Connected Work Zones Implementation Guide and Standard v00.23

Recommended Standard

Guidance to Setting Up and Operating a Connected Work Zone

June 2024

Developed by: American Association of State Highway and Transportation Officials (AASHTO), ITE- A Community of Transportation Professionals, and National Electrical Manufacturers Association (NEMA)

Supported/Sponsored by: The United States Department of Transportation (USDOT)

U.S. Department of Transportation

Revision History

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Filename	Date	Author	Notes
CWZ_Standard_ConOps_draft_v00.01.docx	02/22/23	M. Insignares / V. Gonzales	Initial compilation of materials and review.
CWZ_Standard_ConOps_draft_v00.02.docx	03/21/23	M. Insignares / V. Gonzales	ConOps Walkthrough comments.
CWZ_Standard_ConOps_Requirements draft_v00.03.docx	05/30/23	M. Insignares / V. Gonzales	Includes: • ConOps walkthrough updates • Complete draft set of requirements • Preliminary design content and traceability matrices incorporating material from the WZDx v4.2 specification as a reference during the Requirements Walkthrough.
CWZ_Standard_ConOps_Requirement_draft_v00.04.docx	06/24/23	V. Gonzales	Includes: • Requirements Walkthrough Day 1 edits and discussion
CWZ_Standard_ConOps_Requirement_draft_v00.05.docx	06/30/23	V. Gonzales / M. Insignares	Includes: Requirements Walkthrough Day 2 edits and discussion.
CWZ_Standard_ConOps_Requirement_draft_v00.06.docx	07/18/23	V. Gonzales / M. Insignares	Includes: Instructions and clarifications for comment resolution.
CWZ_Standard_ConOps_Requirement_Design_draft_v00.07.docx	08/17/23	V. Gonzales	Includes comment resolution of Section 3, Section 5, and edits to the PRL/RTM.
CWZ_Standard_ConOps_Requirement_Design_draft_v00.08.docx	08/23/23	M.Insignares / V. Gonzales	Includes comment resolution of Section 3, Section 4, and edits to Section 2, Annex E, and the PRL/RTM. Review of all sections. Submitted to ITE.
CWZ_Standard_ConOps_Requirement_Design_draft_v00.10.docx	9/18/23	V. Gonzales / M. Insignares	Includes Design Walkthrough Day 1 edits.
CWZ_Standard_ConOps_Requirement_Design_draft_v00.11.docx	9/27/23	V. Gonzales	Includes comment resolution of Section 5 and edits to Section 3 and RTM.

Filename	Date	Author	Notes
CWZ_Standard_ConOps_Requirement_Design_draft_v00.12.docx	10/13/23	M. Insignares	Includes comments from working group and participants reviewing contents of Annex C.
CWZ_Standard_pUCD_draft_v00.13.docx	10/16/23	M. Insignares	Includes updates to the PRL, comments outstanding from design walkthrough and identified in the Comment Resolution Report.
CWZ_Standard_pUCD_draft_v00.14.docx	10/21/23	M. Insignares	Incorporated additional comments received on Annex C, and added Annex F listing changes between WZDx v4.2 JSON Schemas and the Section 5 JSON Schemas contained in this standard. Clean copy distributed to Working Group as Proposed User Comment Draft. Clean and markup copies placed in the ITE Teams repository and announced.
CWZ_Standard_pUCD_draft_v00.15.docx	11/10/23	M. Insignares / V. Gonzales	Addressed comments received during the working group pUCD review period.
CWZ_Standard_UCD_draft_v00.16.docx	12/12/23	M. Insignares / V. Gonzales	Draft UCD. Addressed comments received during the working group UCD acceptance meeting. Submitted to ITE. Clean and markup copies placed in the ITE Teams repository and announced.
CWZ_Standard_pRS_draft_v00.17.docx	2/26/24	V. Gonzales / M. Insignares	Proposed Recommended Standard. UCD draft comments resolution. Addressed comments received during UCD review period.
CWZ_Standard_pRS_draft_v00.18.docx	3/25/24	M. Insignares / V. Gonzales	Incorporates resolution of comments related to pRS v00.17. Several comments remain OPEN, to be discussed at Mar 28/29 WG Meeting.
CWZ_Standard_pRS_draft_v00.19.docx	3/28 – 3/29/24	M. Insignares / V. Gonzales	pRS Vote Working Group Meeting Comments.
CWZ_Standard_pRS_draft_v00.20.docx	4/17/24	V. Gonzales	Cleaned version. Removed travel time elements. Implemented changes from meeting comments.

Filename	Date	Author	Notes
CWZ_Standard_pRS_draft_v00.21.docx	4/19/24	M. Mockett	Implementing changes for WZ projects in tracked changes
CWZ_Standard_pRS_draft_v00.21a.docx	5/03/24	M. Insignares	WG Discussion and Vote on proposed comment resolution and v00.21 changes.
CWZ_Standard_pRS_draft_v00.22.docx	6/07/24	M. Insignares	Recommended Standard submitted to ITE.
CWZ_Standard_pRS_draft_v00.23.docx	6/18/24	V. Gonzales	Fixed 5.4.2.10.6.

Acknowledgement

SAE International served as a partner Standards Development Organization throughout the development of this CWZ Implementation Guide and Standard. SAE International represents the interests of many stakeholders including the automotive industry and was represented by several members on the Connected Work Zones Working Group. The CWZ Implementation Guide and Standard project SDO partners included AASHTO, ITE, NEMA and SAE International.

Foreword

This Connected Work Zones (CWZ) Implementation Guide and Standard was developed by engaging with stakeholders representing the industry at large including but not limited to infrastructure owners/operators, automobile original equipment manufacturers, work zone equipment manufacturers, and the end users of data and services. The work was supported by the United States Department of Transportation (USDOT) Intelligent Transportation Systems (ITS) Joint Program Office (JPO). Several associations such as the American Association of State Highway Transportation Officials (AASHTO), the ITE- A Community of Transportation Professionals, the National Electrical Manufacturers Association (NEMA), and SAE International were involved in ensuring a balanced and effective stakeholder representation and adherence to standards development processes as Standards Development Organizations (SDOs).

This CWZ Implementation Guide and Standard addresses gaps identified by early deployers and provides guidance for organizations seeking to develop interoperable connected work zones across the United States, especially for automated transportation systems. This document focuses on harmonizing the existing Work Zone Data Exchange (WZDx) Specification, CWZ research and pilot deployments, and related standards activities related to connected work zones, as a starting point.

More information on this effort can be found on the ITE Website.

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Additional Contributors and Reviewers

In addition to the SDOs, Co-chairs, and Working Group Members, there were many others that contributed to the development of this standard and their input and assistance were critical to the final product. The following list includes those who volunteered their time to help ensure that the resulting guidance and standard met connected work zone community needs, and contributed to the input and review during the development of this guide and standard:

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- The United States Department of Transportation (USDOT)

User Comment Instructions

The term “User Comment” includes any type of written inquiry, comment, question, or proposed revision, from an individual person or organization, about any CWZ Implementation Guide and Standard content. A “Request for Interpretation” is also classified as a User Comment. User Comments are solicited at any time. In preparation of this standards publication, input of users and other interested parties was sought and evaluated. User Comments are generally referred to the Working Group responsible for developing and/or maintaining the CWZ Implementation Guide and Standard. The CWZ Working Group chairpersons, or their designee, may contact the submitter for clarification of the User Comment. When the CWZ Working Group chairpersons or designee reports the CWZ Working Group's consensus opinion related to the User Comment, that opinion is forwarded to the submitter. The CWZ Working Group chairpersons may report that action on the User Comment may be deferred to a future CWZ Working Group meeting and/or a future revision of the standards publication.

A User Comment should be submitted to this address:

ITE- A Community of Transportation Professionals
1627 Eye Street, NW, Suite 550
Washington, DC 20006
e-mail: standards@ite.org

A User Comment should be submitted in the following form:

Standard Publication number and version:
Section, Paragraph:
Editorial or Substantive:
Suggested Alternative Language:
Reason:

Please include your name, organization, and email address in your correspondence.

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Executive Summary

Project Objectives and Scope

The purpose of the ITE's Connected Work Zones project is to develop and publish a Connected Work Zone (CWZ) Implementation Guide and Standard that focuses on interoperable data exchanges between the various components of a connected work zone.

This CWZ Implementation Guide and Standard addresses gaps identified by early deployers and provides guidance for organizations seeking to develop interoperable connected work zones across the United States, especially for automated transportation systems. This document focuses on harmonizing the existing Work Zone Data Exchange (WZDx) Specification, CWZ research and pilot deployments, and related standards activities addressing connected work zones.

This document identifies key aspects of the interoperability needs of connected work zone systems and provides guidance to enable deployment of consistent CWZ environments across institutional and organizational boundaries. The goal of this document is to identify and document the following:

1. **Interoperable Data Exchanges**. Identify and document the needs for interoperable data exchanges. This includes documenting the data formats, data definitions, data structure, and specifications to enable interoperable data exchanges between CWZ systems and components.
2. **Operational Scenarios**. Identify and document system actors, including end-users, data consumers, and data providers, and their interactions that enable interoperable data exchanges between system components.
3. **Institutional and IOO Guidance Needs**. Identify and document institutional guidance needs, operational policies, constraints, and best practices for using this standard so that deployers can maximize the benefits from their deployments.
4. **Technical Expert Guidance Needs**. Identify and document developer and technical expert guidance needs to enable them to develop project specifications and designs that will result in nationally interoperable data exchanges across CWZ deployments from diverse organizations.

Development of the CWZ Implementation Guide and Standard follows a systems engineering process to be followed by a validation phase to verify the requirements and concepts in this guide. A report summarizing the findings from the validation phase will be developed and accompany this guide.

Background

The USDOT is sponsoring this project to develop, publish, verify, and validate a Connected Work Zone (CWZ) Standard that defines the data elements, capabilities, and interfaces a connected work zone must support to ensure interoperability between components of a connected work zone.

A **connected work zone** is defined as a set of technologies that generates or collects work zone information (whether automatically or manually) and the infrastructure that broadcasts/distributes this information to the public and to vehicles. The CWZ Standard will:

- address ambiguities and gaps identified by early deployers and consolidate multiple independent implementation and standards efforts to lead to the national interoperability of future CWZ deployments across the United States; and
- be published as a Connected Transportation Interoperability (CTI) document.

The CWZ Implementation Guide and Standard employs a systems engineering process, referencing design elements from existing standards and solidifying design content that satisfies multiple SDOs. The result is harmonization of standards activities across centers, vehicles, field devices, and vulnerable road

users/workers. The systems engineering process involves the production of a Concept of Operations (ConOps), System Requirements, System Design Details, and a validation phase.

The draft completion of each of these deliverables is followed by a review period, a formal walkthrough process, comment resolution, updates, and finally another review period of the updated document. This process allows the document to be fine-tuned and reviewed by all contributors and stakeholders until each detail is deemed technically proficient and approved. This level of detail, accompanied by reviews by the project team, subject matter experts (SMEs), and other contributors, allows for the production of a CWZ Implementation Guide and Standard that contains both technical depth and clarity.

Purpose of this Document

This document identifies the CWZ deployer needs, sets the requirements, and provides guidance for nationally interoperable connected work zones across the United States. The focus of this document is on system-to-system interfaces to enable interoperable CWZ applications. This document is envisioned to be a living document.

Who Should Read this Document?

Stakeholders from multiple industries may benefit from this CWZ Implementation Guide and Standard. These industries include IOOs deploying connected work zones, OEMs, third parties such as mobile app developers and navigation companies, work zone device manufacturers, multimodal partners, developers of connected work zone applications, and end users of data and services.

Document Overview

In addition to this Executive Summary, this document contains five (5) main sections, as follows:

- **Executive Summary.** This section provides a high-level overview of the entire document and how to use the document.
- **Section 1: General Information.** This section provides introductory and background information about the document, its purpose, and why it is needed. This section discusses the scope of work, references to other documentation.
- **Section 2: Concept of Operations.** This section includes the content of the Concept of Operations, including the Architectural and Data Exchange Needs for a Connected Work Zone as well as Operational Scenarios illustrating representative examples of interactions between components of a CWZ.
- **Section 3: System Interface Requirements.** This section includes the System Interface Requirements that satisfy the Architectural and Data Exchange Needs for a Connected Work Zone. A Protocol Requirements List (PRL) is provided, where each need is mapped to all the requirements that satisfy that need.
- **Section 4: System Interface Design Details: Data Exchange Dialogs.** This section includes details on how each data exchange requirement is fulfilled.
- **Section 5: System Interface Design Details: Data Concepts**. This section includes details on how each data content requirement is fulfilled.
- **Section 6: Connected Work Zones Testing.** This section describes the testing required to validate conformance with the normative sections of this CWZ Implementation Guide and Standard and includes example test cases with a Requirements to Test Case Traceability Matrix (RTCTM).

The CWZ Implementation Guide and Standard also includes the following Annexes that provide additional background information on various topics:

- **Annex A: Requirements Traceability Matrix.** This normative annex provides a mapping of each requirement to all the design elements that fulfill the requirement.
- **Annex B: Connected Work Zones Guidance Needs.** This informative annex contains a summary of potential guidance needs topics to help organizations plan development and deployment of connected work zones using this standard.
- **Annex C: Guidance for Deployments Involving Multiple Work Zone Related Standards.** This annex provides guidance for CWZ deployers who may need to use multiple standards.
- **Annex D: Recommendations to SDOs.** This annex summarizes comments and recommendations by the CWZ Working Group or its task forces to Standards Development Organizations on existing standards that are referenced by this CWZ Implementation Guide and Standard.
- **Annex E: User Requests.** This informative annex identifies user needs, requirements, and design details that were identified and considered by the CWZ Working Group but were ultimately not included in this version of the CWZ Implementation Guide and Standard. The rationale on why these needs, requirements, and design details were not included is also provided.
- **Annex F: Listing of Differences between the CWZ Standard and the WZDX v4.2 Specification JSON Schemas.** This informative annex lists differences between the JSON Schemas contained in Section 5 of this standard and the WZDX v4.2 Specification JSON Schemas.

Validation Phase

Following the development of the draft final CWZ Implementation Guide and Standard, the CWZ Working Group anticipates releasing a solicitation for Letters of Interest to public agencies to participate in a validation phase to validate and verify the needs, requirements, and design specified in the CWZ Implementation Guide and Standard. The validation process consists of data collection from each validation site to test for conformance to the CWZ Implementation Guide and Standard. Feedback is also solicited on the usefulness of the CWZ Implementation Guide and Standard and any further ambiguities of the guidance. The CWZ Working Group anticipates that some of the analysis results and feedback will be incorporated into the draft final version of the CWZ Implementation Guide and Standard. A separate report summarizing the findings from the analysis and feedback from the validation sites will be released at the end of the validation phase.

Next Steps

This document is intended to be a living document and is an important first step towards developing interoperable connected work zones and supporting connected work zone safety applications. Potential follow-up activities for the ITE Connected Work Zones will be identified for when additional funding is available.

Section 1
General Information [Informative]

1.1 Scope

The purpose of the ITE's Connected Work Zones project is to develop and publish a Connected Work Zone (CWZ) Implementation Guide and Standard that focuses on providing interoperable data exchanges between the various components of a connected work zone.

This CWZ Implementation Guide and Standard addresses gaps identified by early deployers and provides guidance for organizations seeking to develop interoperable connected work zones across the United States, especially for automated transportation systems. This document focuses on harmonizing the existing Work Zone Data Exchange (WZDx) Specification, CWZ research and pilot deployments, and related standards activities addressing connected work zones.

Development of the CWZ Implementation Guide and Standard follows a systems engineering process to be followed by a validation phase to verify the requirements and concepts in this guide. A report summarizing the findings will be developed and accompany this Guide.

1.2 References

At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on the CWZ Implementation Guide and Standard are encouraged to investigate the possibility of applying the most recent editions of the standard listed.

1.2.1 Normative References

Normative references contain provisions that, through references in this text, constitute provisions of this CWZ Implementation Guide and Standard. Other references in this document might provide a complete understanding or additional information. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this CWZ Implementation Guide and Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed.

Identifier	Title
IETF RFC 7946	The GeoJSON Format, August 2016
IETF RFC 3339	Date and Time on the Internet: Timestamps, July 2002
IETF RFC 4122	A Universally Unique Identifier (UUID) URN Namespace, July 2005
IETF RFC 8259	The JavaScript Object Notation (JSON) Data Interchange Format, December 2017
IETF RFC 9110	HTTP Semantics, June 2022
IETF RFC 3986	Uniform Resource Identifier (URI): Generic Syntax, January 2005
Open Mobility Foundation	Curb Data Specification (CDS), v1.0.0, April 29, 2022
NTCIP 1203 v03	Object Definitions for Dynamic Message Signs (DMS), September 2014 *For the definition of MULTI.

1.2.2 Other References

The following documents and standards may provide the reader with a more complete understanding of connected work zones; however, these documents do not contain direct provisions that are required by the CWZ Implementation Guide and Standard.

