending on the legal jurisdiction of these entities in each state, and the facility on which it occurred. With a few exceptions (e.g., tribal law enforcement), all police officers are trained to collect highway crash data on their state designated crash report forms. Changing or adding data elements requires consultation with law enforcement, road agencies, and others that utilize crash data. All states have some type of user group that initiates and monitors activities related to any changes or additions to the existing crash report form. Typically this group is referred to as the Traffic Records Coordinating Committee (TRCC) that works to “improve the collection, management, and analysis of traffic safety data at the State and Federal level” (2).

Each state’s TRCC operates following a charter or goal(s) as well as a mission statement that describes the mission, principles, rights, and responsibilities. They help create and monitor a traffic record strategic plan that addresses existing deficiencies in crash data collection and specifies how the state will use their funds to help mitigate these issues.

2.1 Crash Data Collection and Reporting Process

Collection of crash data generally occurs during the response phase after first responders have arrived on the scene and secured the area in which the crash occurred. Public safety agencies are trained to secure the site, clear the crash site, remove the crash vehicle, and restore traffic operations to normal. For crashes where fault is readily apparent and injuries are minor, filling out crash data collection forms can be conducted while the scene is being cleared and reopened to traffic. Crashes involving severe injuries and/or fatalities require a more extensive investigation, which can include field measurements of the location of skid marks (if available), vehicle damage details, location of the first harmful event, intermediate event, and final event (if any), crash scene photographs, and other data that are pertinent to the investigation.

Some agencies utilize electronic forms to streamline data collection in the field, which can reduce errors due to handwriting quality or filter out form elements that are not relevant for a particular crash. Some agencies take this a step further and allow transmission of electronic data forms from the scene to a central recordkeeping office, which can facilitate real-time error checking and requests for additional information, while the officer is still at the crash scene. Some, however, still require officers to fill out paper forms on the scene that are converted into a digital format at a later time. When this occurs with more than one person involved, it introduces an increased possibility for errors and omissions.

A typical crash report form requires a multitude of data elements that need to be collected and entered. These data elements provide details regarding the crash, vehicle, driver, passenger (as applicable), and roadway. All crash report forms also include a diagram and narrative section where an officer can provide additional information. Typically the work zone related crash data element (see Figure 1) is located with other related crash data elements. Crash report forms may also include work zone related attribute values associated with other data elements used to describe a contributing roadway circumstance (see Figure 2) or sequence of harmful events (see Figure 3).

WORK ZONE CRASH INFORMATION				
For all numeric fields: 99 = 'Unknown'		Complete all for crashes occurring in a Work Zone		
WORK ZONE 01. No 02. Yes	LOCATION 01. Before the First Work Zone Warning Sign 02. Advance Warning Area 03. Transition Area 04. Activity Area 05. Termination Area 88. Not Applicable	TYPE 01. Lane Closure 02. Lane Shift / Crossover 03. Work on Shoulder or Median 04. Intermittent or Moving Work 88. Not Applicable 97. Other	WORKERS PRESENT 01. No 02. Yes 88. Not Applicable	ENFORCEMENT PRESENT 01. No 02. Yes 88. Not Applicable
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 1: Connecticut Uniform Police Crash Report Form (PR-1 REV June 2014.01)

(12-13) Contributing Circumstances, Roadway (Maximum - two per crash)

- 0 None (no unusual conditions)
- 1 Road Surface Condition
- 2 Debris
- 3 Rut, holes, bumps
- 4 Work zone (construction, maintenance, utility)**

Figure 2: North Carolina Crash Report Form (DMV-349)

SEQUENCE OF EVENTS/HARMFUL EVENTS

- | | |
|---|-------|
| S. MOTOR VEHICLE IN TRANSPORT | LL. T |
| T. PARKED MOTOR VEHICLE | MM. T |
| U. STRUCK BY FALLING, SHIFTING CARGO OR ANYTHING SET IN MOTION BY MOTOR VEHICLE | NN. C |
| V. WORK ZONE/MAINTENANCE EQUIPMENT | OO. F |
| | PP. M |
| | QQ. C |

Figure 3: State of Louisiana Uniform Motor Vehicle Traffic Crash Report (DPSSP 3105 REV. MAR, 2005)

2.2 MMUCC Guideline Crash Data Elements

The *MMUCC Guideline* is a document to help inform states on what “minimum set” of data elements should be included when updating their crash report form. The *MMUCC Guideline* promotes uniformity to help improve the sharing of data at a national level, and includes crash, vehicle, person, and roadway related data elements. Each data element contains multiple attribute values that explain the crash and other contributing factors. The work zone related crash data element contains five attribute subfields to provide further details about the crash.

The *MMUCC Guideline* briefly discusses all crash data, therefore, the discussion of work zone related data collection does not go into great detail on why it is important to collect these items. This guide provides a detailed breakdown of the work zone related crash data element and defines the meaning of each work zone attribute subfield along with their values, as well as explains the purpose of collecting the work zone crash data necessary for better addressing work zone safety. It also includes these elements in the updating process of each state’s crash report form.

2.3 Work Zone Related (Construction / Maintenance / Utility) Crash Data Element

The *MMUCC Guideline* includes one work zone related crash data element (C19 – Work Zone Related) that should be included on the Police Accident Report (PAR) and collected at the scene of the crash. The following is the *MMUCC Guideline’s* rationale for inclusion in the PAR:

“Important to assess the impact on traffic safety of various types of on-highway work activity, to evaluate Traffic Control Plans used at work zones, and to make adjustments to Traffic Control Plans for the safety of workers and the traveling public. This data element needs to be collected at the scene because work zones are temporary or moving operations that are not recorded in the permanent road inventory files.”

This data element includes the following five subfields to further clarify the work zone related crash attributes:

- **Subfield 1:** Was the crash in a construction, maintenance, or utility work zone or was it related to activity within a work zone?
- **Subfield 2:** Location of the Crash
- **Subfield 3:** Type of Work Zone
- **Subfield 4:** Workers Present
- **Subfield 5:** Law Enforcement Present

Subfield 1: Was the crash in a construction, maintenance, or utility work zone or was it related to activity within a work zone?

Determine if the crash is considered a work zone related crash:

- Yes
- No (then remaining subfields do not apply)
- Unknown

This field represents a high-level flag to identify whether the crash is “work zone related.” The *MMUCC Guideline* defines a work zone related crash as:

“A crash that occurs in or related to a construction, maintenance, or utility work zone, whether or not workers were actually present at the time of the crash. “Work zone-related” crashes may also include those involving motor vehicles slowed or stopped because of the work zone, even if the first harmful event occurred before the first warning sign.”

The determination of whether or not a crash is “work zone related” may sometimes be immediately apparent, such as a crash involving a fixed-object collision with a jersey barrier. However, a crash occurring a half-mile upstream from the first warning sign, due to queuing from a work zone related lane closure, may not be as obvious. To make this determination

requires an understanding of how work zones influence traffic and is one of the more important responsibilities of on-site personnel in charge of crash data collection.

If a crash is considered to be a work zone related crash, the officer should indicate “Yes” on the form and fill out the remaining subfields. If the crash is not considered to be a work zone related crash, the officer should indicate “No” and no further action is then required. If it is unknown whether or not the crash is work zone related, the officer should indicate “Unknown” and fill out the remaining subfields.

Subfield 2: Location of Crash

After determination of the work zone related nature of a crash, it is important to indicate the location. The *MMUCC Guideline* defines the location of the crash into the following five different areas which are graphically presented in Figure 4 [adapted from the Manual on Uniform Traffic Control Devices (MUTCD) (3)]:

- **Before the First Work Zone Warning Sign:** Any crash that occurs ahead of the first advance warning sign, but is still related to the work zone. This type of crash is frequently associated with traffic congestion and queuing from a capacity restriction associated with the work zone. Another possibility could be drivers reacting to traffic notifications from mobile navigational aids or radio traffic reports and making a sudden action to avoid a work zone (i.e., suddenly exiting at a ramp). Drivers may react to traffic control devices not directly related to the work zone, such as permanent variable message signs, that display information about work zones downstream – technically ahead of the first “work zone warning sign,” by the MUTCD definition of work zone warning signs. When the officer first arrives at the scene of the crash, a judgement call on whether or not the crash was indirectly related to the work zone must be made. For this data element to provide effective data, it is necessary that an agency have consistent practice with respect to (1) identifying downstream conditions as associated with work zone activity and (2) basing their determination of “work zone related” crashes uniformly.

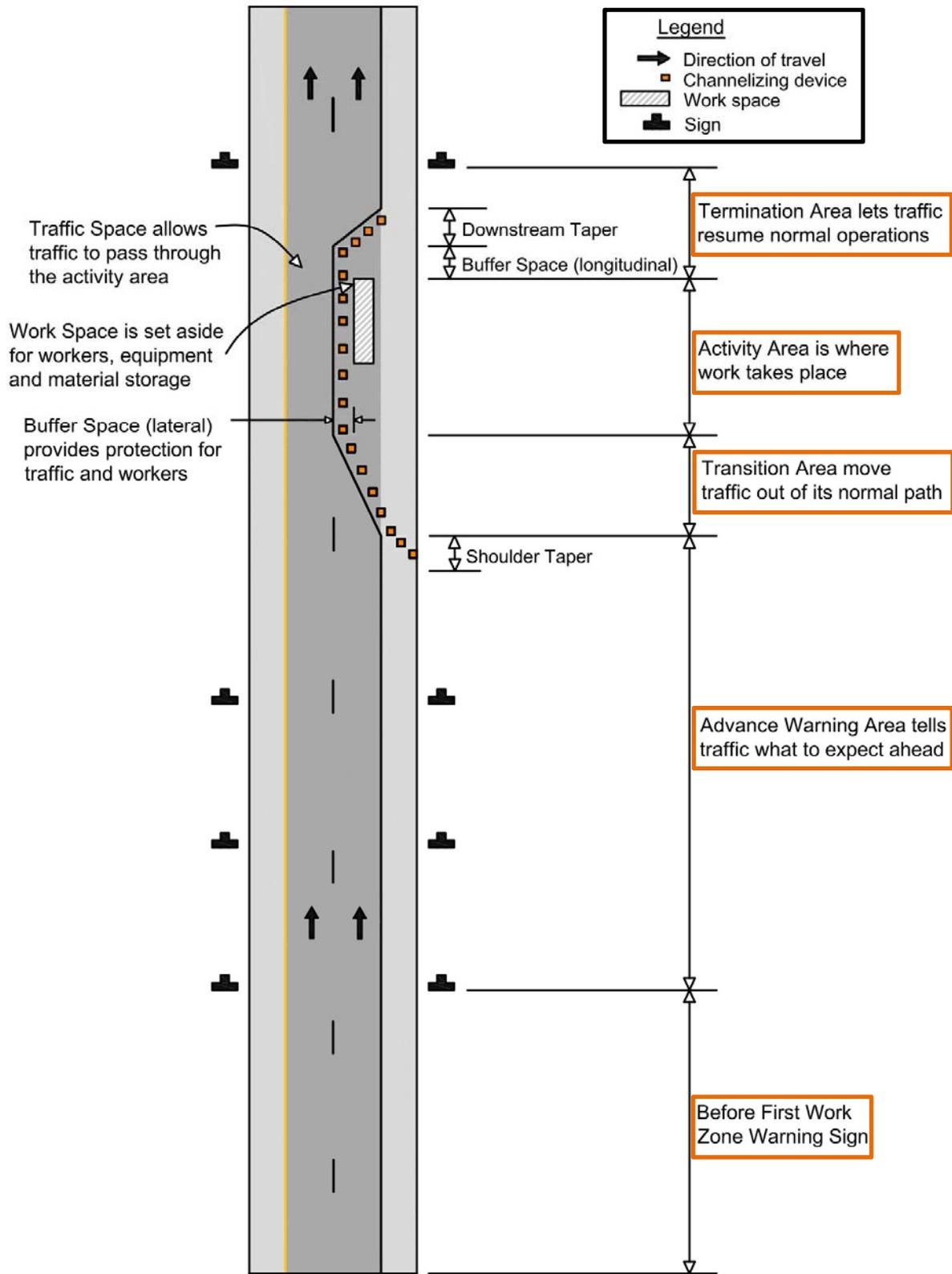


Figure 4: Component Parts of a Temporary Traffic Control Zone (Adapted from 6C-1)