Identifier	Title
U.S. Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)	Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), USDOT, http://local.iteris.com/arc-it/
IEEE Std 610.12-1990	IEEE Standard Glossary of Software Engineering Terminology, IEEE, 1990
IEEE Std 829-2008	IEEE Std 829 IEEE Standard for Software and System Test Documentation, IEEE, 2008
IEEE Std 1016-1998	IEEE Recommended Practice for Software Design Descriptions, IEEE, 1998
IEEE Std 1362-1998	IEEE Guide for Information Technology System Definition - Concept of Operations (ConOps) Document, IEEE, 1998
FHWA MUTCD	The Manual on Uniform Traffic Control Devices for Streets and Highways, 2009.
NTCIP 1218 v01	National Transportation Communications for ITS Protocol Object Definitions for Roadside Units (RSUs), v01.38, 2020.
OMG UML-2007, Superstructure	OMG Unified Modeling Language (OMG UML), Superstructure, V2.1.2, 2007.
SAE J2945/4_202305	Road Safety Applications, May 10, 2023
ITE/AASHTO TMDD Standard v3.1	Traffic Management Data Dictionary (TMDD) Standard for the Center to Center Communications, January 13, 2020
USDOT WZDx v4.2	Work Zone Data Exchange Specification, USDOT, February 2023
NEMA TS 10	Connected Vehicle Infrastructure – Roadside Equipment, NEMA, March 2021
FHWA Work Zone ITS Implementation Guide 2014	Work Zone Intelligent Transportation Systems Implementation Guide - Use of Technology and Data for Effective Work Zone Management, January 2014

1.2.3 Contact Information

1.2.3.1 ARC-IT Documents

The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) may be viewed online at:

https://local.iteris.com/arc-it/

1.2.3.2 FHWA Documents

USDOT Federal Highway Administration (FHWA) documents (with designations FHWA-JPO-…) are available at the USDOT National Transportation Library, Repository & Open Science Access Portal (ROSA P):

https://rosap.ntl.bts.gov/

1.2.3.3 IEEE Standards

IEEE standards can be purchased online in electronic format or printed copy from the following:

Techstreet
6300 Interfirst Drive
Ann Arbor, MI 48108
(800) 699-9277
www.techstreet.com/ieee

1.2.3.4 Internet Documents

Obtain Request for Comment (RFC) electronic documents from several repositories on the World Wide Web, or by “anonymous” File Transfer Protocol (FTP) with several hosts. Browse or FTP to the following:

www.rfc-editor.org
https://www.rfc-editor.org/retrieve/

1.2.3.5 ITE Standards

Copies of ITE standards may be obtained from the following:

ITE- A Community of Transportation Professionals
1627 Eye Street, NW, Suite 600
Washington, DC 20006
(202) 785-0060
www.ite.org/technical-resources/

1.2.3.6 NTCIP Standards

Copies of NTCIP standards may be obtained from the following:

NTCIP Coordinator
National Electrical Manufacturers Association
1300 N.17th Street, Suite 900
Rosslyn, Virginia 22209-3801
www.ntcip.org
e-mail: ntcip@nema.org
https://www.ntcip.org/document-numbers-and-status/

1.2.3.7 SAE International Documents

Copies of SAE International documents may be obtained from the following:

SAE International
400 Commonwealth Drive
Warrendale, PA 15096
www.sae.org

1.3 Terms

The following terms, definitions, acronyms, and abbreviations are used in this document.

Term	Definition
Actor	An actor specifies a role played by a user or any other system that interacts with the subject. Source: OMG UML-2007, Superstructure.
Component	One of the parts that make up a system. A component may be hardware or software and may be subdivided into other components. Source: IEEE Std 610.12-1990.

Term	Definition
Connected Work Zone (CWZ)	A connected work zone is defined as a set of technologies that generates or collects work zone information (whether automatically or manually) and the infrastructure that broadcasts/distributes this information to the public and to vehicles. Source: USDOT, Intelligent Transportation Systems (ITS) Joint Program Office Performance Work Statement for ITE's Connected Work Zone Implementation Guidance, 2022
CWZ Deployers	A collective term to describe IOOs, contractors, or any organization that deploys a CWZ, with responsibilities for actor components within a CWZ.
External Center	A center, whether virtual, mobile, or stationary, interacting with a Traffic Management Center or Work Zone Center. Typically used to describe a Third-Party Center, such as a back-office or cloud.
Generic Vehicle	A vehicle (passenger vehicle, van, bus, or truck) traveling through a connected work zone, but not associated with any activities within it.
Interface	A shared boundary across which information is passed. Source: *IEEE Std 610.12-1990.*
Interoperability	The ability of two or more systems or components to exchange information and to use the information that has been exchanged. Source: *IEEE Std 610.12-1990.*
Traffic Management Center	Centers, typically managed by IOOs, that tracks (collects) work zone status and conditions, and distribute Work Zone Information.
Universally Unique Identifier (UUID)	A UUID is 128 bits long, and can guarantee uniqueness across space and time. Source: *IETF RFC 4122.*
Work Zone Center	Centers that directly collect information from Work Zone Field Devices, Work Zone VRUs, Work Zone Work Vehicles to generate a composite view of the status and conditions of a work zone.
Work Zone Device	Devices and electronic systems that monitor and affect work zone operations on a roadway. Examples include arrow boards, location marker devices, and roadside units (for connected vehicle environments).

Term	Definition
Work Zone Vulnerable Road User (WZVRU)	A term to describe a class of persons at risk of harm within or near an active roadway, such as a work zone, i.e., those unprotected by an outside shield. In the case of a work zone this may include work zone workers. This standard assumes that WZVRUs wear devices that are able to communicate with a work zone center, work zone equipment and/or vehicles. Sub-categories of WZVRUs may include: - Work Zone Worker - Non-workers passing through the work zone (a.k.a., casually involved) - Other Work Workers including first responders, and incident responders - A person with a disability
Work Zone Work Vehicle	A term to describe a class of vehicles within or near an active roadway, such as a work zone. This may include maintenance vehicles, construction vehicles, attenuator vehicles, or in some cases first responder vehicles in a work zone. This standard assumes that work zone vehicles have devices that are able to communicate with a work zone center, work zone equipment and/or vehicles.

1.4 Abbreviations

The abbreviations and acronyms used in this document are defined below.

AASHTO	American Association of State Highway Transportation Officials
API	Application Programming Interface
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATMS	Advanced Traffic Management System
CAMP	Collision Avoidance Metrics Partners
CWZ	Connected Work Zone
ConOps	Concept of Operations
C/AV	Connected/Automated Vehicle
C-V2X	Cellular Vehicle to Everything
CV	Connected Vehicle
CVE	Connected Vehicle Environment
DOT	Department of Transportation
DSRC	Dedicated Short Range Communication
FHWA	Federal Highway Administration
GeoJSON	Geospatial JSON (see JSON)
GIS	Geographic Information System
GNSS	Global Navigation Satellite System

IEEE	Institute of Electrical and Electronics Engineers
IOO	Infrastructure Owner/Operator
ICD	Interface Control Document
IT	Information Technology
ITE	Institute of Transportation Engineers
JSON	JavaScript Object Notation
LIDAR	Light Detection and Ranging (also LiDAR)
MPH	miles per hour
MUTCD	Manual of Uniform Traffic Control Devices
NEMA	National Electrical Manufacturers Association
ngTMDD	Next Generation Traffic Management Data Dictionary
NOCOE	National Operations Center of Excellence
NTCIP	National Transportation Communications for ITS Protocol
OBU	On-Board Units
OEM	Automotive Original Equipment Manufacturers
PRL	Protocol Requirements List
RSM	Roadside Safety Message
RSU	Roadside Unit
RTCM	Radio Technical Commission for Maritime Services
RTM	Requirements Traceability Matrix
SAE	SAE International
SCMS	Security Credentials Management System
SDO	Standards Development Organizations
SEP	Systems Engineering Process
TIM	Traveler Information Message
TIM-PM	Traffic Incident Management Performance Measures
TMDD	Traffic Management Data Dictionary
USDOT	United States Department of Transportation
UUID	Universally Unique Identifier
WZDx	Work Zone Data Exchange Specification
VRU	Vulnerable Road User

Section 2
Concept of Operations (ConOps) [Normative]

Section 2 defines the needs that subsequent sections of this CWZ Implementation Guide and Standard address. Accepted systems engineering processes detail that requirements should only be developed to satisfy well-defined needs. The first stage in this process is to identify the ways in which the CWZ system interface is intended to be used.

This concept of operations provides the reader with the following:

a) A detailed description of the scope (or problem statement) covered in this CWZ Implementation Guide and Standard document;
b) the key capabilities and interfaces for a connected work zone;
c) the relationship to the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT).

Section 2 is intended for all readers and users of the CWZ Implementation Guide and Standard, including the following:

a) **Transportation Managers.** Personnel responsible for making decisions about transportation strategies to implement connected work zones.
b) **Transportation Operators.** Personnel responsible for monitoring connected work zones and implementing transportation strategies to address the impacts on travel stemming from work zones.
c) **Transportation Engineers.** Personnel responsible for the design and engineering of connected work zones.
d) **Maintenance Personnel.** Personnel responsible for ensuring that connected work zones are maintained as intended.
e) **Data Consumers.** Personnel at organizations, where the organization consumes connected work zone information and provides additional value based on that information.
f) **Data Aggregators, Providers and Distributors.** Personnel at organizations, where the organization gathers and aggregates connected work zone information, adds value, and distributes the work zone information.
g) **System Integrators.** Entities that bring together different components or subsystems into a whole system that functions together.
h) **Application Developers.** Developers providing applications that rely on data exchanges between CWZ component actors whether work zone vulnerable road users, work zone field devices, work zone work vehicles, work zone center; and applications that exchange work zone information from a connected work zone and other centers, with a cloud service or back-office location.
i) **Temporary Traffic Control Contractor.** A contractor, and possibly the equipment supplier (rental agency), responsible for deploying and maintaining equipment including the connectivity aspects of the equipment, and between the field and vehicle.

2.1 Tutorial [Informative]

A concept of operations describes a proposed system from the users' perspective. Typically, a concept of operations is used to ensure that system developers understand the users' needs. However, for the purposes of this system interface standard we will use the term “user” to mean one or more system components of a CWZ, with the intent of describing representative examples of benefits that may arise for human end-users.

The terms “Normative” and “Informative” are used to distinguish parts of this ConOps that must be conformed to (Normative) and those that are there for informational purposes (Informative). It is possible

for a section to be identified as Normative but have subsections that are identified as Informative. If a section is Normative then all of its subsections are Normative unless identified otherwise. This entire ConOps section is Normative unless otherwise indicated.

The concept of operations starts with a discussion of the current situation and issues that have led to the need to develop CWZ implementation guidance and a data exchange standard to enable interoperable connected work zones. This discussion is presented in layman's terms such that both the potential users of the system and the system developers can understand and appreciate the situation.

The concept of operations then documents key aspects about the proposed system, including the following:

- **Reference Physical Architecture.** The reference physical architecture (view) defines the overall context of a connected work zone system and defines what component actors and interfaces are addressed by this CWZ Standard & Implementation Guide.
- **Needs.** The needs identify and describe the interfaces and data exchanges that users may want in order to accomplish some benefit. These needs address a specific aspect of the problem statement (Section 2.2). The needs are structured and organized into a more manageable structure that forms the basis of the traceability table that relates needs to the functional requirements contained in Section 3.
- **Operational Scenarios.** The operational scenarios allow a reader to understand the different parts and functions of a CWZ. An operational scenario explains how the component actors of a CWZ interact to enable the benefits of deploying connected work zones using this standard. The operational scenarios are representative examples illustrating interactions between component actors of a CWZ.
- **Operational Policies and Constraints.** A narrative description of specific policies or constraints relative to the operational environment that have a direct impact on the deployment of connected work zones using this CWZ Implementation Guide.
- **Relationship to the National ITS Architecture Reference.** This section describes how the elements of a CWZ are described by the National ITS Architecture Reference (ARC-IT).

Section 3 applies the needs identified in the ConOps to define the interface requirements for a CWZ. Each need traces to one or more requirements, and each requirement is derived from at least one need. This traceability is documented in a Protocol Requirements List (PRL) in Section 3.10, where each need is mapped to all the requirements that satisfy that need.

Like needs, the requirements are identified by a collaboration of a broad base of stakeholders. Each requirement is captured in Section 3 in a formal manner as “shall” statements. Each requirement identified is then presented in the Requirements Traceability Matrix (RTM) in Annex A, which defines how the requirement is fulfilled by a design element.

2.2 Current Situation and Problem Statement [Informative]

Work zone safety is of utmost concern to transportation agencies. According to the National Highway Traffic Safety Administration, in 2020, there were 857 fatalities and an estimated 102,000 work zone crashes in the United States. There have been numerous research projects, deployments and standards development to support work zone safety, but there have been inconsistencies with the interpretations and implementation of the existing standards, and inconsistencies with the use and expectations of the data exchanges. There are also inconsistencies between deployments, such as usage of different data and data formats across interfaces, and security requirements. Another discovery was that most infrastructure owner operators (IOOs) do not have the manpower nor technical knowledge to properly deploy and operate connected work zones. These deployment issues highlight a need for an industry standard that enables national interoperability and provides guidance for how to deploy, operate and maintain connected work zones.

2.3 Reference Physical Architecture [Informative]

2.3.1 Connected Work Zone Physical Architecture

This section presents an overview of the actor components that make up the CWZ Architecture as defined for this document. Two figures are presented depending on the needs of the deployers. While the 2 diagrams may be combined into one, we provide 2 diagrams to show clarity. Please note that the 2 diagrams are consistent and can be mixed and matched depending on the deployments needs.

Figure 1 illustrates sharing of WorkZoneFeed and DeviceFeed information without the use of a Work Zone Data Exchange Intermediary.

Note: The term 'actor component' as used in this context and shown as a rectangle in the diagram, is a computing device, and does not represent a person nor a stakeholder. An actor component is the end-point of a data interface between computing devices with the purpose of work zone information data exchange. Our intent is to specify an architecture for data exchanges to communicate information between computing devices, whether in centers, in vehicles, in field devices, or on persons.

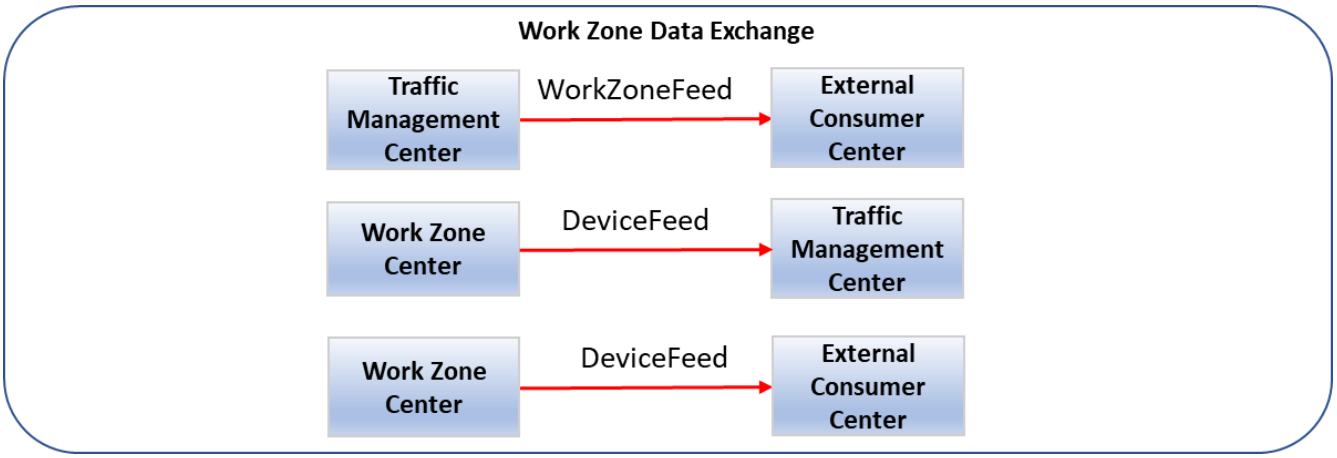


Figure 1. Physical Architecture: Work Zone Data Collection and Distribution

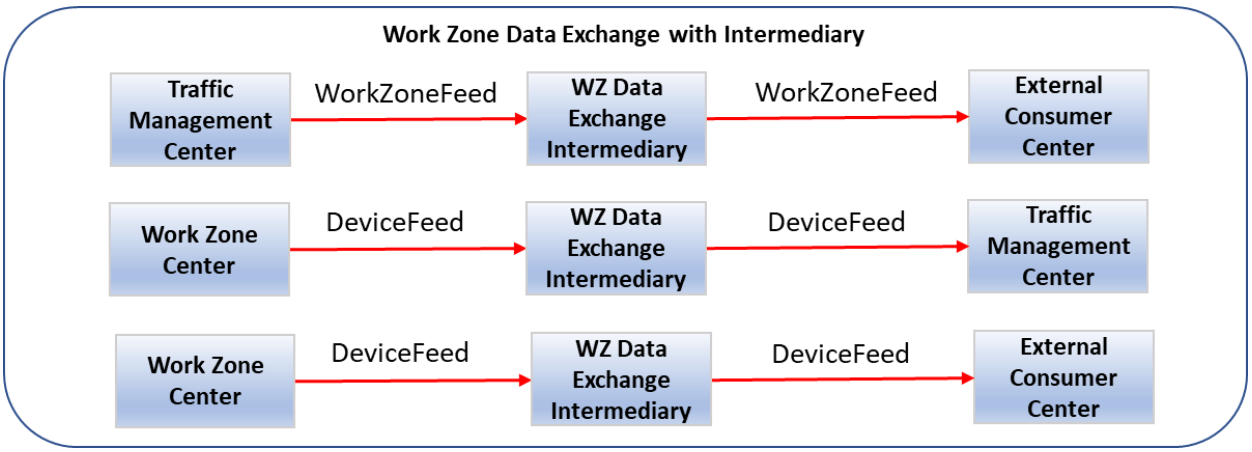


Figure 2. Physical Architecture: Work Zone Data Collection and Distribution with Intermediary

Figure 1 and Figure 2 above is not intended to identify every combination of information exchanges between actor components involving WorkZoneFeeds and DeviceFeeds. There are potentially many other reasonable combinations, for example, Traffic Management Centers may blend the device feed information with other work zone information resulting in a work zone feed. This is illustrated later in this document as Operational Scenario 2.6.3.

Definitions for WorkZoneFeed and DeviceFeed are presented below:

- **WorkZoneFeed**. Provides high-level information about events occurring on roadways related to work zones that impact the characteristics of the roadway and involve a change from the default state (such as a lane closure).
- **DeviceFeed**. Provides information (location, status, dynamic data) about field devices deployed on the roadway in work zones.

The actor components that interact to provide the benefits of a CWZ are described below.

Primary Actors. Communications with these actors as defined in this standard is generally in-scope.

- **Traffic Management Center.** Centers, typically managed by IOOs, that track (collect) status and conditions, and distribute Work Zone Information.
- **Work Zone Center.** Centers that directly collect information from Work Zone Field Devices, Work Zone VRUs, Work Zone Work Vehicles to generate a composite view of the status and conditions of a work zone. Data may be collected from equipment in the work zone or data entered manually by a person.
- **External Center.** A center, whether virtual, mobile, or stationary, interacting with Traffic Management Center or Work Zone Center. Typically used to describe a Third-Party Center, such as a back-office or cloud.
- **Work Zone Data Exchange Intermediary.** A center that may collect, aggregate, store, and distribute work zone information on behalf of other centers.

Peripheral Actors. Communication with these actors is generally out-of-scope of this standard.

- **Work Zone Devices.**
  - **Work Zone Field Device.** Devices and electronic systems that monitor and affect work zone operations on a roadway. Examples include arrow boards, location marker devices, and roadside units (for connected vehicle environments), or other. This may include hub field device master that communicates with other equipment in the work zone.
  - **Work Zone Vulnerable Road User Device.** Devices worn by persons at risk of harm within or near an active roadway, such as a work zone.
  - **Work Zone Work Vehicle Device.** Devices in work vehicles within or near an active roadway, such as a work zone. In the case of a work zone this may include maintenance vehicles, construction vehicles, attenuator vehicles, or in some cases first responder vehicles in a work zone.
- **Generic Vehicle.** A vehicle (passenger vehicle, van, bus, or truck) traveling through a connected work zone, but not responsible for any activities within it.

2.4 Tutorial - Data Exchange Roles and Mechanisms [Informative]

2.4.1 Data Exchange Roles

CWZs have multiple actors as described in the prior section. For any particular set of data exchanges there are actor roles that need to be defined to accomplish data exchanges.

- Data Provider Role. A data provider is an actor component that has data, and is able to provide that data through a defined communications interaction, with another actor component that needs and is able to consume that data.
- Data Consumer Role. A data consumer is an actor component that needs data, and is able to acquire and consume the data through a defined communications interaction, with another actor component that can provide the data that is needed.

- Data Exchange Intermediary Role. An actor component that fulfills the roles of data provider and data consumer. For example, an actor that collects data (consumer), aggregates it, and then distributes (provides) it.

2.4.2 Data Exchange Mechanism

For the purposes of this CWZ ConOps, we will define a polling data exchange mechanism as follows:

- Polling is a communications interaction between system actors where a data consumer system initiates the data exchange with a request for information. Upon request, the data provider system sends information to the data consumer system.

2.4.3 Communications Interactions in Lay Terms

Polling is a way for a consumer to request data from a provider.

The human interaction scenario is described as follows, with Chris as the Data Consumer, and Paula as the Data Provider.

Chris walks up to a counter where Paula is standing behind the counter. Chris presents Paula with a slip of paper (let's call this an authentication), and has Chris's name on it. Paula looks at the piece of paper, nods yes for approval, and walks off. Paula presents Chris with a 3-ring binder with 500 pages of information (one for each work zone) that represents all of the work zone activities within the State of Florida. The binder is a metaphor for a complete set of work zone data at some given point in time.

Chris checks to see how often Paula is able to provide updates, and let's say Paula is able to provide updates every 5 minutes. With polling, the same procedures of presenting a slip of paper, and receiving a 3-ring binder (a single poll) happen again, and again. Within a 24-hour period, Chris has polled 288 times, and Paula has provided 288 binders.

One example use of the polling method is the General Transit Feed Specification (GTFS).

2.5 Needs

The needs for a connected work zone are organized as follows:

- Architectural Needs. These needs identify and describe the various interactions between component actors of a CWZ system, and higher-level needs that apply to all actors and most, if not all, interactions.
- Data Exchange Needs. These needs describe data exchanged between actors where one or more actors have the role of data provider or data consumer. Please note that the role of data provider and data consumer may change depending on the need being described. These data exchange needs also reflect data content needs.

2.5.1 Architectural Needs

This section stating the architectural needs of CWZs is organized into sub-sections as follows:

- Backward Compatibility
- GeoJSON Data Exchange [Constraint]
- GeoJSON Data Format [Constraint]
- GeoJSON Data Validation
- Frequency of Data Updates
- UTC Date-Time Format [Constraint]

Note: The term ‘CWZ Deployer’ is used sparingly throughout Section 2.5 Needs when neither a data provider or data consumer can be identified as an actor. This happens, for example, when describing the architectural needs below.

2.5.1.1 Architectural Need - Compatibility with the WZDx Specification

CWZ deployers need to describe and implement a mechanism to support compatibility with the design elements described in the WZDx v4.2 specification.

2.5.1.2 Architectural Need - GeoJSON Data Exchange [Constraint]

2.5.1.2.1 GeoJSON Data Exchange - Poll for Data [Constraint]

CWZ deployers need to share the current status of work zone information, where the work zone information is provided in the GeoJSON data format. Poll for Data is a synchronous method of data communications.

2.5.1.3 Architectural Need - GeoJSON Data Format [Constraint]

CWZ deployers need to maintain using the GeoJSON data format (as applied in the WZDx specification). A JSON schema is used to describe the GeoJSON format. In addition, the JSON schema can be used to validate conformance of work zone data with the specification described in the JSON schema.

Feedback from CWZ deployers is that the JSON schema and GeoJSON data format work well, as follows:

- The GeoJSON data format provides a framework to support the geospatial Information value chain;
- The GeoJSON data format works well for high-bandwidth communications (e.g., internet connections);
- The GeoJSON data format provides outputs that support visualization of data. For example, the data can be used with off-the-shelf GIS “out of the box”.

2.5.1.4 Architectural Need - GeoJSON Data Validation [Constraint]

CWZ deployers need to verify conformance of work zone data against the design. Currently, the verification of work zone data (e.g., a WZDx WorkZoneFeed) is accomplished using off-the-shelf software that verifies the work zone data against the specification's JSON Schema.

2.5.1.5 Architectural Need - Frequency of Data Updates

CWZ data providers use the frequency of updates time to reflect how often real time condition information about work zones is made available.

CWZ data consumers need to know how often (frequency) to expect work zone data to be updated if new information is available.

2.5.1.6 Architectural Need - UTC Date-Time Format Specification [Constraint]

CWZ deployers need to exchange date-time data in a common format.

CWZ deployers need to maintain using the UTC Date-Time format specification.

2.5.2 Data Exchange Needs

In this section, we introduce the terms “zone” and “project.” Zone describes a section of roadway where VRUs are present, vehicles are present, and devices are present. A zone will generally have consistent characteristics throughout the section of roadway. A project may include one or more zones to represent varying roadway characteristics, either changing in space and/or in time.

This section states the data exchange needs between CWZ actor components and is organized into sub-sections as follows:

- Zone Metadata

- Zone Location
- Zone Schedule
- Zone Status
- Zone Lanes
- Zone Speed Limit
- Zone Traffic Data
- Zone Device
- Zone Vulnerable Road Users (VRUs) Device
- Zone Work Vehicle Device

The diagram below provides a high-level visual interpretation of the sections, that taken together, reflect the data exchange needs of connected work zones. The diagram is not a schematic representation suitable for software, application, or database design.

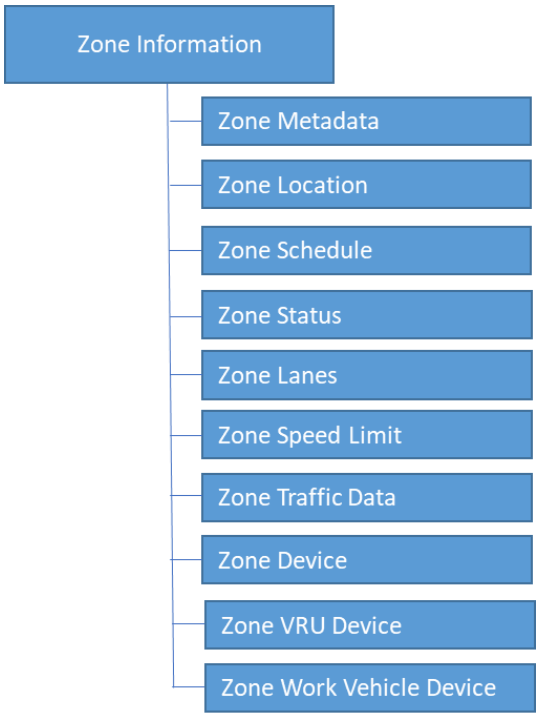


Figure 3. Data Exchange Needs - Zone Information Organization

2.5.2.1 Zone Metadata

CWZ data providers need to provide metadata about work zone information to data consumers. Metadata may support the need for data discovery, and may provide information about the provenance of the data, trustworthiness, and chain of custody.

2.5.2.1.1 Zone Metadata - Zone Data Standard Version

CWZ data providers need to provide the version of the standard so that data consumers can determine and support multiple versions of the standard.

2.5.2.1.2 Zone Metadata - Zone Identifier

2.5.2.1.2.1 Support Zone Identifier for Zones

CWZ data providers need to provide the zone identifier when providing work zone information to data consumers.

2.5.2.1.2.2 Support Unique Zone Identifiers

CWZ deployers need zone identifiers that uniquely identify zones.

2.5.2.1.2.3 Support Unique Zone Group Identifiers

CWZ deployers need unique identifiers that identify zones as a group when part of the same project.

2.5.2.1.2.4 Support Zone Identifiers for VRUs, Devices, Work Zone Vehicles, Lanes, Speed Limit Zones

CWZ deployers need to associate VRUs, devices, work vehicles, lane configurations, speed limit zones, etc. with a uniquely identifiable zone or group of zones comprising a project.

2.5.2.1.3 Zone Metadata - Zone Activity Type

CWZ providers need to provide the activity type present within a zone when providing work zone information to a CWZ data consumer. Activity type may include: repair of spring cracks, pothole repairs, striping, mowing, guard rail repairs, repaving, construction, etc.

2.5.2.1.4 Zone Metadata - Zone Data Timestamp

CWZ data providers need to provide a timestamp reflecting the creation time of the zone data when providing work zone information to data consumers. Data consumers need to know how old zone data is to assess the accuracy and reliability of the data.

2.5.2.1.5 Zone Metadata - Zone Data Source

CWZ data providers need to provide a data source identifier that indicates the original source or the data and most recent source of updates when providing work zone information to data consumers.

2.5.2.2 Zone Location

2.5.2.2.1 Zone Location - Geometry

CWZ deployers want to notify/alert distracted drivers ahead of their arrival at the work zone so that drivers can travel safely through a work zone.

CWZ data providers need to provide zone location geometry when providing work zone information to data consumers.

2.5.2.3 Zone Schedule

2.5.2.3.1 Zone Schedule – Date Times

CWZ data providers need to provide date times when a work zone is scheduled to be active when providing work zone information to work zone data consumers.

2.5.2.4 Zone Segmentation

2.5.2.4.1 Zone Segmentation – Geometry

CWZ data providers need to provide zone geometries that correspond to a roadway segment with consistent zone characteristics (including, but not limited to road name, direction, lanes closed, start or end location). If characteristics vary along a section of roadway, CWZ data providers need to represent the area as multiple related zones.

2.5.2.4.2 Zone Segmentation – Date Times

CWZ data providers need to provide zone schedules that correspond to a roadway segment with consistent zone characteristics (including, but not limited to road name, direction, lanes closed, start or end time). If characteristics vary over the duration of the work, CWZ data providers need to represent the work as multiple related zones with different schedules.

Discussion:
- Serge: What about worker presence and speed limit properties?
- Mark: The sections above reflect mandatory needs. Worker presence and speed limit are optional and not precluded.
- Dagan: We call out worker presence and these properties in BR#1.
- Neil: Probably do not need to specify speed limit in BR#1. Fine with Worker Presence.
- Serge: Agreed with the changes.

    - Mike: Asked about width restrictions.
    - Mark: width restrictions are not precluded.

2.5.2.5 Zone Status

2.5.2.5.1 Zone Status - Is Active

One of the biggest challenges of CWZ data providers is knowing when the active work is actually occurring. Knowledge about when activity is planned in the future is generally not reliable and insufficient to satisfy the timeliness requirements of safety applications.

CWZ data providers need to provide when a work zone is active when providing work zone information to work zone data consumers.

2.5.2.5.2 Zone Status – Length

CWZ deployers manage work zone activities that stretch across long distances, for example, as large as 60 miles.

CWZ data providers need to provide zone length when providing work zone information to work zone data consumers.

2.5.2.5.3 Zone Status - Number of Lanes Open

CWZ data providers need to provide number of lanes open (available for traffic) when providing work zone information to work zone data consumers.

2.5.2.5.4 Zone Status - Ad-hoc (Unscheduled/Unplanned)

Many work zones are dynamic and can pop up without prior notice and for short periods of duration.

CWZ data providers need to provide zone information for ad-hoc work zones when providing work zone information to work zone data consumers.

2.5.2.5.5 Zone Status - Is Rolling / Moving

Many work zones are dynamic, without a fixed location, and move continuously across time - examples include work zones for mowing, striping operations, and repaving.

CWZ data providers need to provide zone information for rolling/moving work zones when providing work zone information to work zone data consumers.

2.5.2.6 Zone Lanes

2.5.2.6.1 Zone Lanes - Numbering and Identification

2.5.2.6.1.1 Lane Information

CWZ deployers have stated the need to report information for every lane affected by construction or maintenance in a work zone.

2.5.2.6.1.2 Lane Numbering is Left-to-Right or Right-to-Left

CWZ deployers have stated the need for a nationally consistent method of lane numbering.

CWZ data providers need to provide lane numbering method, whether counting is left-to-right or right-to-left and the starting number for the first lane time when providing work zone information to work zone data consumers.

2.5.2.6.2 Zone Lanes - Lane Type

CWZ data providers need to provide standardized lane types when providing work zone information to work zone data consumers. For example, “shoulder,” but also indication of whether the lane is drivable, or a special-use lane.

2.5.2.6.2.1 Zone Lanes - Lane is Drivable

CWZ data providers need to indicate whether a lane is drivable when providing work zone information to work zone data consumers.

2.5.2.6.2.2 Zone Lanes - Special Use

CWZ data providers need to indicate whether a lane is special use when providing work zone information to work zone data consumers.

2.5.2.6.2.3 Zone Lanes - Reversible Lane

CWZ data providers need to identify whether a lane is reversible, its status, and direction when providing work zone information to work zone data consumers. In addition, lane numbering that is normally left-to-right becomes right-to-left when the lane direction reverses.

2.5.2.6.3 Zone Lanes - Connected Vehicle Environment Roadside Safety Applications

CWZ deployers developing applications for the connected vehicle environment may need detailed geometry attributes to be assigned to each node per lane of a work zone to account for road curvature. Specifically, we are addressing the need for a MAP message as part of the CV application. One example of deployers with this need are connected vehicle applications, CV pilots, and CV research projects.

CWZ data providers need to provide zone lane level geometry when providing work zone information to work zone data consumers.