- **Advance Warning Area** includes any crash that occurs in the space between the first advance warning sign and the start of the transition area. This type of crash may result from erratic or distracted driver behavior due to an improper advance warning area setup. Indications of an improper advance warning area setup may include the following:
 - Poor Visibility of Advance Warning Signs (i.e., covered by tree, poor retro-reflectivity, sign placement and visibility issues, etc.)
 - Effect: Sudden Lane Changing Maneuvers
 - Potential Result: Sideswipe Same Direction Crash
 - Longer than Expected Queuing
 - Effect: Sudden Braking
 - Potential Result: Rear-End Crash
- **Transition Area** includes any type of crash that occurs in the roadway space that accommodates the tapers. This area moves the traffic out of the normal path of travel to a new path, often through the use of channelizing devices (e.g., drums, cones, barricades, etc.). This type of crash may occur due to an improper taper length, spacing of cones, and high approach speed.
- **Activity Area** includes any type of crash that occurs where the work is taking place, such as the work space, which is the area of the roadway where workers, equipment, and material are located and is closed to road users, the traffic space which is the area of the roadway where road users are routed through the activity area, and the buffer space which is a lateral or longitudinal area of unoccupied space that provides added protection to the worker(s). This type of crash may happen if the activity area encroaches the travel space and there is insufficient space to allow road users to pass through.
- **Termination Area** includes any type of crash that occurs between the end of the work space and the last temporary traffic control device. Temporary traffic control devices may include an “End Road Work” or “Speed Limit” sign to inform road users they are no longer in a work zone. This type of crash may happen when road users are transitioning back to their original path and there is an improper downstream taper or no taper at all.

Subfield 3: Type of Work Zone

“Type” of work zone refers to the degree to which traffic control represents a modification to the existing traffic pattern. The *MMUCC Guideline* lists four work zone types along with an “Other” category if the work zone type is unique:

- A **lane closure** is when the number of lanes is reduced that requires traffic to merge into an adjacent travel lane.
- A **lane shift/crossover** is when the lane(s) is maintained, but the alignment is modified to affect a lateral shift to avoid the need for closure of the travel lane(s). Typical temporary traffic control (TTC) devices indicating a lane shift/crossover would include a shifting taper and/or a “STAY IN LANE” sign.
- **Work on a shoulder or median** occurs when the shoulder is closed to traffic in order to accommodate an activity area near or overlapping the roadway shoulder. Typical TTC devices indicating work on a shoulder or median would include a shoulder taper, a “SHOULDER WORK” sign, or a “RIGHT SHOULDER CLOSED” sign.
- **Intermittent or moving work** is when the work area is continuously or intermittently moving. Such work may include roadway striping, street sweeping, mowing, joint sealing, pothole filling, pavement marking removal, or cleaning activities (e.g., debris removal, storm drain cleaning, etc.). Typical TTC devices indicating intermittent or moving work may include a convoy of multiple work vehicles (e.g., work vehicles, shadow vehicles, etc.), truck mounted arrow boards, active law enforcement traffic control, portable changeable message signs, and temporary roll-up signs.
- **Other** can be selected if the type of work zone does not fit any of these categories.

Subfield 4: Workers Present

Indicate whether or not workers were present in the TTC zone at the time of the crash.

- No
- Yes
- Unknown

Workers do not need to be present in order for the crash to be considered a work zone related crash. Anecdotal evidence suggests that drivers react differently to work zones, depending upon whether or not work activities are ongoing.

Subfield 5: Law Enforcement Present

Determine if law enforcement was present:

- No
- Officer Present
- Law Enforcement Vehicle Only Present

The presence of law enforcement in the work zone helps to prevent speeding or errant vehicles from entering the activity area and will deter vehicles from driving recklessly. Law enforcement may also be used to help direct traffic in conditions where traffic control is needed, such as at intersections or detours. Depending on the scenario, the officer can be stationed on the shoulder within the advance warning area, within the activity area upstream of the work space, or as part of a mobile operation convoy. The MUTCD (3) notes law enforcement may be present in the following typical work zones:

- Temporary Road Closure (TA-13)
 - Law Enforcement Location: Upstream of Work Space
- Mobile Operations (TA-17)
 - Law Enforcement Location: Additional Shadow Vehicle
- Closure at Side of Intersection (TA-27)
 - Law Enforcement Location: Upstream of Work Space
- Work in Vicinity of Grade Crossing (TA-46)
 - Law Enforcement Location: Upstream of Work Space and Rail Tracks

2.4 Work Zone Related Attribute Values Associated with Other Data Elements

The *MMUCC Guideline* also includes work zone related attribute values for other data elements to further clarify whether or not a work zone influenced the motor vehicle crash. The work zone related attribute value should be selected by an officer if it was associated with any of the other MMUCC data elements as well:

C7. First Harmful Event – “The first injury or damage-producing event that characterizes the crash type”

- Collision with Person, Motor Vehicle, or Non-Fixed Object
 - Work Zone / Maintenance Equipment