2.5.2.6.4 Zone Lanes - Lane Tapers

CWZ deployers need to identify lane tapers. In addition, CWZ deployers have referenced the MUTCD and determined that tapers should be developed as a function of speed of the roadway.

CWZ deployers involving vehicles with driver assist functionality can navigate a work zone taper, and need to know taper start and end, and the number of lanes left/right to change.

2.5.2.6.4.1 Taper Start and End Positions, Direction of Taper, and Number of Lanes to Taper

CWZ data providers need to provide lane taper information including start location, end location, direction (left-to-right, right-to-left), and number of lanes to taper when providing work zone information to work zone data consumers.

2.5.2.6.5 Zone Lanes - Lane Closure Status

CWZ data providers need to indicate whether a lane is open or closed when providing work zone information to work zone data consumers.

2.5.2.7 Zone Speed Limit

CWZ deployers need real-time indications about speed limit changes in work zones including speed limit change and start/end points.

2.5.2.7.1 Zone Speed Limit - Positions/Geometry

CWZ data providers need to provide speed limit zone geometry, including start and end of speed limit changes, when providing work zone information to work zone data consumers.

2.5.2.7.2 Zone Speed Limit - Speed Limit Change

CWZ data providers need to provide speed limit changes when providing work zone information to work zone data consumers.

2.5.2.8 Zone Traffic Data

CWZ deployers need to develop and maintain historical work zone traffic data for later data analysis about work zones.

2.5.2.8.1 Zone Traffic Speed, Volume, and Occupancy

CWZ deployers may deploy devices to capture information about traffic speed, volume, and occupancy.

CWZ data providers need to provide traffic speed, volume, and occupancy for vehicles traveling through the work zone when providing work zone information to work zone data consumers.

2.5.2.8.2 Zone Traffic – Queue Warning

CWZ data providers need to provide queue warnings for work zone data consumers entering a work zone when providing work zone information to work zone data consumers.

2.5.2.9 Zone Device

2.5.2.9.1 Zone Device - Inventory and Status

CWZ deployers send alerts to devices that flash warnings, e.g., flashing beacons, to work zone VRUs, and to alert drivers traveling through work zones.

CWZ data providers need to provide device inventory, availability, and status information when providing work zone information to data consumers.

CWZ deployers need information about devices deployed in work zones, including:

- Device type
- Device location
- Device status

2.5.2.9.2 Zone Device - Location Marker Type

CWZ deployers use location marker devices to identify and broadcast many work zone attribute locations, such as zone approach start/end, work zone start/end, VRU presence start/end, taper zones start/end, speed limit reduction zones start/end, etc.

CWZ data providers need to provide location marker type and position when providing work zone information to data consumers.

2.5.2.9.3 Zone Device - Device Type

CWZ data providers need to provide device type when providing work zone information to work zone data consumers.

Representative examples of zone device types include the following:

- Arrow boards
- Cameras
- Portable Message Signs
- Speed Limit Signs
- Speed Feedback Signs
- Location Markers
- Roadside Units

CWZ data providers need to provide device type when providing work zone information to work zone data consumers.

2.5.2.9.4 Zone Device - Position/Geometry

CWZ data providers need to provide device location when providing work zone information to work zone data consumers.

2.5.2.9.5 Zone Device - Device Status

CWZ data providers need to provide device status when providing work zone information to work zone data consumers.

2.5.2.9.6 Zone Device - Zone Identifier

CWZ data providers need to provide the zone identifier and/or project identifier associated with a work zone device when providing work zone information to work zone data consumers.

2.5.2.10 Zone Vulnerable Road Users (VRU) Device

2.5.2.10.1 Zone VRU Device - Worker Presence Status/Activity

The statements contained in this need may be generalized to apply to VRUs, a superset of work zone workers.

CWZ deployers have stated that there is a mission-critical need to absolutely identify when there are workers present in a work zone. For example, an OEM may allow the autodrive feature on a vehicle to stay active if no workers are present, but if there are workers present, the OEM may return control of the vehicle to the driver. Real time worker presence is a mission-critical information need.

CWZ data providers need to provide real time indication of whether workers are present in the work zone when providing work zone information to work zone data consumers.

2.5.2.10.2 Zone VRU Device - Position/Geometry

The statements contained in this need includes work zone workers, which are a subset of VRUs.

CWZ deployers need to address real-time VRU presence identification. This includes:

- Providing a geographic description of an area within a work zone where VRUs are present.
- Providing a point location to describe the location where workers are present, for example if the worker is wearing a vest that contains electronics for determination of the VRUs position/location.

CWZ deployers need VRU location information.

CWZ data providers need to provide real time indication of areas within the work zone where VRUs are present when providing work zone information to work zone data consumers.

CWZ data providers need to provide real time indication of VRU position/location where VRUs are present when providing work zone information to work zone data consumers.

2.5.2.11 Zone Work Vehicle Device

CWZ deployers need to know real-time position/location information about work vehicles in the work zone. In addition, CWZ deployers state that vehicles in a work zone present a hazardous condition. Generally, vehicle types for which location is needed to be shared includes:

- Attenuator vehicles
- Construction vehicles
- Maintenance vehicles
- Emergency vehicles
- Stalled or disabled vehicles

2.5.2.11.1 Zone Work Vehicle Device – Vehicle Type

CWZ data providers need to provide work vehicle type when providing work zone information to work zone data consumers. Work vehicle types includes: attenuator vehicle, construction vehicle, maintenance vehicle, emergency vehicle, and stalled or disabled work zone traveler's vehicle.

2.5.2.11.2 Zone Work Vehicle Device – Vehicle Position

CWZ data providers need to provide work vehicle location when providing work zone information to work zone data consumers. Work vehicles parked or stalled near travel lanes present a hazard.

2.6 Operational Scenarios [Informative]

A scenario is a step-by-step description of how the proposed set of system interfaces should operate under a given set of conditions. Operational Scenarios help readers understand how all the components of a system interact to provide operational capabilities. [Adapted from IEEE 1362-1998]

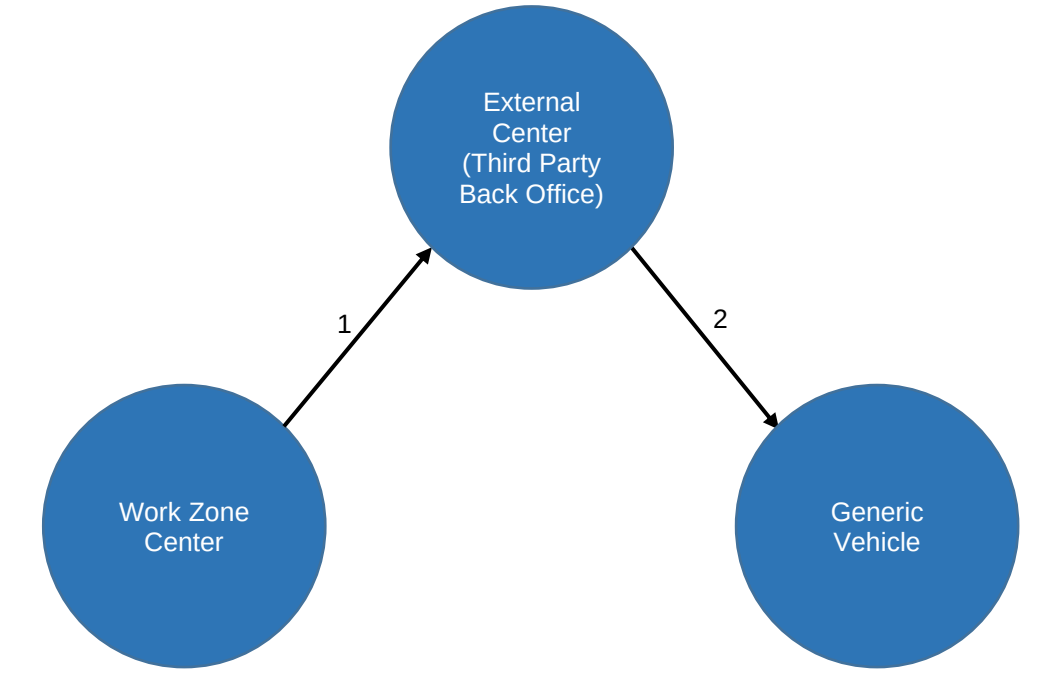
For the purposes of this project, the proposed system is a connected work zone. The operational scenarios allow a reader to understand the different component actors of a CWZ, proposed functions, and data exchanges under a given set of conditions. Pre-conditions are described, and a narrative provided to guide the reader through the sequence of events and data exchanges that complete with a desired end state or condition.

These are intended to illustrate representative examples of interactions between component actors. They are not intended to be all-encompassing.

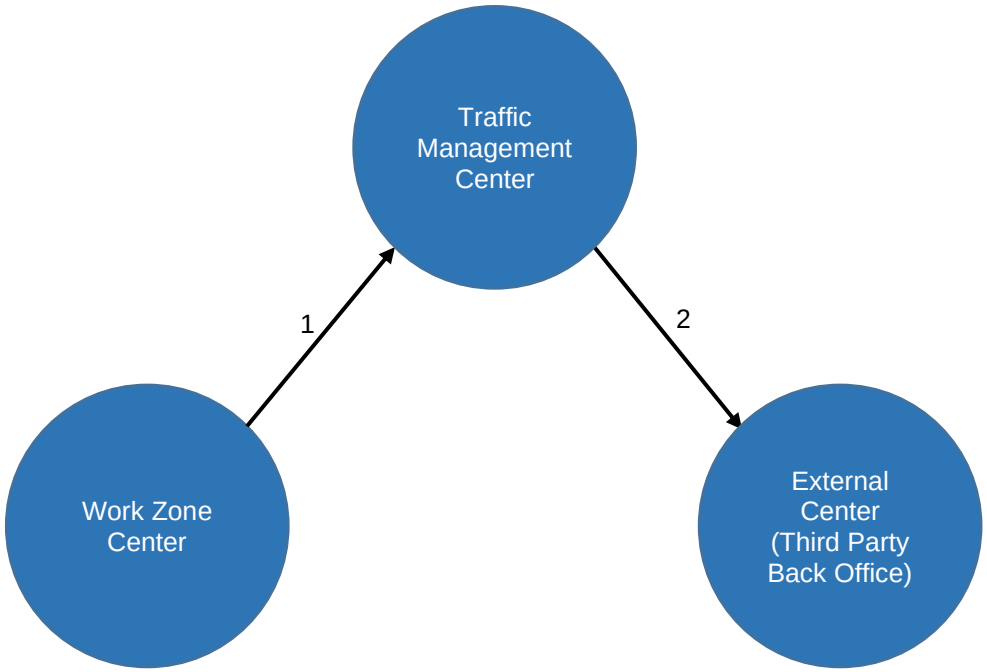
Table 1. Operational Scenario Template

Title	Operational Scenario Title. Shortest possible problem statement, and usually stating the desired end-condition.
Problem Aspect	Some situation of concern, for example Work Zone Vulnerable Road User and Driver Safety.
Description	A description of the scenario. For example, the purpose of this scenario is to provide advisories, warnings, or alerts to drivers.
Pre-Conditions	A listing of factors, attributes, or measures about the environment/conditions describing the beginning state of the operational scenario.
Optional Diagram	A sequence diagram showing actors and a numbered sequence of interactions and events to demonstrate how to step between pre-condition and end-condition states.
Narrative and Sequence of Steps	1) A narration that usually describes the steps shown in the sequence diagram.
End Conditions or State	Everyone safe! A listing of factors, attributes, or measures about the environment/conditions describing the end state of the operational scenario.

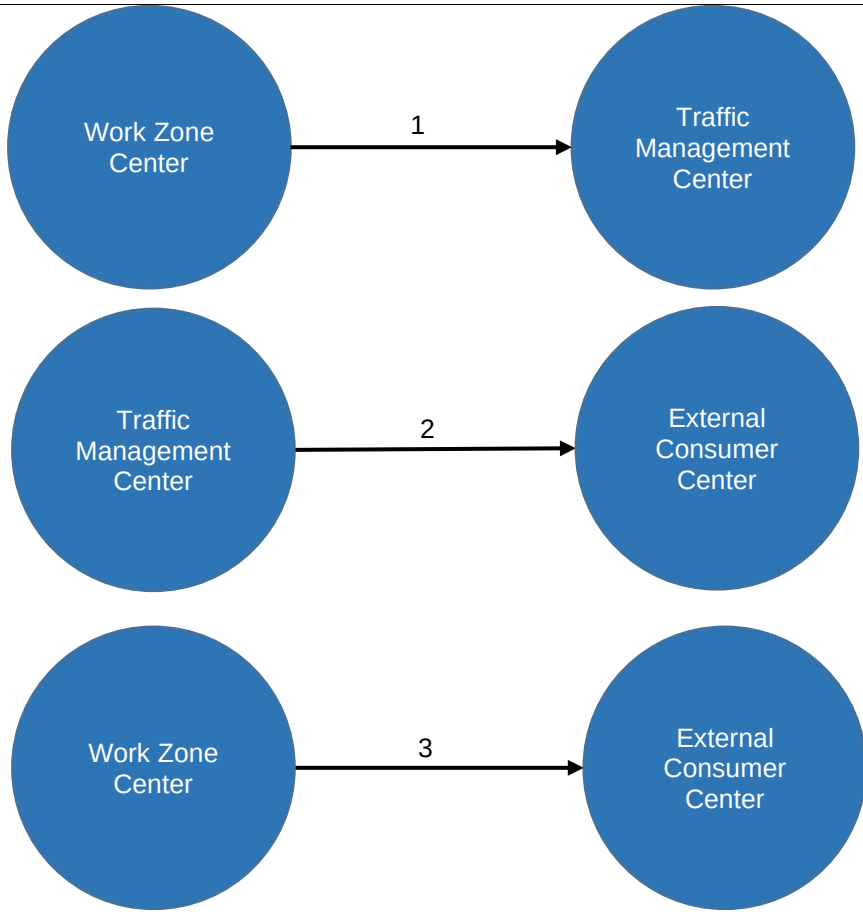
2.6.1 Ad-hoc Notification of Work Zone Ahead

Title	Ad-hoc Notification of Work Zone Ahead
Problem Aspect	Work zones may want to provide advanced notification of its presence to vehicles.
Description	The work zone may want to provide advanced notification to vehicles of its presence. This may be achieved with the cooperation of a third party such as an OEM or smartphone navigation application. Some deployers refer to this as ad-hoc.
Pre-Conditions	• The work zone location is known by the work zone center. • The work zone center is connected to an external center with vehicle notification abilities. • In this scenario, a TMC does not know about this work zone (ad-hoc).
Optional Diagram	
Narrative and Sequence of Steps	1) The work zone center sends work zone information (Device Feed) to an external center. 2) The external center provides the work zone ahead notification to a generic vehicle (proprietary).
End Conditions or State	The driver of the generic vehicle is notified of the work zone ahead through their smartphone navigation app or vehicle notification system.

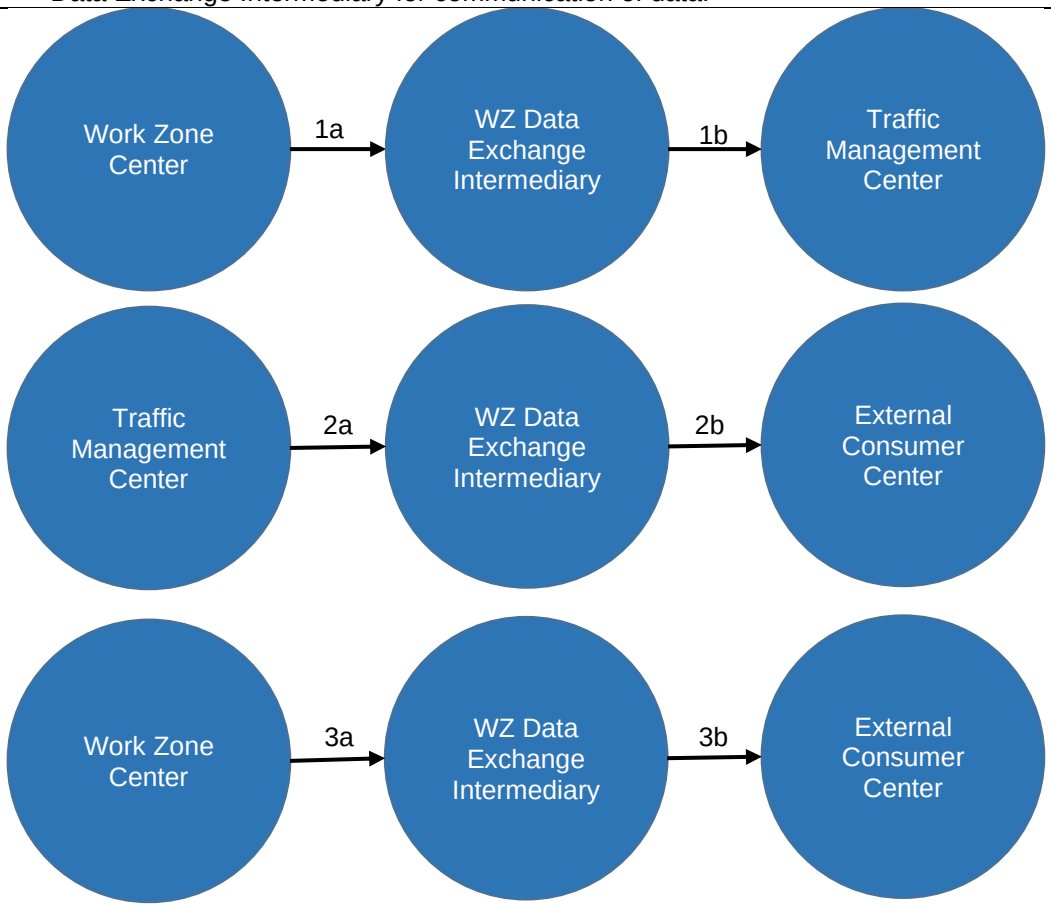
2.6.2 IOO Notification of Work Zone Information

Title	IOO Notification – Work Zone Information
Problem Aspect	Work zones may want to share advanced notification of its presence to external centers.
Description	The IOO may want to provide advanced notification to external centers of the presence of a work zone.
Pre-Conditions	• The work zone location is known by the work zone center. • The work zone center is connected to a traffic management center, which assigns an IOO work zone identifier.
Optional Diagram	
Narrative and Sequence of Steps	1) The work zone center sends work zone information (Device Feed) to a Traffic Management Center. 2) The Traffic Management Center provides work zone information to an External Center.
End Conditions or State	The External Center has notification of work zone information.

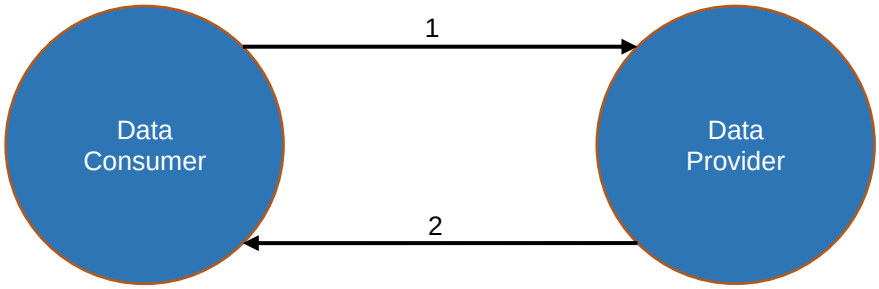
2.6.3 Work Zone Data Collection and Distribution

Title	Work Zone Data Collection and Distribution
Problem Aspect	Work zone actors may wish to communicate with each other.
Description	Collection and distribution of work zone and device information.
Pre-Conditions	• The work zone center, TMC, and external consumer center are connected to each other for communication of data.
Optional Diagram	
Narrative and Sequence of Steps	1) WZ Center sends the DeviceFeed for all devices managed by the Work Zone Center. Each device id has a UUID, assigned by the Work Zone Center. 2) A work zone id is unique, assigned by the TMC in the WorkZoneFeed. The TMC matches the device id to their work zone id to determine device status, i.e., an arrow board is active, and therefore the work zone is active. The TMC sends WorkZoneFeed information to an external consumer center. 3) WZC sends DeviceFeed to External Consumer Center.
End Conditions or State	The Traffic Management Center and External Consumer Center have up-to-date information about work zones and conditions.

2.6.4 Work Zone Data Collection and Distribution (Data Exchange Intermediary)

Title	Work Zone Data Collection and Distribution (Intermediary)
Problem Aspect	Work zone actors may wish to communicate through an intermediary.
Description	Collection and distribution of work zone and device information via an intermediary system.
Pre-Conditions	• The work zone center, TMC, and external consumer center are connected to the WZ Data Exchange Intermediary for communication of data.
Optional Diagram	
Narrative and Sequence of Steps	1a) WZ Center sends device information for all devices managed by the Work Zone Center (DeviceFeed) to a WZ Data Exchange Intermediary. Each device ID has a UUID, assigned by the Work Zone Center. 1b) The WZ Data Exchange Intermediary sends information (DeviceFeed) to the TMC. 2a) A work zone ID is unique, assigned by the TMC in the WorkZoneFeed. The TMC matches the device status, i.e., an arrow board is active, and therefore the work zone is active. The TMC sends information to the WZ Data Exchange Intermediary (WorkZoneFeed). 2b) The WZ Data Exchange Intermediary sends information to an External Consumer Center (WorkZoneFeed). 3a) WZC sends all device data to the WZ Data Exchange Intermediary (DeviceFeed). 3b) WZ Data Exchange Intermediary sends information (DeviceFeed) to External Consumer Center.
End Conditions or State	The Traffic Management Center and External Consumer Center have up-to-date information about work zones and conditions.

2.6.5 Generic Work Zone Information Data Exchange (Poll for Data)

Title	Generic Work Zone Information Data Exchange (Poll for Data)
Problem Aspect	A data consumer (a CWZ component actor) requires current up-to-date information from a data provider (another CWZ component actor).
Description	When a data consumer requires current information from a data provider, whether as an update or to establish a baseline of information the data consumer will poll the data provider to establish data currency of work zone information and conditions.
Pre-Conditions	• The data consumer is an authorized connection to the data provider.
Optional Diagram	
Narrative and Sequence of Steps	1) The data consumer sends a request for information to the data provider. 2) The data provider responds with (returns) information to the data consumer.
End Conditions or State	The data consumer has up-to-date information about work zones and conditions.

2.7 Operational Policies and Constraints

The following operational policies and constraints apply to the use of this CWZ Implementation Guide and Standard document.

2.7.1 Operational Policies and Constraints - Manual of Uniform Control Devices (MUTCD)

The operation and maintenance of connected work zones are governed by the regulatory guidelines or policies for the operating agency (IOO) that may include USDOT's and the relevant states' Manual of Uniform Traffic Control Devices (MUTCD), and state and local ordinances, policies, and procedures.

2.7.2 Operational Policies and Constraints – Security

The operation and maintenance of connected work zone information and system security are governed by the regulatory guidelines and policies of the data provider.

2.7.3 Operational Policies and Constraints – Uniform Resource Identifiers

The operation and maintenance of connected work zone information and web site, including determination of uniform resource identifiers, are governed by the regulatory guidelines and policies of the data provider.

2.7.4 Operational Policies and Constraints – Universally Unique Identifiers (UUID)

The assignment of UUIDs is governed by the regulatory guidelines and policies of the data provider. For example, the assignment of uniform resource identifiers may be governed by policies to guarantee privacy. As a result, UUIDs may need to change over time. Likewise, data consumers may need to specify the need for UUIDs to remain consistent or the same across time.

2.8 Relationship to the Architecture Reference for Cooperative and Intelligent Transportation [Informative]

This section describes which portions of the Architecture Reference for Cooperative and Intelligent Transportation, known as ARC-IT, are addressed by this CWZ Implementation Guide and Standard.

At the highest level of abstraction, the physical architecture consists of center components, field components, vehicle components and personal components. The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) defines these components as follows:

- **Center.** An entity that provides application, management, administrative, and support functions from a fixed location not in proximity to the road network. The terms "back office" and "center" are used interchangeably. Center is traditionally a transportation-focused term, evoking management centers to support transportation needs, while back office generally refers to commercial applications.
- **Field.** These are intelligent infrastructure elements distributed near or along the transportation network which perform surveillance (e.g., traffic detectors, cameras), traffic control (e.g., traffic signal controllers), information provision (e.g., dynamic message signs) and local transaction (e.g., tolling, parking) functions. Typically, their operation is governed by transportation management functions running in back offices. Field also includes RSU, LTE-CV2X, and other non-Dedicated Short Range Communication (DSRC) wireless communications infrastructure that provides communications between mobile elements and fixed infrastructure.
- **Personal.** Equipment used by travelers to access transportation services pre-trip and enroute. This includes mobile/handheld as well as desktop equipment owned and operated by the traveler.
- **Vehicle.** Vehicles, including driver information and safety systems applicable to all vehicle types.

Service Packages and associated diagrams show the key interfaces and flow of information exchanged between components. The service package in ARC-IT that best identifies the scope of Connected Work Zones is MC06: Work Zone Management.

2.8.1 ARC-IT Work Zone Management Service Package

MC06: Work Zone Management. This service package manages work zones, controlling traffic in areas of the roadway where maintenance, construction, and utility work activities are underway. Traffic conditions are monitored using CCTV cameras and controlled using dynamic message signs (DMS), Highway Advisory Radio (HAR), gates and barriers. Work zone information is coordinated with other groups (e.g., traveler information, traffic management, other maintenance and construction centers). Work zone speeds and delays are provided to the motorist prior to the work zones. This service package provides control of field equipment in all maintenance and construction areas, including fixed, portable, and truck-mounted devices supporting both stationary and mobile work zones.

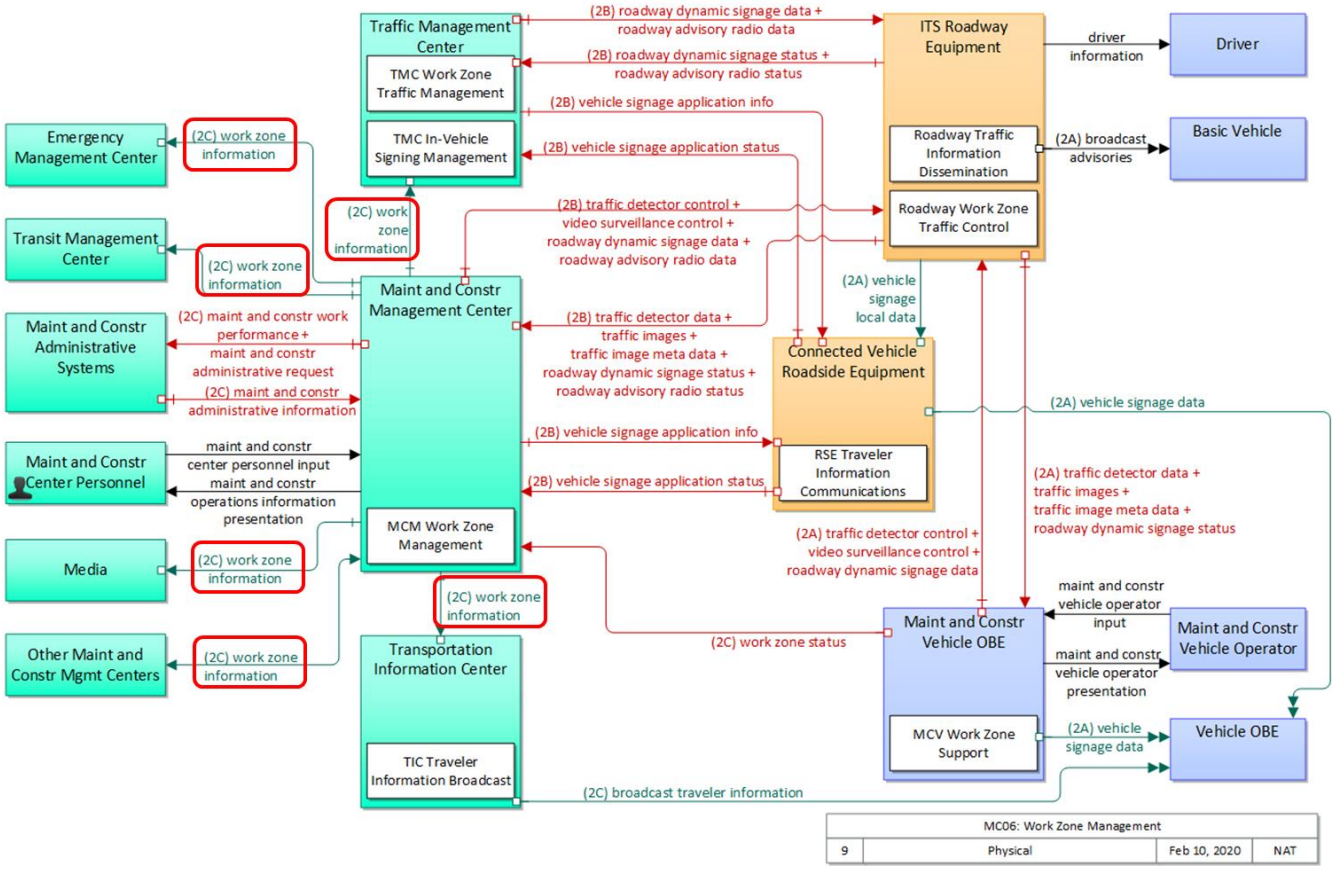


Figure 4. ARC-IT – Work Zone Management Service Package Diagram.

This standard covers definition of the work zone information flows (encapsulated in red).

Section 3
System Requirements [Normative]

3.1 Introduction [Informative]

The requirements for the CWZ Standard and Implementation Guide follow.

3.2 Architectural Requirements

The architectural requirements for the CWZ Standard and Implementation Guide follow.

3.2.1 Compatibility with the WZDx Specification

The CWZ WG believes that the approach described here supports the objective to preserve the investment of deployers in prior versions of WZDx, lessening the burden of legacy deployments to upgrade to this standard. The general approach below states that where applicable, a WZDx specification design element shall be reused, instead of developing a new data requirement and design element.

3.2.1.1 Exceptions

During development of this standard, the CWZ WG asserted that full backward compatibility was not required, and that the following exceptions superseded the need for full backward compatibility with the WZDx v4.2 specification:

a) Elements described as DEPRECATED have been removed in this standard.
b) Some elements described as OPTIONAL have been made MANDATORY in this standard.
c) Some elements were renamed to generalize the choice of units, for example the choice of miles or kilometers for reference post. Elements described as having metric units were left as-is.
d) Some elements within enumerations were renamed for clarity in this standard.

3.2.1.2 Requirement

The data requirements described in this standard shall be re-used, where applicable, based on the data specification and requirements contained in WZDx 4.2 specification to maintain compatibility with the WZDx specification, and numerous current deployments, with exceptions as defined above in Section 3.2.1.1.

3.2.2 GeoJSON Data Format

Work Zone information shall be provided in the GeoJSON data format.

3.2.3 GeoJSON Data Validation

Work Zone information provided in the GeoJSON data format shall be validated (verified) using the JSON Schema contained in this standard.

3.2.4 Business Rules

The following business rules help assure a standardized and interpretable use of the requirements in this standard. This standard describes the required structure and data fields to describe a work zone, whereas business rules are additional requirements for using the standard in a consistent manner at the national level. Note that business rules are distinct from best practices in that the latter are suggestions and business rules are requirements that cannot be validated by the JSON schema.

3.2.4.1 Event Segments Follow Attribute Changes

A work zone or detour must be segmented into separate WorkZoneRoadEvents or DetourRoadEvents if certain characteristics vary **within the overall location and/or time frame of the work zone or detour**. This rule exclusively applies to characteristics represented by the properties: road_name, direction, start_date, end_date **,** vehicle_impact, lanes, and worker_presence**.**

The following guidelines are provided:

- A road event should identify any related WorkZoneRoadEvents and DetourRoadEvents using the related_road_events and project_id properties on the RoadEventCoreDetails object.
- A series of sequential or recurring road events comprising a complex work zone or detour should use the first- and next-in-sequence or first- and next-occurrence enumerations of the RelatedRoadEventType. A work zone or detour represented by multiple road events should also use the project_id property to identify the project that the events correspond to.
- A WorkZoneRoadEvent should identify any prescribed detour using the related-detour enumeration; a DetourRoadEvent should identify the work zone necessitating the detour using the related-work-zone enumeration; both may refer to the same project identifier as other work zones and detours in the project area.

3.2.4.2 WorkZoneRoadEvent Lanes

If the lanes property on the WorkZoneRoadEvent is provided, it must include one entry for every lane in the road event. Providing lane information for only some of the lanes in a road event is not allowed.

3.2.4.3 Lane Order

A Lane order or TrafficSensorLaneData lane_order value of 1 must represent the left-most lane when facing downstream traffic and an increase in 1 must represent moving a single lane to the right.

3.2.4.4 Data Source ID Referential Integrity

The data_source_id value must match to the data_source_id property of a FeedDataSource included within the same GeoJSON document on the WorkZoneRoadEvents and DetourRoadEvents.

3.2.4.5 UTC Date-Time Format Specification

All dates and times must be expressed in UTC.

3.2.4.6 UUID Format Specification

All universally unique identifiers must comply with the UUID standard (RFC 4122) reference. There may be cases (e.g., cases of privacy) where the UUID may need to change over time.

3.3 Data Exchange Requirements

Requirements for data exchange follow.

3.3.1 Exchange WorkZoneFeed Information

Requirements for the exchange of WorkZoneFeed information follow.

3.3.1.1 Send WorkZoneFeed Upon Request

A data provider shall send WorkZoneFeed information upon request from a data consumer.

3.3.2 Exchange DeviceFeed Information

Requirements for the exchange of DeviceFeed information follow.

3.3.2.1 Send DeviceFeed Upon Request

A data provider shall send DeviceFeed information upon request from a data consumer.