C15. Contributing Circumstances, Road – “Apparent condition of the road which may have contributed to the crash”

- Road Circumstances
 - Work Zone (construction/maintenance/utility)

V20. Sequence of Events – “The events in sequence related to this motor vehicle, including both non-collision as well as collision events”

- Collision with Person, Motor Vehicle, or Non-Fixed Object
 - Work Zone / Maintenance Equipment

V21. Most Harmful Event for this Motor Vehicle – “Event that resulted in the most severe injury or, if no injury, the greatest property damage involving this motor vehicle”

- Collision with Person, Motor Vehicle, or Non-Fixed Object
 - Work Zone / Maintenance Equipment

2.5 Justification for Inclusion of the Work Zone Crash Data Elements

Identifying work zone crashes, injuries, and fatalities is essential to develop programs and initiatives that are targeted to improve safety and mobility in construction and maintenance work zones. Highway and permanent traffic control designs generally follow AASHTO and MUTCD standards, whereas in temporary traffic control, proper strategies may not be in place due to a variety of factors including:

- Lack of site-specific design considerations in work zone traffic control
- Deficiency in field inspection
- Lack of nighttime inspection and deterioration of retro-reflective performance of the traffic control devices used in temporary traffic control

Understanding work zone crash causation factors allows for the inclusion of various work zone crash data elements and attributes. It may also assist in developing crash countermeasures. For example, identifying the type of work zone such as construction, maintenance or utility work zone is useful in developing future countermeasures that can alleviate similar work zone crashes. The location of work zone crashes is most important in:

- Providing/increasing buffer spaces
- Creating safety protection for workers in case an errant vehicle intrudes into the work area
- Developing countermeasures related to increasing visibility, reducing approach speed, and other measures, not only for future work zone traffic control of similar situations, but also to implement additional traffic control treatments in the same work zones if they happen to be in intermediate or long term projects. For example:
 - If a crash occurs in the taper area that is indicative of an excessive approach speed, various measures such as, increasing the taper length and/or reducing the drum/cone spacing to increase work zone visibility may be implemented
 - Crashes associated with a high approach speed may be treated with installing removable rumble strips

- Crashes occurring in the work zone approach area may require a human factor-related analysis to identify various causal factors such as, information system deficiency, information overload, and others that may require additional positive guidance treatments through the work zone

Availability of location data for work zone crashes allows safety analysts/engineers to identify potential issues/factors that may have contributed to a specific crash. Identifying such potential factors may also assist in selecting countermeasures that will alleviate similar occurrences. For example, Table 1 in Section 6.0 shows some typical work zone crash types, probable issues, and possible countermeasures. The table shown is an example of what state agencies should study with regard to work zone crashes and developing similar data. This will allow construction engineers/supervisors to identify and implement countermeasures in the field to alleviate the possibility of similar crashes occurring again, especially for intermediate and long term construction projects.

3.0 BEST PRACTICES - WORK ZONE CRASH DATA COLLECTION

Each of the 50 states, as well as the District of Columbia, has their own crash report form along with supplemental reports that an officer has to fill out when a crash occurs. Every state crash report form, including the District of Columbia, along with applicable supplemental reports, can be found by accessing the Wayne State Work Zone Safety Crash Report Form Website (http://workzone.eng.wayne.edu/crash_report/report.html) (4). The crash report forms are organized in alphabetical order, indicating the report number and last revision date; however, the crash report form may change based on the updating efforts from individual states.

The *MMUCC Guideline* provides guidance on recommended practices regarding what work zone attributes should be included in a typical crash report form with the intention of promoting a consistent structure for crash reporting, enhancing the interchangeability of crash data between states, and facilitating a broad examination of crash characteristics on a national level. However, there is still a wide variance among the 50 states regarding the types of work zone crash data that are collected. Some states, such as Louisiana, will only classify a crash as “work zone related” if it occurs within the limits of the first warning sign. Such practices can exclude crashes resulting from secondary work zone effects.

This type of variability does not allow comparison of work zone safety across states or allow for the development of reliable national performance measures for work zone safety. This section describes the distribution of states according to the extent to which their process mirrors the *MMUCC Guideline*, other similarities between how individual states collect work zone crash data, and the existence of state practices that go further than the *MMUCC Guideline’s* recommended practice. The status of each state is highlighted in Figure 5.

3.1 Full MMUCC Guideline Inclusion of Work Zone Crash Data Element

Ten states, including Alaska, Connecticut, Florida, Idaho, Iowa, Maine, New Hampshire, Ohio, Pennsylvania, and Virginia collect data in accordance with the *MMUCC Guideline’s* work zone crash data element C19. This includes all work zone related attribute subfields and values as indicated in Section 2.3.

3.2 Partial MMUCC Guideline Compliance

Even though all states do not fully collect work zone crash data in accordance with the *MMUCC Guideline*, 90% of the states have some sort of determination on their crash report form to acknowledge whether or not the crash occurred in or was related to a work zone. Figure 5 (page 16) shows 23 states indicate the location of the crash within the work zone, 24 states indicate the type of work zone, 25 states indicate if workers were present, and 10 states indicate if law enforcement was present.

3.3 States Not Following MMUCC Guideline Recommended Practices

Five states, including California, Delaware, Kentucky, Nevada, and Vermont, do not follow any of the *MMUCC Guideline's* recommended practices for collecting work zone crash data. However, California, Kentucky, Nevada, and Vermont do include a work zone related attribute value(s) for other data elements, such as contributing circumstances, to further clarify whether or not a work zone influenced the crash.

3.4 Other State Practices Not Included in MMUCC Guideline

Some states include work zone attributes that are not listed in the *MMUCC Guideline*. Sixteen states include a work zone related attribute subfield named, “Work Zone Activity,” or similar, indicating whether the crash occurred during a construction, maintenance, or utility activity. Minnesota’s crash report form includes a diagram specifying the different locations (e.g., Transition Area, Activity Area, etc.) of a work zone to help assist the officer filling it out. Pennsylvania and West Virginia include work zone speed limit and Pennsylvania includes additional lane closure information.