3.4 WorkZoneFeed Requirements

The WorkZoneFeed includes the following data definitions, some of which are defined as optional.

3.4.1 Contents of WorkZoneFeed

The WorkZoneFeed shall consist of the following required and optional requirements.

- **a)** **feed_info.** Information about the Work Zone Feed. See 3.5 FeedInfo Requirements. **Required**.
- **b)** **type.** The GeoJSON object type. For a WorkZoneFeed, this must be the string 'FeatureCollection'. **Required.**
- **c)** **features.** An array of GeoJSON Feature objects (RFC 7946 Section 3.2) which represents a WorkZoneFeed's road events. The array consists of one or more instances of the RoadEventFeature. See 3.6 RoadEventFeature Requirements. **Required.**
- **d)** **bbox.** Information on the coordinate range for all RoadEventFeatures in the feed. Must be an array of length '2n' where 'n' is the number of dimensions represented in the contained geometries, with all axes of the most southwesterly point followed by all axes of the more northeasterly point. The axes order of a bbox follows the axes order of geometries. See 3.9 BoundingBox Requirements. **Optional.**

3.5 FeedInfo Requirements

The FeedInfo includes the following data definitions, some of which are defined as optional.

3.5.1 Contents of FeedInfo

The FeedInfo shall consist of the following required and optional requirements.

- **a)** **publisher.** The organization responsible for publishing the feed. Example: 'State DOT'. **Required.**
- **b)** **contact_name.** The name of the individual or group responsible for the data feed. Example: 'Jo Help'. **Optional.**
- **c)** **contact_email.** The email address of the individual or group responsible for the data feed. Example: 'abc@testcity1.gov'. **Optional.**
- **d)** **update_frequency.** The frequency in seconds at which the data feed is updated. Example: '60'. A value of '-1' indicates that the data feed is not being updated. A value of '0' indicates update on change. **Required.**
- **e)** **update_date.** The UTC date and time when the GeoJSON file (representing the instance of the feed) was generated. The recency of the value of this property depends on if the feed producer is generating a new feed GeoJSON file for each request or generating the file in advance and making it available for download (this standard does not mandate a particular distribution method). Note all date-time formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. Business Rule #5. **Required.**
- **f)** **version.** The specification version used to create the data feed in 'major.minor' format. Note this mandates that all data in a feed complies to a single version of WorkZoneFeed. Examples: '1.1', '2.0'. **Required.**
- **g)** **license.** The URL of the license that applies to the data in the feed. The recommended string is "https://creativecommons.org/publicdomain/zero/1.0/". **Required.**
- **h)** **data_sources.** A list of specific data sources for the road event data in the feed. Length of array must be at least one. See 3.5.2 FeedDataSource. **Required.**

3.5.2 Contents of FeedDataSource

The FeedDataSource shall consist of the following required and optional requirements.

a) **data_source_id.** A unique identifier for the data source organization providing work zone data. This identifier is a Universally Unique IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds and over time. Linked to a road event by the 'data_source_id' property on the road event's core details or a field device by the 'data_source_id' property on the device's core details. See Business Rule #4. **Required.**
b) **organization_name.** The name of the organization for the authoritative source of the work zone data. Example: County DOT. **Required.**
c) **contact_name.** The name of the individual or group responsible for the data source. Example: 'Jo Help'. **Optional.**
d) **contact_email.** The email address of the individual or group responsible for the data source. **Optional.**
e) **update_frequency.** The frequency in seconds at which the data source is updated. A value of '-1' indicates that the data source is not being updated. A value of '0' indicates update on change. **Required.**
f) **update_date.** The UTC date and time when the data source was last updated. All date-time formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**

3.6 RoadEventFeature Requirements

The RoadEventFeature includes the following data definitions, some of which are defined as optional.

3.6.1 Contents of RoadEventFeature

The RoadEventFeature shall consist of the following required and optional requirements.

a) **id**. A unique identifier issued by the data feed provider to identify the road event. This identifier is a Universally Unique IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds and over time. This is a GeoJSON property. **Required.**
b) **type.** The GeoJSON object type. This MUST be the string 'Feature'. This is a GeoJSON property. **Required.**
c) **properties.** The specific details of the road event. This is a GeoJSON property. The road event consists of either a WorkZoneRoadEvent or a DetourRoadEvent. See 3.6.2 Contents of WorkZoneRoadEvent or 3.6.3 Contents of DetourRoadEvent. **Required.**
d) **geometry.** The geometry of the road event. The Geometry object's 'type' property MUST be LineString (RFC 7946 Section 3.1.4) or Point (RFC 7946 Section 3.1.2). 'LineString' allows specifying the entire road event path and should be preferred. ‘LineString’ should be used when at least the start and end coordinates are known. The order of coordinates is meaningful: the first coordinate is the first (furthest upstream) point a road user encounters when traveling through the road event. ‘Point' should be used when only one coordinate is known. Where both start and end data are required (e.g., is_start_position_verified and is_end_position_verified), the ‘Point’ type is allowed. **Required.**
e) **bbox.** Information on the coordinate range for this RoadEventFeature. Must be an array of length '2n' where 'n' is the number of dimensions represented in the 'geometry' property, with all axes of the most southwesterly point followed by all axes of the more northeasterly point. The axes order of a bbox follows the axes order of the 'geometry'. This is a GeoJSON property. See 3.9 BoundingBox Requirements. **Optional.**

3.6.2 Contents of WorkZoneRoadEvent

The WorkZoneRoadEvent shall consist of the following required and optional requirements.

a) **core_details.** The core details of the road event that are shared by all types of road events, not specific to work zones. See Business Rule #1. See 3.6.4 Contents of RoadEventCoreDetails. **Required.**
b) **beginning_cross_street.** Name or number of the nearest cross street along the roadway where the event begins. **Optional.**

c) **ending_cross_street.** Name or number of the nearest cross street along the roadway where the event ends. **Optional.**
d) **beginning_reference_post.** The linear distance measured against a reference post marker along a roadway where the event begins. A reference post may be a milepost or mile marker, a surveyed distance posted along a roadway measuring the length (in miles or tenth of a mile) from the south west to the north east. These markers are typically notated on State and local government digital road networks. **Optional.**
e) **ending_reference_post.** The linear distance measured against a reference post marker along a roadway where the event ends. A reference post may be a milepost or mile marker, a surveyed distance posted along a roadway measuring the length (in miles or tenth of a mile) from the south west to the north east. These markers are typically notated on State and local government digital road networks. **Optional.**
f) **reference_post_unit.** Unit of measurement for the WorkZoneRoadEvent 'beginning_reference_post' and 'ending_reference_post', if applicable. See 3.6.19 Enumeration of UnitOfMeasurement. **Conditional;** required if either 'beginning_reference_post' or ending_reference_post' is not null.
g) **is_start_position_verified.** Indicates if the start position (first geometric coordinate pair) is based on actual reported data from a GPS-equipped device that measured the location of the start of the work zone. **Required.**
h) **is_end_position_verified.** Indicates if the end position (last geometric coordinate pair) is based on actual reported data from a GPS-equipped device that measured the location of the end of the work zone. **Required.**
i) **start_date.** The UTC time and date when the event begins. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
j) **end_date.** The UTC time and date when the event ends. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
k) **is_start_date_verified.** Indicates if work has been confirmed to have started, such as from a person or field device. **Required.**
l) **is_end_date_verified.** Indicates if work has been confirmed to have ended, such as from a person or field device. **Required.**
m) **work_zone_type.** The type of work zone road event, such as if the road event is static or actively moving as part of a moving operation. See 3.6.13 Enumeration of WorkZoneType. **Optional.**
n) **vehicle_impact.** The impact to vehicular lanes along a single road in a single direction. See 3.6.14 Enumeration of VehicleImpact. **Required.**
o) **location_method.** The typical method used to locate the beginning and end of a work zone impact area. See 3.6.5 Enumeration of LocationMethod. **Required.**
p) **worker_presence.** Information about whether workers are present in the road event area. See 3.6.11 Contents of WorkerPresence. **Optional.**
q) **reduced_speed_limit_kph.** The reduced speed limit posted within the road event, in kilometers per hour. This property only needs to be supplied if the speed limit within the road event is lower than the posted speed limit of the roadway. **Optional.**
r) **restrictions.** A list of zero or more road restrictions that apply to the roadway segment described by this road event. Restrictions can also be provided on an individual lane. See 3.6.9 Contents of Restriction. **Optional.**
s) **types_of_work.** A list of the types of work being done in a road event and an indication of if each type results in an architectural change to the roadway. See 3.6.7 Contents of TypeOfWork. **Optional.**
t) **lanes.** A list of individual lanes within a road event (roadway segment). See Business Rules #1 and #2. See 3.6.8 Contents of Lane. **Optional.**
u) **impacted_cds_curb_zones.** A list of references to external CDS Curb Zones impacted by the work zone. See 3.6.10 Contents of CdsCurbZonesReference. **Optional.**

3.6.3 Contents of DetourRoadEvent

The DetourRoadEvent shall consist of the following required and optional requirements.

a) **core_details.** The core details of the road event that are shared by all types of road events, not specific to detours. See Business Rule #1. See 3.6.4 Contents of RoadEventCoreDetails. **Required.**
b) **beginning_cross_street.** Name or number of the nearest cross street along the roadway where the event begins. **Optional.**
c) **ending_cross_street.** Name or number of the nearest cross street along the roadway where the event ends. **Optional.**
d) **beginning_reference_post.** The linear distance measured against a reference post marker along a roadway where the event begins. A reference post may be a milepost or mile marker, a surveyed distance posted along a roadway measuring the length (in miles or tenth of a mile) from the south west to the north east. These markers are typically notated on State and local government digital road networks. **Optional.**
e) **ending_reference_post.** The linear distance measured against a reference post marker along a roadway where the event ends. A reference post may be a milepost or mile marker, a surveyed distance posted along a roadway measuring the length (in miles or tenth of a mile) from the south west to the north east. These markers are typically notated on State and local government digital road networks. **Optional**.
f) **reference_post_unit.** Unit of measurement for the DetourRoadEvent 'beginning_reference_post' and 'ending_reference_post', if applicable. See 3.6.19 Enumeration of UnitOfMeasurement. **Conditional;** required if either 'beginning_reference_post' or ending_reference_post' is not null.
g) **start_date.** The UTC time and date when the event begins. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
h) **end_date.** The UTC time and date when the event ends. All datetime formats shall follow RFC 3339 Section 5.6 Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
i) **is_start_date_verified.** Indicates if the detour has been confirmed to have started, such as from a person or device in the field or a report from a traffic management center. **Required.**
j) **is_end_date_verified.** Indicates if the detour has been confirmed to have ended, such as from a person or device in the field or a report from a traffic management center. **Required.**

3.6.4 Contents of RoadEventCoreDetails

The RoadEventCoreDetails shall consist of the following required and optional requirements.

a) **data_source_id.** Identifies the data source from which the road event originates. See Business Rule #4. **Required.**
b) **event_type.** The type/classification of road event. See 3.6.12 Enumeration of EventType. **Required.**
c) **related_road_events.** A list describing road events which are related to this road event. Examples of related road event include but are not limited to the sequence along the roadway, recurring work zones, related detours or other road events that encompass a similar work area. See 3.6.6 Contents of RelatedRoadEvent. **Optional.**
d) **project_id.** An identifier for the project that the event is part of. A project is the highest-level representation of an area where road work takes place and may cover multiple roadways if adjacent or intersecting. A project will contain one or more RoadEventFeatures. This project ID does not correspond to an object in a WorkZoneFeed. It is used to group events (and devices, see FieldDeviceCoreDetails). This identifier is a Universally Unique IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds and over time. **Optional.**
e) **road_names.** A list of publicly known names of the road on which the event occurs. This may include the road number designated by a jurisdiction such as a county, state or interstate (e.g. I-5, VT 133). **Required.**
f) **direction.** The digitization direction of the road that is impacted by the event. This value is based on the standard naming for US roadways and indicates the direction of the traffic flow regardless of the real heading angle. Example 'northbound' (for I-5 North). See 3.8 Direction Requirements. **Required.**
g) **name.** A human-readable name for the road event. **Optional.**
h) **description.** Short free text description of road event. **Optional.**

i) **creation_date.** The UTC time and date when the activity or event was created. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Optional.**

j) **update_date.** The UTC date and time when any information in the RoadEventFeature (including child objects) that the RoadEventCoreDetails applies to was most recently updated or confirmed as up to date. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Optional.**

3.6.5 Enumeration of LocationMethod

The LocationMethod Enumerated Type describes the typical method used to locate the begin and end of a work zone impact area.
The following identifies the enumerations for LocationMethod.

- **channel-device-method.** Location of first and last channeling device (e.g., cone or barrier) that is part of a “travel impact effect” (taper) or designation of a work zone transition area. *This is the preferred location method.*
- **sign-method.** Location of first and last work zone-related signs.
- **junction-method.** Location of a junction (e.g., a cross street or exit/entrance ramp) before and after a work zone.
- **other.** Location method does not match any of the other options.
- **unknown.** Location method is not known.

Additional Information
The following sections detail the usage of each of the location method.

- **channel-device-method** (Preferred Method)
  Location of first and last channeling device (e.g., cone or barrier) that is part of a “travel impact effect” (taper) or designation of a work zone transition area. For complex work zones with multiple activities, begin and end locations are the first channeling device for first activity up to the last channeling device of the last activity.

  - **Simple Scenario**
    See Figure 5.

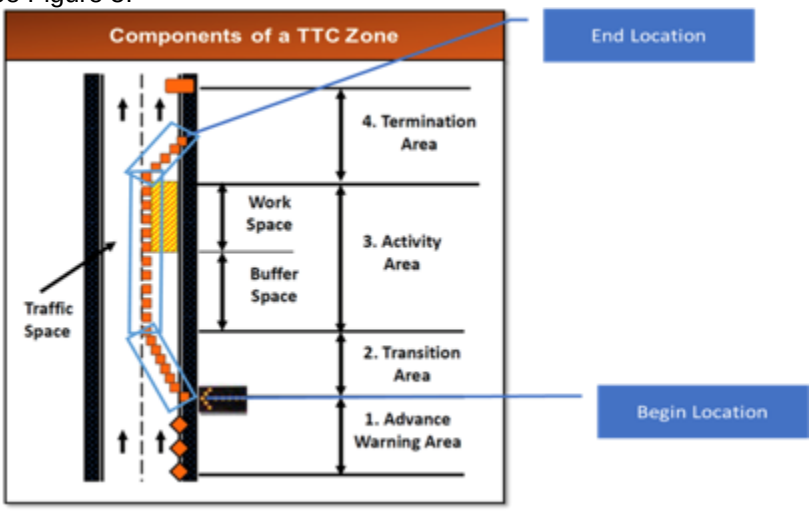
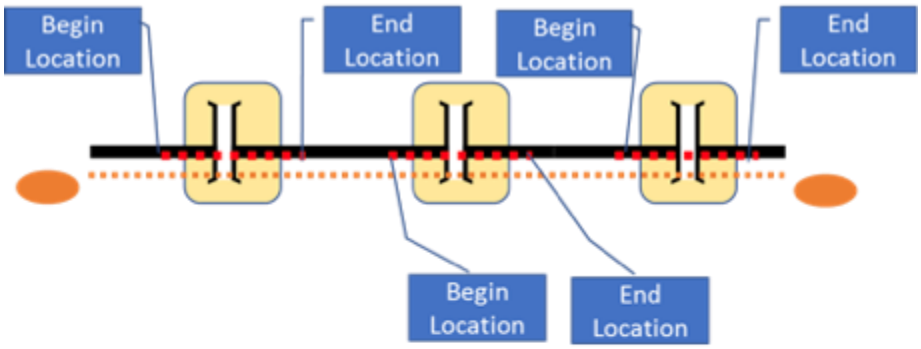


Figure 5. Simple Scenario

  - **Complex Scenario**

This example shows three work zone activity areas that are part of a work zone project. Each activity area is treated as an independent work zone activity record, with its own begin and end location where each lane taper begins and ends. See Figure 6.



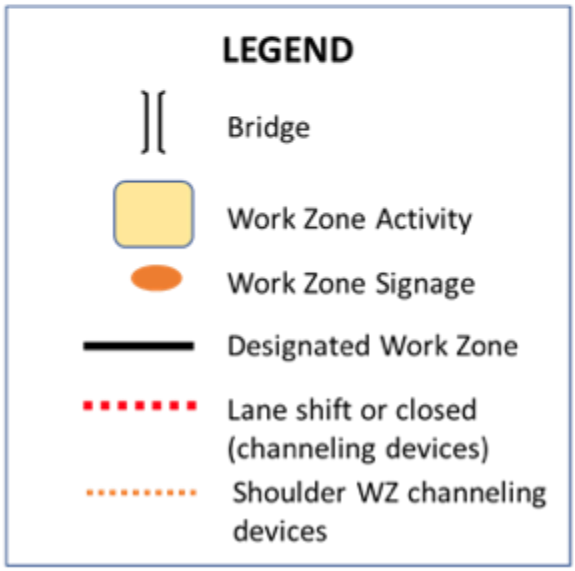


Figure 6. Complex Scenario

- **sign-method**
  Location of first and last work zone-related signs. This may be different from the channelization location. For complex work zones, begin would be the first sign before the first activity and end would be the last sign following the last activity. See Figure 7.

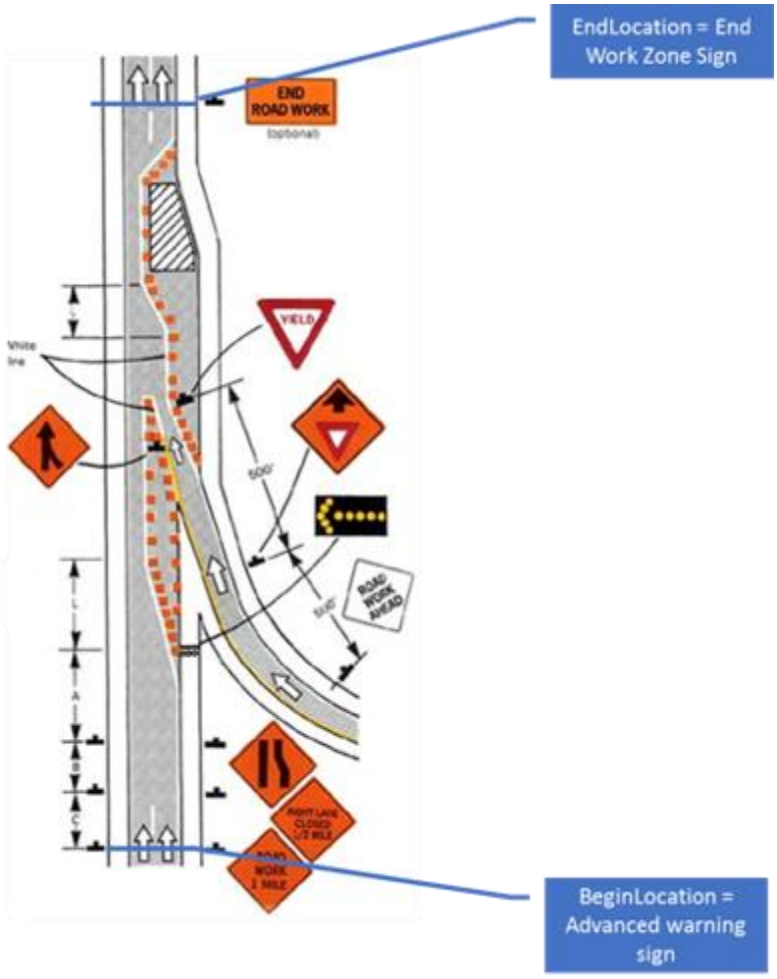


Figure 7. Sign Method

- **junction-method**
  Location of a Junction (e.g., a cross street or exit/entrance ramp) before and after a work zone. Note that this is similar to the approach used by Waze to designate a road closure event.

    - **Arterial Scenario**
      See Figure 8.

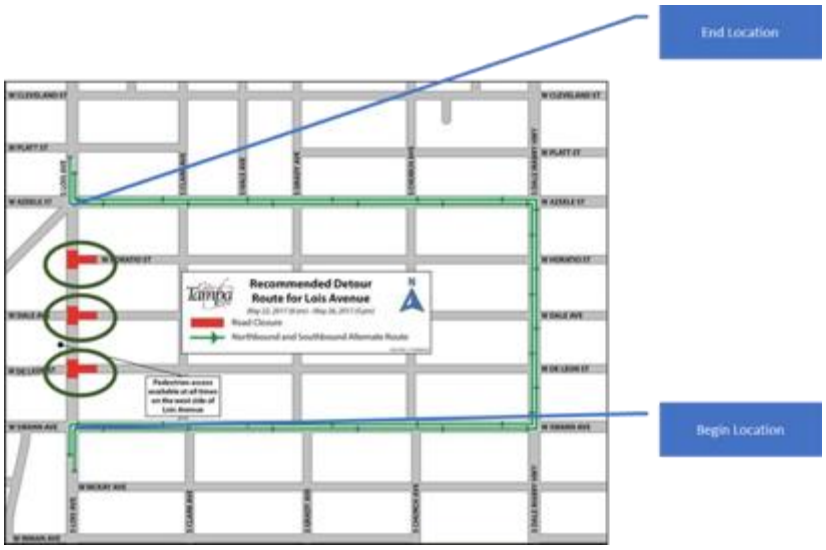


Figure 8. Arterial Scenario

- **Highway Scenario**
  See Figure 9.

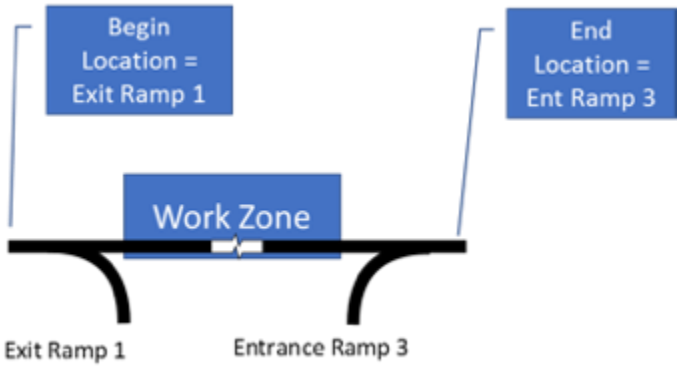


Figure 9. Highway Scenario

3.6.6 Contents of RelatedRoadEvent

The RelatedRoadEvent shall consist of the following requirements.

a) **type.** The type of relationship with the road event being identified, such as another sequence of related work zones, a detour, or next road event in sequence. See 3.6.23 Enumeration of RelatedRoadEventType. **Required.**

b) **id.** An identifier for the related road event. The value of this property should correspond to the 'id' of a RoadEventFeature within the same feed. **Required.**

3.6.7 Contents of TypeOfWork

The TypeOfWork shall consist of the following required and optional requirements.

a) **type_name.** A high-level text description of the type of work being done. See 3.6.16 Enumeration of WorkTypeName. **Required.**

b) **is_architectural_change.** A flag indicating whether the type of work will result in an architectural change to the roadway. **Optional.**

3.6.8 Contents of Lane

The Lane shall consist of the following required and optional requirements.

a) **order.** The position of a lane in sequence on the roadway. This value is used as an index to indicate the order of all lanes provided for a road event, starting with 1 for the left-most lane. See Business Rule #3. **Required.**
b) **status.** Status of the lane for the traveling public. See 3.6.17 Enumeration of LaneStatus. **Required.**
c) **type.** An indication of the type of lane or shoulder. See 3.6.18 Enumeration of LaneType. **Required.**
d) **restrictions.** A list of zero or more restrictions specific to the lane. See 3.6.9 Contents of Restriction. **Optional.**

3.6.9 Contents of Restriction

The Restriction shall consist of the following required and optional requirements.

a) **type.** The type of restriction being enforced. See 3.6.15 Enumeration of RestrictionType. **Required.**
b) **value.** A value associated with the restriction, if applicable. For example, if 'type' is 'reduced-height', 'value' and 'unit' together would allow indicating what value the height was reduced to. **Optional.**
c) **unit.** Unit of measurement for the restriction 'value', if applicable. See 3.6.19 Enumeration of UnitOfMeasurement. **Conditional:** required if 'value' is not null.

3.6.10 Contents of CdsCurbZonesReference

The CdsCurbZonesReference shall consist of the following requirements. See OpenMobilityFoundation's Curb Data Specification at https://github.com/openmobilityfoundation/curb-data-specification.

a) **cds_curb_zone_ids.** A list of CDS Curb Zone 'id's. **Required.**
b) **cds_curbs_api_url.** An identifier for the source of the requested CDS Curbs API. This MUST be a full HTTPS URL pointing to the main curbs API that contains detailed information about each curb zone identified in 'cds_curb_zone_ids'. **Required.**

3.6.11 Contents of WorkerPresence

The WorkerPresence shall consist of the following required and optional requirements.

a) **are_workers_present.** Whether workers are present in the work zone event area. This value should be set in accordance with the definition provided in the 'definition' property if it is provided. **Required.**
b) **method.** Describes the method for how worker presence in a work zone event area is determined. See 3.6.20 Enumeration of WorkerPresenceMethod. **Optional.**
c) **worker_presence_last_confirmed_date.** The UTC date and time at which the presence of workers was last confirmed. All datetime formats shall follow RFC 3339 Section 5.6. See Business Rule #5. **Optional.**
d) **confidence.** The data producer's confidence in the value of 'are_workers_present'. See 3.6.22 Enumeration of WorkerPresenceConfidence. **Optional.**
e) **definition.** A list of situations in which workers are considered to be present in the jurisdiction of the data provider. See 3.6.21 Enumeration of WorkerPresenceDefinition. **Optional.**
f) **other_method.** Details the method for how worker presence in a work zone event area is determined if 'other' enumeration of method is selected. **Conditional;** required if 'method' enumeration is 'other'.

3.6.12 Enumeration of EventType

The EventType Enumerated Type describes the type of a WorkZoneFeed road event.
The following identifies the enumerations for EventType.

- **work-zone.** An area of a trafficway with highway construction, maintenance, or utility-work activities. A work zone is typically marked by signs, channeling devices, barriers, pavement markings, and/or work vehicles. It extends from the first warning sign or flashing lights on a vehicle to the "End of Road Work" sign or the last traffic control device. A work zone may be for short or long durations and may include stationary or moving activities.
  Inclusions:
  1. Long-term stationary highway construction such as building a new bridge, adding travel lanes to the roadway, and extending an existing trafficway.
  2. Mobile highway maintenance such as striping the roadway, median, and roadside grass mowing/landscaping, and pothole repair.
  3. Short-term stationary utility work such as repairing electric, gas, or water lines within the trafficway.

  Exclusions
  1. Private construction, maintenance, or utility work outside the trafficway.

  *The AASHTO term equivalent to roadway is traveled way.
  *The AASHTO term equivalent to trafficway is highway, street, or road.
  Source: https://www.fhwa.dot.gov/publications/publicroads/99mayjun/workzone.cfm
- **detour.** A temporary rerouting of road users onto an existing trafficway to avoid a work zone or other impedance
  Source: https://mutcd.fhwa.dot.gov/htm/2009/part6/part6c.htm

3.6.13 Enumeration of WorkZoneType

The WorkZoneType Enumerated Type describes the type of work zone road event.
The following identifies the enumerations for WorkZoneType.

- **static.** The road event statically placed - not moving.
- **moving.** The road event is actively moving on the roadway. As opposed to 'planned-moving-area', the road event geometry changes as the operation moves.
- **planned-moving-area.** The planned extent of a moving operation. The active work area will be somewhere within this road event. As opposed to 'moving', the road event geometry typically does not actively change.

3.6.14 Enumeration of VehicleImpact

The VehicleImpact Enumerated Type describes the impact to vehicular lanes along a single road in a single direction.
The following identifies the enumerations for VehicleImpact.

- **all-lanes-closed.** All lanes are closed
- **some-lanes-closed.** Some lanes are closed
- **all-lanes-open.** All lanes are open
- **alternating-one-way.** The roadway is alternating one way
- **some-lanes-closed-merge-left.** Some lanes merge to the left
- **some-lanes-closed-merge-right.** Some lanes merge to the right
- **all-lanes-open-shift-left.** All lanes are open, shift to the left
- **all-lanes-open-shift-right.** All lanes are open, shift to the right
- **some-lanes-closed-split.** Some lanes end and split & merge to the right and left
- **flagging.** A flagging operation is in effect
- **temporary-traffic-signal.** A temporary traffic signal is in operation
- **unknown.** The vehicle impact is unknown

3.6.15 Enumeration of RestrictionType

The RestrictionType Enumerated Type describes the type of vehicle restriction on a roadway.
The following identifies the enumerations for RestrictionType.

- **local-access-only.** Only vehicles accessing addresses along the segment being described are allowed; this includes emergency services, deliveries, and direct property access.
- **no-trucks.** Trucks are prohibited from traveling this part of the network.
- **travel-peak-hours-only.** Travel restricted to travel peak hours only.
- **hov-3.** Travel restricted to high occupancy vehicles of three or more.
- **hov-2.** Travel restricted to high occupancy vehicles of two or more.
- **no-parking.** No parking along the segment being described.
- **reduced-width.** Lane width reduced along the segment being described.
- **reduced-height.** Height restrictions reduced along the segment being described.
- **reduced-length.** Vehicle length restrictions reduced along the segment being described.
- **reduced-weight.** Vehicle weight restrictions reduced along the segment being described.
- **axle-load-limit.** Vehicle axle-load-limit restrictions reduced along the segment being described.
- **gross-weight-limit.** Vehicle gross-weight-limit restrictions reduced along the segment being described.
- **towing-prohibited.** Towing prohibited along the segment being described.
- **permitted-oversize-loads-prohibited.** “Permitted oversize loads” prohibited along the segment being described; this applies to annual oversize load permits.
- **no-passing.** Crossing the center line markings for passing is prohibited.

3.6.16 Enumeration of WorkTypeName

The WorkTypeName Enumerated Type is a high-level text description of the type of work being done in a road event.
The following identifies the enumerations for WorkTypeName.

- **non-encroachment.** Work with no impact on the roadway. This includes events such as trash pickup, mowing, landscaping.
- **minor-road-defect-repair.** Pothole repair, road crack repair and sealing, and other small road defect repairs.
- **roadside-work.** Work that is isolated to the side of the road and not in the main travel way, such as repair, replacement, or addition of streetlights, VMS, signs (guide, warning, regulatory, and information signs) in the ground.
- **overhead-work.** Work that occurs above the road, such as repair/replacement of overpasses, overhead VMS, wires, overhead signs, signals, etc. This type of work requires a bucket truck or similar setup rather than being isolated to the side of the road.
- **below-road-work.** Work occurring below the road such as boring or bridge repair.
- **barrier-work.** Repair, replacement, addition, or change of barriers, guardrails, retaining walls, K-barriers, or similar.
- **surface-work.** New resurfacing, such as adding new lanes, moving lanes, or adding or changing connectivity (turn lanes), as well as creation or repair of non-drivable surfaces such as the shoulder or median.
- **painting.** Repainting, re-striping, adding new lanes, moving lanes, adding stop bars/lines, etc. *Note: 'is_architectural_change' (See 3.6.7 b)) field should be false when new paint is expected to be within 1 meter of the old paint.*
- **roadway-relocation.** Physically relocating the road, such as adding a bridge or removing a sharp curve.
- **roadway-creation.** Adding a new road.

3.6.17 Enumeration of LaneStatus

The LaneStatus Enumerated Type describes the status of a lane for the traveling public.
The following identifies the enumerations for LaneStatus.

- **open.** The lane is open for normal usage
- **closed.** The lane is closed to normal usage
- **shift-left.** The lane shifts left from its current bearing and continues
- **shift-right.** The lane shifts right from its current bearing and continues
- **merge-left.** The lane gradually tapers while merging into the lane directly to the left
- **merge-right.** The lane gradually tapers while merging into the lane directly to the right
- **alternating-flow.** Traffic may travel in either direction, depending on certain conditions. Example conditions include time of day (e.g. reversible lanes), automated controls, or on-site personnel

3.6.18 Enumeration of LaneType

The LaneType Enumerated Type provides a description of the static properties of a section of the roadway, intended to reflect information about its function that is not covered by its status (see LaneStatus).
The following identifies the enumerations for LaneType.

- **general.** A generic lane type, intended to be used for general purpose travel lanes.
- **exit-lane.** A lane leading towards an egress from the current roadway. An 'exit-lane' usually becomes an 'exit-ramp' after a gore point.
- **exit-ramp.** A lane at an interchange leading away from the current roadway to another roadway.
- **entrance-lane.** A lane leading away from an ingress to the current roadway. An 'entrance-ramp' usually becomes an 'entrance-lane' after a gore point.
- **entrance-ramp.** A lane at an interchange for traffic to ingress from another roadway to the mainline.
- **sidewalk.** A path for pedestrians, usually on the side of the roadway.
- **bike-lane.** A lane on the roadway for use by cyclists only.
- **shoulder.** A portion of the roadway that is outside (either right or left) of the main travel lanes. A shoulder can have many uses but is not intended for general traffic.
- **parking.** A lane used for parking, not allowed for travel.
- **median.** An often unpaved, non-drivable area that separates sections of the roadway. In most cases a median should only be described if it separates lanes in a single direction of travel, as per Business Rule #1 each direction of travel must be represented by a separate road event.
- **two-way-center-turn-lane.** A lane in the center of a bidirectional roadway that traffic from both directions uses to make a turn that crosses opposite direction of traffic (i.e. left in right-side driving countries, and right in left-side driving countries).

Additional Information
The LaneType enumerated type was originally based on the TMDD LaneRoadway Enumeration, which is imported into TMDD from SAE 2540 (ITIS Standard). In later release, other standards were examined for inspiration. These include SAE J2735 and the ISO 20524-1 Geographic Data Files (GDF) standard.