4.0 CRASH DATA REPORTING

Crash data collection is a field activity that is performed by the police officer arriving at the scene of a traffic crash. This officer can belong to a local city/township, be a county sheriff, or belong to a state police department. Typically, all police officers in the field are trained to collect necessary data for the crash report form in the jurisdiction within which they were certified. All states have a report review protocol that the supervising officer must follow before reporting the data at the respective state's data repository. In some instances, the field crash report forms (hard copy) are reviewed for accuracy and then entered to form digital databases. The digital database is then transferred to the statewide repository and further reviewed for accuracy. Any modifications required are completed before finalizing the unified statewide database. The final step in the reporting process is to provide the necessary data to a national database system, such as the FARS Encyclopedia for all fatal crashes.

The implementation of quality assurance when using hard copy crash data collection can be time consuming and labor intensive due to the following:

- Transitioning and archiving manual data entry from a hard copy to a digital database
- Trying to interpret illegible handwriting often compounded by changing environments while notetaking in the field
- Trying to verify inconsistent notation and technique between officers in preparation of crash diagrams
- Correcting errors, such as duplicate crash report numbers, incomplete data fields, or incorrect data element codes

A transition to methods allowing electronic crash data collection forms and utilizing appropriate tools, software, and proper training for both officers and supervisors can correct some of these issues. The implementation of quality assurance when using most electronic in-field crash data collection software is simplified and more reliable due to the following benefits:

- Misspellings and coding errors associated with data elements are reduced by limiting options for data entry into drop down lists of plain-text responses and auto-filling text
- A supervisor's review can be expedited since submission of the electronic form is instantaneous using a web-based deployment and centralized database
- Time for data entry is minimized with drop down lists and auto-filling text since an officer no longer needs to review a "cheat sheet" to find the correct code associated with various data elements
- The location of a crash can now be exact using Global Positioning System (GPS) units rather than approximating the distance to the nearest intersection
- Data can easily be exported to other databases to share with state and federal agencies

Many states are transitioning to electronic traffic crash reporting to help simplify the data collection process and reduce administrative responsibilities. There are various online tools and software available for states to perform electronic traffic crash reporting, such as Traffic and Criminal Software (TraCS) (5), ReportBeam (6), LexisNexis eCrash (7), Spillman (8), and Advanced Public Safety eCrash (9). Among the 50 states, there are at least 14 states that have agencies (local and/or state) that use the TraCS software (10). ReportBeam is currently available in over 25 states with the states of Mississippi, West Virginia, Virginia, and Wyoming adopting ReportBeam as their statewide reporting software (6). Spillman currently serves more than 1,800 agencies in 43 states nationwide (11). While most of the electronic traffic crash data collection and reporting software is comparable, the Arizona Department of Transportation performed a study (12) that further breaks down the system elements of each one.

Some states also use state-specific online tools and software, such as Alabama, who uses their eCite (13), Georgia, who uses their Georgia Electronic Accident Reporting System (GEARS) (14), Indiana, who uses their Electronic Vehicle Crash Records System (eVCRS) (15), and Louisiana, who uses their LACRASH (16). It is evident that the trend of states transitioning to electronic traffic crash reporting is moving in an upward direction.

5.0 CHALLENGES TO IMPLEMENTING UNIFORM WORK ZONE CRASH DATA ELEMENTS

The number of work zone related elements included is typically a small number of the entire data entry requirements for crash data collection forms. However, in encouraging agencies to institutionalize the collection of more detailed work zone elements in their crash data collection processes, the benefits must be communicated while balancing the competing needs for data space. These may include engineering, driver related, and enforcement related elements. The following strategies may assist agencies in expanding their collection of work zone data elements:

1. Emphasizing the importance of the minimum requirements set forth in the *MMUCC Guideline* and encouraging stakeholders/policy makers to use the work zone related crash data element with the corresponding attribute subfields and values included. Agencies may develop other work zone related data elements and options that are not included in the *MMUCC Guideline*, such as work zone activity (maintenance, utility, and construction), to determine how the activity relates to work zone crashes.
2. Preparing a concise document articulating short term, and long term benefits of work zone crash data. For example, location, characteristics, and type of crashes in intermediate or long term work zones may allow the application of treatments that could be site-specific, and would alleviate the occurrence of similar crashes at the same site. An analysis of crashes considering several similar sites and traffic scenarios may allow for the development of a targeted countermeasure that can be used as a part of the future temporary traffic control plan (TTCP) development.
3. Presenting your proposal to the state's crash report task force/user group that is often referred to as the Traffic Records Coordinating Committee (TRCC). These groups include local and state enforcement officials, engineers, trainers, and administrators. Changing a crash report form requires the understanding and approval of all stakeholders, and the consideration of impacts on current software and grass-root training. However, making changes to include or modify work zone related attributes can accompany other changes in the crash report form.

6.0 WORK ZONE CRASH DATA ANALYSIS

In order to perform an effective work zone safety analysis, the appropriate work zone crash data needs to be available. The availability of this data is only as good as what is collected on the state crash report form. In order to develop work zone traffic control safety countermeasures, it is essential to have usable work zone data, such as the location of the crash, type of work zone, etc. Using data analysis tools, such as the FARS Encyclopedia or other tools, as described in Section 6.1, allow agencies to review the number of work zone crashes and determine if additional work zone crash data is needed to perform an effective safety analysis. If it is determined that certain work zone subfields are needed, then agencies can encourage the TRCC to include them as a part of the next state crash report form update.

Including appropriate work zone crash data elements in the crash report form will allow stakeholders to:

1. Perform an area-wide effectiveness evaluation of work zone treatments
2. Perform an effectiveness evaluation of typical countermeasures and emerging technology applications
3. Determine the safety consequences of work zone traffic control strategies
4. Conduct an analysis of site specific crashes in intermediate and long term work zones.

Such analyses may result in modifying traffic control treatments in future work zone projects and developing standards that enhance safety and make work zones user friendly. While the crash analyses noted above are often completed to improve safety for future projects, access to work zone crash data and analysis tools may assist work zone traffic control professionals in the implementation of countermeasures during construction to alleviate the recurrence of some of the same crashes at the same site, especially for intermediate and long term work zones.

Analysis of work zone crash data may consist of the following:

1. A site specific analysis of individual crashes that may lead to modifying work zone traffic control treatments at the site for intermediate and long term work zones (see Table 1).
2. Analyzing groups of similar work zone sites to develop future TTCPs for such situations.
3. Determining crash and severity trends at typical work zone locations.
4. Developing safety performance functions and crash modification factors for highway work zones for application in the prediction of safety consequences in work zones. Such data will improve the crash prediction and analysis of future projects and in the development of optimal work zone traffic control strategies as well as in implementation planning (17).

Improvements to work zone crash data collection will provide a better long-term understanding of crash causation within a work zone. Developing countermeasures to assist with possible policies and standards, in order to create safer work zones, may require a systematic analysis that would include:

1. Determining the location of the crash, the time of day or night, the type of crash (e.g., single vehicle, rear end, head-on, etc.), and environmental conditions.
2. Based on the crash report and the investigating officer's narrative and diagram, possible relevant factors can be determined, such as speeding under the current conditions, distracted driving, sight distance problems due to roadway geometry, visual clutter, information overload, and other relevant factors.
3. Additional data needs, such as a detailed crash report, construction and maintenance plans and standards, citation reports, drive through studies, reviews of TTC, traffic volume data, and approach speed data should be determined. Some of the noted data are generally available and some may need to be collected.

Table 1: Work Zone Traffic Control Safety Countermeasures

CRASH TYPE	POTENTIAL ISSUE	OBJECTIVE	WORK ZONE MODIFICATION
Single Motor Vehicle	Improper Use of Channelizing Devices	Mitigate Errant Vehicles	Decrease Channelizing Device Spacing
			Increase Buffer Zone
			Add Temporary Traffic Barriers and/or Crash Attenuators as appropriate
			Add Barricades, Warning Lights, and/or Delineators
			Various Intelligent Transportation Systems (ITS) Deployment
Rear-End	Sudden Queuing	Increase Braking Distance	Increase Distance of Advance Warning Signs. Consider Adding Beyond the Minimum Traffic Control Device
	Speeding	Promote Alert Driving	Decrease Work Zone Speed Limit
			Add Law Enforcement
			Add Portable Rumble Strips
Various ITS Deployment			
Angle	Sight Distance Issue at Access Points (e.g., Driveways)	Increase Line of Sight	Provide Flagger
			Provide Alternate Access and Temporarily Close Driveway
			Restrict Left-Turning Movements Out of Driveway
Head-On Left-Turn	Improper Signal Timing	Create Greater Temporal Separation of Conflicting Traffic	Provide Protected Left-Turns (e.g., Split Phasing)
Head-On; Sideswipe-Opposite	Improper Lane Delineation (e.g., Lane Shift)	Improve Adherence to Lane Lines	Increase Lane Width
			Add Temporary Raised Pavement Markers and/or Islands
			Add Temporary Pavement Markings (i.e., Override Permanent Pavement Markings)
			Add Temporary Lane Separators
	Improper One-Way Traffic Control		Provide Temporary Traffic Control Signal
			Provide Flagger
Sideswipe-Same	Improper Merging Maneuvers	Restrict Lane Change Behavior	Modify Taper to Accommodate Approach Speed
			Provide Arrow Board

4. Countermeasures to alleviate similar crash occurrences may include use of:
 - a) Dominant traffic control devices, such as arrow boards, changeable message signs, etc.
 - b) Speed reduction measures such as portable rumble strips
 - c) Increased buffer space
 - d) Enforcement
 - e) Advanced warning strategies, such as end of queue warning systems, dynamic lane merge systems (early and late)
 - f) Increased inspection and maintenance of traffic control devices for nighttime visibility
 - g) Lighting

It is important to note road user characteristics may vary, and therefore, the effectiveness of a standard TTCP may require modifications to minimize the risk of work zone related traffic crashes and injuries.

Considerations for developing safety performance functions and crash modification factors are the topic of another guideline (17).

6.1 Data Analysis Tools

All data elements such as crash type, crash severity, traffic control, weather, lighting condition, road condition, year, area of road, time of day, speed, driver citation data, and driver distraction data can be used to analyze work zone crashes. Many states have their own “Excel-based” or similar analysis tool available that stores data collected from every crash report and provides the opportunity for use by stakeholders and in some cases the public. Each state’s online storage tool typically contains a query of a wide variety of filters that can be used to search for crashes that meet a set of specific criteria. Comprehensive data summaries that are updated annually are also made available online for users. The work zone safety compendium (<http://workzone.eng.wayne.edu/#compendium>) provides access to all states’ data query tools or the annual data summaries that can be used by the road agencies to perform the necessary

analysis. The following sections (6.2 and 6.3) discuss some example problems using the State of Michigan's and FARS's data query tool.

6.2 Michigan Traffic Crash Facts Data Query Tool

Michigan uses an online data query tool, Michigan Traffic Crash Facts (MTCF) [<https://www.michigantrafficcrashfacts.org> (18)], where a user can build their own query and filter any of the data elements identified on the Michigan crash report form (UD-10). The MTCF can provide the results of the query in the form of a map, table, list, chart, and calendar, or provide a copy of the actual crash report (UD-10) form(s).

For example, if a user is interested in determining the overall frequency of “sideswipe same direction” type of work zone crashes in the transition areas within the State of Michigan for the year 2013 by using the MTCF data query tool, the following filters can be used:

1. Year – 2013
2. Geographic Area – Entire State
3. Analysis Level – Crash
4. Construction Type – Construction/Maintenance; Utility
5. Crash Type – Sideswipe Same Direction
6. Construction Lane Closed – Lane Closed

Once the noted characteristics and appropriate optional categories are selected, the results will be displayed. In the above example, the result was 318 crashes. In this case, there were no other work zone related variables/attributes in the crash report form (UD-10) in 2013. Therefore, other necessary details related to location within the work zone for any crashes were not possible. Queries can be performed by any geographic area, route designation, and other variables.

Another example would be if a user is interested in determining sideswipe same direction crashes in work zones with and without arrow board devices included in the TTCP, using similar filters as above, an analysis can be performed using the following criteria:

1. Select route names/numbers to form test and control sites with and without the use of arrow boards from the construction document files. A group of locations may be selected for both the test and control sites.
2. Select locations for both groups can then be queried individually to capture sideswipe same direction crashes for the selected year. The severity of crashes can also be determined.
 - a. Geographic Area – Intersection
 - b. Worst Injury in Accident – Fatal; A; B; C; No Injury
3. Compare number of crashes at the selected locations that used an arrow board in the temporary traffic control against selected locations that did not.
4. Perform an appropriate analysis including statistical tests.
5. Summarize the results and prepare reports.

6.3 Fatality Analysis Reporting System Data Query Tool

While individual states vary in the extent to which they account for work zones in crash data collection procedures, the involvement of work zones is identified for all fatal crashes nationwide in the FARS Encyclopedia [<http://www.nhtsa.gov/FARS> (19)]. The FARS Encyclopedia, created by NHTSA, is an online tool made available to the crash data user containing data on all vehicle crashes involving fatalities in the United States occurring on public roads. Similarly, a user can build their own query by selecting specific crash, occupant, vehicle, driver, or pre-crash fields to filter fatal crashes meeting specific criteria. There is also the option to filter the tool by state. The FARS Encyclopedia provides the results in the form of a table that can be extracted into Excel or a chart.

If a user wants to determine the overall frequency of fatal “rear-end” crashes, nationwide, for the year 2013 by using the FARS data query tool, the following can be used:

1. Choose a Year – 2013
2. Choose the Tables to Query – Option 1 (Crash / Person)
3. Choose Variables to Use – Work Zone; Manner of Collision
4. Choose the Condition Criteria

- State – All
- Manner of Collision – Front-to-Rear (Rear-End)
- Work Zone – Construction; Maintenance; Utility; Work Zone Type Unknown

5. Choose the Report Format Options

Once the noted steps have been completed, the report will be displayed. In this case, the output is 107 crashes. Other than allowing the user to query the work zone activity (Construction, Maintenance, Utility, Unknown), the FARS Encyclopedia does not include any other work zone attribute subfields as mentioned in Section 2.3. Therefore, other necessary details, such as location within the work zone or type of work zone, are not possible.

Further analysis of fatal work zone crashes can also be performed using the FARS data query tool. For example, in determining if fatal rear-end crashes are occurring due to sudden queuing upstream from the work zone, performing similar steps as noted above can result in an analysis being performed using the following filters:

1. It is assumed sudden queuing within the work zone would primarily occur during the peak hour of traffic, so the user can search for the frequency of rear-end fatal crashes within a work zone during the AM and PM peak hour of traffic.
 - a. Additional Variables to Use – Crash Hour; Day of Week
 - b. Additional Condition Criteria
 - i. Crash Hour – 7:00 am to 8:59 am and 4:00 pm to 5:59 pm
 - ii. Day of Week – Monday through Friday
2. Compare the number of total fatal rear-end crashes (107) against the number of fatal rear-end crashes during the peak hour of traffic (18).

It should be noted the FARS database currently does not include any work zone data elements as included in the *MMUCC Guideline*. States are encouraged to model their crash report form to follow the data elements outlined in the *MMUCC Guideline* since these data elements are different and more detailed than the data elements included in the FARS database. For example, the work zone related attribute subfields included in the *MMUCC Guideline* are comprehensive, and the FARS database only allows a user to query the work zone activity (Construction, Maintenance, and Utility).

7.0 CONCLUSIONS AND RECOMMENDATIONS

Work zone data elements, as recommended in the *MMUCC Guideline*, are essential for identifying factors that may have caused or contributed towards a crash in or around a highway construction zone. Many states update their PAR forms based on stakeholder needs and desires. Coordination with existing and ongoing PAR updating efforts can make work zone data element additions easier to implement. TRCC members at the state level are also a great source of information and guidance to learn about the needs and desires for upcoming PARs. In addition, preparing documentation that includes stakeholder needs and desires, and potential safety benefits related to work zone crash analysis and development of countermeasures generally assist in convincing policy makers and leaders to support initiatives to add work zone data elements in a PAR. States that have been successful in implementing, and in some instances exceeding the *MMUCC Guideline* suggested work zone crash related attributes, have done so with the support of a key policy maker/leader that champions the cause. In all of the instances, the crash data user groups have created a “needs” list to inform the policy makers of desired changes. The following steps may assist in achieving the work zone related data element inclusion at the state level:

1. Recognize the use of various data elements in safety data analysis, countermeasure selection, and safety evaluation.
2. Build a coalition of stakeholders who are interested in the inclusion of additional work zone data elements in the state PAR.
3. Prepare documentation for state policy makers to consider.
4. Prepare a cost estimate, as necessary, for such a change. Cost and time of training is generally a major factor that often influences the frequency of changes in the PAR.
5. Identify agency champions that have the authority to institute change in work zone crash data collection.
6. Consult the Federal Highway Administration (FHWA), NHTSA and other states who have already achieved the inclusion of work zone data elements in their PAR.

At a national level, increased standardization of state PARs around the *MMUCC Guideline* will facilitate data sharing and development of national policies, considering the broad examination of state work zone crash history with the end goal of improving work zone safety.

8.0 ADDITIONAL RESOURCES

- Refer to the Wayne State University – Transportation Research Group Work Zone Safety Homepage (<http://workzone.eng.wayne.edu>) for other products developed under the FHWA Work Zone Safety Grant, as well as the *Temporary Traffic Control Plan Selection Software* and *Work Zone Safety Compendium of Documents*.
- National Work Zone Safety Information Clearinghouse:
<https://www.workzonesafety.org>
- FHWA Work Zone Management Program:
<https://ops.fhwa.dot.gov/Wz/index.asp>
- American National Standard ANSI D16.1-2007 Manual on Classification of Motor Vehicle Traffic Accidents 7th Edition:
<https://safety.fhwa.dot.gov/rsdp/toolbox-content.aspx?toolid=7>
- American Association of Motor Vehicle Administrators ANSI-D20 Standard for Traffic Records Systems
<http://www.aamva.org/D20>
- National Highway Traffic Safety Administration Traffic Records Website:
<https://www.nhtsa.gov/research-data/traffic-records>
- National Cooperative Highway Research Program (NCHRP) Synthesis 350 Crash Records System: A Synthesis of Highway Practice:
<http://www.trb.org/Publications/Blurbs/152328.aspx>
- Investigator’s Manual for the Connecticut MMUCC V4 Crash Report, January 1, 2015
http://www.cti.uconn.edu/wp-content/uploads/2013/01/Investigator-Guide-V12_8_26_2014.pdf

9.0 REFERENCES

1. Model Minimum Uniform Crash Criteria (MMUCC) Guideline, Fourth Edition, NHTSA and GHSA, 2012.
2. DOT / TRCC Home: <https://www.transportation.gov/trcc>
3. Manual on Uniform Traffic Control Devices (MUTCD), FHWA, 2009.
4. State Crash Report Forms: http://workzone.eng.wayne.edu/crash_report/report.html
5. TraCS: <http://www.teginc.com/software.html#TraCS>
6. Report Beam: <http://reportbeam.com/reportbeam/default.aspx>
7. LexisNexis eCrash: <http://www.lexisnexis.com/risk/products/government/ecrash.aspx>
8. Spillman Technologies: <https://www.spillman.com>
9. Advanced Public Safety: <http://ww2.aps.us>
10. State Usage for TraCS: http://www.teginc.com/nationalmodel/nm_about.html
11. State Usage for Spillman: <https://www.spillman.com/about-us>
12. Harris, J, et al. Data Collection Software Used by Law Enforcement Agencies in Arizona. Final Report TRQS-04. September 2007.
13. Alabama eCite: <http://www.officer.com/product/10053022/center-for-advanced-public-safety-caps-ecite>
14. Georgia GEARS: <https://gearsportal.com/Pages/Public/Home.aspx>
15. Indiana eVCRS: <http://ghsa.madwolf.com/html/resources/showcase/in1.html>
16. Louisiana LACRASH: <http://lacrash.lsu.edu>
17. Edara, P. et al. *Development and Application of Work Zone Crash Modification Factors*. University of Missouri-Columbia. August 2016.
18. Michigan Traffic Crash Facts (MTCF): <http://www.michigantrafficcrashfacts.org>
19. Fatality Analysis Reporting System (FARS): <http://www.nhtsa.gov/FARS>

10.0 GLOSSARY

Attribute Subfield: Subdivided heading used when a detailed data element needs to be broken into more specific categories to describe a motor vehicle crash

Attribute Value: Selectable options under data element on police accident report (PAR) for officers to choose from to describe a motor vehicle crash

Countermeasure: Action intended to improve safety and reduce crash frequency for a problematic site

Crash Modification Factor (CMF): Multiplicative ratio used to compute expected crash frequency after implementing a given countermeasure at a specific site

Data Element: Crash, vehicle, person, or roadway line item included on a state's crash report form containing attribute values and possibly attribute subfields to describe a motor vehicle crash

Fatal Crash: Motor vehicle accident resulting in death of at least one individual, which could be an occupant of a vehicle or non-occupant of a vehicle, within 30 days of accident

Fatality Analysis Reporting System (FARS): Filterable database created by National Highway Traffic Safety Administration (NHTSA) allowing users to construct a wide variety of filters containing only fatal crashes from all states, District of Columbia, and Puerto Rico

Manual of Uniform Traffic Control Devices (MUTCD): National document containing standards used by transportation practitioners to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public travel

Michigan Traffic Crash Facts (MTCF): Crash data filtering tool allowing users to build specific queries from data elements included on Michigan UD-10 crash report form

Model Minimum Uniform Crash Criteria (MMUCC) Guideline: Document containing a recommended-minimum set of crash, vehicle, person, and roadway data elements for each state to include on their crash report form to describe a motor vehicle crash

Police Accident Report (PAR): Crash form used by law enforcement containing numerous data elements with attribute subfields and values to describe a motor vehicle crash

Safety Performance Function: Statistical model used to predict an average crash frequency at a specific site as a function of traffic volume and roadway or intersection characteristics

Temporary Traffic Control Plan (TTCP): Drawing used to display measures, needs, and devices for facilitating all road users, including motorists, bicyclists, and pedestrians through a work zone

Traffic Records Coordinating Committee (TRCC): User group formed by members from numerous transportation agencies to help improve collection, management, and analysis of traffic safety data at state and federal levels

Work Zone: Area of roadway containing a construction, maintenance, or utility work activity, typically identified by signs, channelizing devices, barricades, pavement markings, or work vehicles

Work Zone Crash: Accident occurring in boundaries of or related to a construction, maintenance, or utility activity