3.6.19 Enumeration of UnitOfMeasurement

The UnitOfMeasurement Enumerated Type indicates the unit of measurement. This enumerated type is intended for use across the specification and more values can be added in the future if needed.
The following identifies the enumerations for UnitOfMeasurement.

- **feet.** Imperial system 'feet'
- **inches.** Imperial system 'inches'
- **centimeters.** Metric system 'centimeters'
- **pounds.** Imperial system 'pounds'
- **tons.** Imperial system 'tons'

- **kilograms.** Metric system 'kilograms'
- **miles.** Imperial system 'miles'
- **kilometers.** Metric system 'kilometers'

3.6.20 Enumeration of WorkerPresenceMethod

The WorkerPresenceMethod Enumerated Type describes methods for how worker presence in a work zone event area may be determined.

The following identifies the enumerations for WorkerPresenceMethod.

- **camera-monitoring.** Cameras in the work zone event area show workers are present.
- **maintenance-vehicle-present.** A GPS-enabled maintenance vehicle is located in the road event area.
- **wearables-present.** Workers wearing wearable detection equipment are present in the work zone.
- **mobile-device-present.** Workers with GPS-enabled mobile device on their person are present in the work zone.
- **check-in-app.** Workers have checked into the work zone via a mobile app.
- **check-in-verbal.** Workers have checked into the work zone via phone or radio to a remote operations center.
- **other.** Worker presence determined through other method. Details in text field for WorkerPresence other_method.

3.6.21 Enumeration of WorkerPresenceDefinition

The WorkerPresenceDefinition Enumerated Type describes situations in which workers may be considered present in a work zone.
The following identifies the enumerations for WorkerPresenceDefinition.

- **workers-in-work-zone-working.** Humans are physically in the work zone event area, doing road work.
- **workers-in-work-zone-not-working.** Humans are physically in the work zone event area but not performing work.
- **mobile-equipment-in-work-zone-moving.** Mobile equipment is moving within the work zone event area, implying the presence of a worker.
- **mobile-equipment-in-work-zone-not-moving.** Mobile equipment is in the work zone event area but is not moving.
- **fixed-equipment-in-work-zone.** Fixed equipment is in the work zone event area.
- **humans-behind-barrier.** Humans are present in the work zone event area but separated from traffic by a barrier.
- **humans-in-right-of-way.** Humans are present on the drivable surface.

3.6.22 Enumeration of WorkerPresenceConfidence

The WorkerPresenceConfidence Enumerated Type is a high-level description of a feed publisher's confidence in the reported value of 'are_workers_present' on the WorkerPresence object.
The following identifies the enumerations for WorkerPresenceConfidence.

- **low.** Feed publisher is not confident in the reported value, such as when data is manually reported or not updated frequently.
- **medium.** Feed publisher is somewhat confident in the reported value, such as when the value is still manually reported but is being updated in a timely manner, or when worker presence is indirectly inferred from other equipment like a smart arrow board.

- **high.** Feed publisher is very confident in the reported value, such as when automated systems with GPS locations are used to generate the value.

3.6.23 Enumeration of RelatedRoadEventType

The RelatedRoadEventType Enumerated Type describes how a road event is related to the road event that the RelatedRoadEvent object occurs on. For example, the first road event in a sequence of events along the roadway, an instance of a recurrent work zone, a nearby work zone-type road event, or a nearby detour-type road event.
In many cases, the related road event type only refers to the first road event as the corresponding "work zone" may encompass multiple road events. In these situations, end users will need to use the "first" road event and iterate through all linked road events to find all related road events.
The following identifies the enumerations for RelatedRoadEventType.

- **first-in-sequence.** The first road event in a sequence of road events that together describe a full work zone or detour
- **next-in-sequence.** The next (subsequent) road event in a sequence of road events that together describe a full work zone or detour
- **first-occurrence.** The first road event in the first occurrence in time of a recurrent work zone
- **next-occurrence.** The first road event in the next occurrence in time of a recurrent work zone
- **related-work-zone.** The first road event of related work zones (i.e. not part of a sequence of road events or recurrent work zone)
- **related-detour.** The first road event of related detours (i.e. not part of a sequence of road events)
- **planned-moving-operation.** The first road event of a related planned moving operation work zones (i.e. not part of a sequence of road events)
- **active-moving-operation.** The first road event of a related active moving operation work zones (i.e. not part of a sequence of road events)

3.7 DeviceFeed Requirements

The DeviceFeed includes the following data definitions, some of which are defined as optional.

3.7.1 Contents of DeviceFeed

The DeviceFeed shall consist of the following required and optional requirements.

a) **feed_info.** Information about the data feed. This is a standard-specific foreign member and is not part of the GeoJSON specification. See 3.5 FeedInfo Requirements. **Required.**
b) **type.** The GeoJSON object type. For this standard, this must be the string 'FeatureCollection'. This is a GeoJSON property. **Required.**
c) **features.** An array of GeoJSON Feature objects which each represent a field device deployed in a work zone. This is a GeoJSON property. See 3.7.2 Contents of FieldDeviceFeature. **Required.**
d) **bbox.** Information on the coordinate range for all 'FieldDeviceFeature's in the feed. The value must be an array of length '2n' where 'n' is the number of dimensions represented in the contained geometries, with all axes of the most southwesterly point followed by all axes of the more northeasterly point. The axes order of a 'bbox' follows the axes order of geometries. This is a GeoJSON property. See 3.9 BoundingBox Requirements. **Optional.**

3.7.2 Contents of FieldDeviceFeature

The FieldDeviceFeature shall consist of the following required and optional requirements.

a) **id.** A unique identifier issued by the data feed provider to identify the field device. This identifier is a Universally Unique IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds and over time. This is a GeoJSON property. **Required.**
b) **type.** The GeoJSON object type. This MUST be the string 'Feature'. This is a GeoJSON property. **Required.**
c) **properties.** The specific details of the field device. This is a GeoJSON property. See 3.7.3 FieldDeviceCoreDetails. **Required.**
d) **geometry.** The geometry of the field device, indicating its location. The Geometry object's 'type' property MUST be Point (RFC 7946 Section 3.1.2). This is a GeoJSON property. **Required.**
e) **bbox.** Information on the coordinate range for this field device. Must be an array of length '2n' where 'n' is the number of dimensions represented in the 'geometry' property, with all axes of the most southwesterly point followed by all axes of the more northeasterly point. The axes order of a bbox follows the axes order of the 'geometry'. This is a GeoJSON property. See 3.9 BoundingBox Requirements. **Optional.**

3.7.3 Contents of FieldDeviceCoreDetails

The FieldDeviceCoreDetails shall consist of the following required and optional requirements.

a) **device_type**. The type of field device. See 3.7.17 Enumeration of FieldDeviceType. **Required**.
b) **data_source_id**. Identifies the data source from which the field device data originates. **Required**.
c) **device_status**. The operational status of the field device. The value of this property indicates if the device is ok or in an error or warning state. See 3.7.18 Enumeration of FieldDeviceStatus. **Required**.
d) **update_date**. The UTC time and date when the field device information was updated. **Required**.
e) **has_automatic_location**. A yes/no value indicating if the field device location (parent FieldDeviceFeature's 'geometry') is determined automatically from an onboard GPS ('true') or manually set/overridden ('false'). **Required**.
f) **road_direction**. The direction of the road that the field device is on. This value indicates the direction of the traffic flow of the road, not a real heading angle. See 3.8 Direction Requirements. **Optional**.
g) **road_names**. A list of publicly known names of the road on which the device is located. This may include the road number designated by a jurisdiction such as a county, state or interstate (e.g. I-5, VT 133). **Optional.**
h) **name**. A human-readable name for the field device. **Optional.**
i) **description**. A description of the field device. **Optional.**
j) **status_messages**. A list of messages associated with the device's status, if applicable. Used to provide additional information about the status such as specific warning or error messages. **Optional**. Note: The content of this property is determined by the producer.
k) **is_moving**. A yes/no value indicating if the device is actively moving (not statically placed) as part of a mobile work zone operation. **Optional**. Note: The 'is_moving' property is optional and should not be provided if it is not known whether the device is moving.
l) **road_event_ids**. A list of one or more IDs of a road event feature. See RoadEventFeature that the device is associated with. **Optional.**
m) **project_id.** An identifier for the project that the device is associated with. A project is the highest-level representation of an area where road work takes place and may cover multiple roadways if adjacent or intersection. This project ID does not correspond to an object in a WorkZoneFeed. It is used to group devices (and events, see RoadEventCoreDetails). This identifier is a Universally Unique IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds and over time. **Optional.**
n) **reference_post**. The linear distance measured against a reference post such as a milepost marker along a roadway where the device is located. **Optional.**
o) **reference_post_unit.** Unit of measurement for the FieldDeviceCoreDetails 'reference_post', if applicable. See 3.7.15 Enumeration of UnitOfMeasurement. **Conditional;** required if 'reference_post' is not null.

p) **make**. The make or manufacturer of the device. **Optional.**
q) **model**. The model of the device. **Optional.**
r) **serial_number**. The serial number of the device. **Optional.**
s) **firmware_version**. The version of firmware the device is using to operate. **Optional.**
t) **velocity_kph**. The velocity of the device in kilometers per hour. **Optional.**
u) **is_in_transport_position.** A yes/no value indicating if the device is in the stowed/transport position ('true') or deployed/upright position ('false'). **Optional.**

3.7.4 Contents of ArrowBoard

The ArrowBoard shall consist of the following required and optional requirements.

a) **core_details.** The core details of the field device that are shared by all types of field devices, not specific to arrow boards. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **pattern.** The current pattern displayed on the arrow board. Note this includes 'blank', which indicates that nothing is shown on the arrow board. See 3.7.16 Enumeration of ArrowBoardPattern. **Required.**

3.7.5 Contents of Camera

The Camera shall consist of the following required and optional requirements.

a) **core_details.** The core details of the field device that are shared by all types of field devices, not specific to cameras. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **image_url.** A URL pointing to an image file for the camera image still. **Optional.**
c) **is_image_url_public.** Identifies whether the image_url is publicly accessible. **Optional.**
d) **image_timestamp.** The UTC date and time when the image was captured. See Business Rule #5. **Conditional;** required if 'image_url' is provided.
e) **video_url.** A URL pointing to a video file for the camera video. **Optional.**
f) **is_video_url_public.** Identifies whether the video_url is publicly accessible. **Optional.**
g) **video_update_frequency.** The frequency at which the video feed is updated. A value of '-1' indicates that the video feed is not being updated (i.e. a video clip). A value of '0' indicates that the video feed is live. A positive integer value indicates that the video feed is being recorded on a loop where the value is the length of one loop in minutes. **Conditional;** required if 'video_url' is not null.

3.7.6 Contents of DynamicMessageSign

The DynamicMessageSign shall consist of the following requirements.

a) **core_details.** The core details of the field device that are shared by all types of field devices, not specific to dynamic message signs. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **message_multi_string.** The MULTI (Mark-Up Language for Transportation Information, see NTCIP 1203 v03) formatted string describing the message currently posted to the sign. If the message is unknown, such as due to an error, the empty string ('') can be used. **Required.**

3.7.7 Contents of FlashingBeacon

The FlashingBeacon shall consist of the following required and optional requirements.

a) **core_details.** The core details of the field device that are shared by all types of field devices, not specific to flashing beacons. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **function.** Describes the function or purpose of the flashing beacon, i.e. what it is being used to indicate. See 3.7.19 Enumeration of FlashingBeaconFunction. **Required.**

c) **is_flashing.** A yes/no value indicating if the flashing beacon is currently in use and flashing. The 'is_flashing' property is optional as it should not be provided if the producer does not know if the beacon is flashing (e.g. if it's in error state or similar). **Optional.**
d) **sign_text.** The message on the sign the beacon is mounted on. **Optional.**

3.7.8 Contents of HybridSign

The HybridSign shall consist of the following required and optional requirements.

a) **core_details.** The core details of the field device shared by all field devices types, not specific to hybrid signs. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **dynamic_message_function.** The function the dynamic message displayed (e.g. a speed limit). See 3.7.20 Enumeration of HybridSignDynamicMessageFunction. **Required.**
c) **dynamic_message_text.** A text representation of the message currently posted to the electronic component of the hybrid sign. **Optional.**
d) **static_sign_text.** The static text on the non-electronic component of the hybrid sign. This property is currently optional, but it is advisable to provide it and will be required in a future release. **Optional.**

3.7.9 Contents of LocationMarker

The LocationMarker shall consist of the following requirements.

a) **core_details.** The core details of the field device shared by all field devices types, not specific to the location marker. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **marked_locations.** A list of locations that the 'LocationMarker' is marking. See 3.7.10 Contents of MarkedLocation. **Required.**

3.7.10 Contents of MarkedLocation

The MarkedLocation shall consist of the following required and optional requirements.

a) **type.** The type of location (e.g. start or end) that is marked. See 3.7.21 Enumeration of MarkedLocationType. **Required.**
b) **road_event_id.** The ID of a RoadEventFeature that the 'MarkedLocation' applies to. This property is optional because the field device information producer may not have road event information. **Optional.**

3.7.11 Contents of TrafficSensor

The TrafficSensor shall consist of the following required and optional requirements.

a) **core_details.** The core details of the field device shared by all field devices types, not specific to traffic sensors. This property appears on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **collection_interval_start_date.** The UTC date and time where the 'TrafficSensor' data began being collected. The averages and totals contained in the 'TrafficSensor' data apply to the inclusive interval of 'collection_interval_start_date' to 'collection_interval_end_date'. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
c) **collection_interval_end_date.** The UTC date and time where the 'TrafficSensor' collection interval ended. The averages and totals contained in the 'TrafficSensor' data apply to the inclusive interval of 'collection_interval_start_date' to 'collection_interval_end_date'. All datetime formats shall follow RFC 3339 Section 5.6. Example: '2016-11-03T19:37:00Z'. See Business Rule #5. **Required.**
d) **average_speed_kph.** The average speed of vehicles across all lanes over the collection interval in kilometers per hour. **Optional.**

e) **volume_vph.** The rate of vehicles passing by the sensor during the collection interval in vehicles per hour. **Optional**.
f) **occupancy_percent.** The percent of time the roadway section monitored by the sensor was occupied by a vehicle over the collection interval. **Optional.**
g) **lane_data.** A list of objects each describing traffic data for a specific lane. See 3.7.12 Contents of TrafficSensorLaneData. **Optional.**

3.7.12 Contents of TrafficSensorLaneData

The TrafficSensorLaneData shall consist of the following required and optional requirements.

a) **lane_order.** The lane's position in sequence on the roadway. If 'road_event_id' is provided, the value of this property corresponds to the associated road event's Lane's 'order' property. See Business Rule #3. **Required.**
b) **road_event_id.** The ID of a RoadEventFeature which the measured lane occurs in, if applicable. **Optional.**
c) **average_speed_kph.** The average speed of traffic in the lane over the collection interval (in kilometers per hour). **Optional.**
d) **volume_vph.** The rate of vehicles passing by the sensor in the lane during the collection interval (in vehicles per hour). **Optional.**
e) **occupancy_percent.** The percent of time the lane monitored by the sensor was occupied by a vehicle over the collection interval. **Optional.**

3.7.13 Contents of TrafficSignal

The TrafficSignal shall consist of the following requirements.

a) **core_details.** The core details of the traffic signal device. This property occurs on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **mode.** The current operating mode of the traffic signal. See 3.7.22 Enumeration of TrafficSignalMode. **Required.**

3.7.14 Contents of RoadsideUnit

The RoadsideUnit shall consist of the following required and optional requirements.

a) **core_details.** The core details of the roadside unit. This property occurs on all field devices. See 3.7.3 Contents of FieldDeviceCoreDetails. **Required.**
b) **message_types.** An array of message types being broadcast by the roadside unit. See 3.7.23 Enumeration of RoadsideUnitMessageTypes. **Optional.**

3.7.15 Enumeration of UnitOfMeasurement

The UnitOfMeasurement Enumerated Type indicates the unit of measurement. This enumerated type is intended for use across the specification and more values can be added in the future if needed.
The following identifies the enumerations for UnitOfMeasurement.

- **feet.** Imperial system 'feet'
- **inches.** Imperial system 'inches'
- **centimeters.** Metric system 'centimeters'
- **pounds.** Imperial system 'pounds'
- **tons.** Imperial system 'tons'
- **kilograms.** Metric system 'kilograms'
- **miles.** Imperial system 'miles'
- **kilometers.** Metric system 'kilometers'

3.7.16 Enumeration of ArrowBoardPattern

The ArrowBoardPattern Enumerated Type defines a list of options for the posted pattern on an ArrowBoard. If the arrow board pattern does not exactly match one of the values described, the closest pattern should be used.
The following identifies the enumerations for ArrowBoardPattern.

- **blank.** No pattern; the board is not displaying anything.
- **right-arrow-static.** Merge right represented by an arrow pattern (e.g. '-->') that does not flash or move.
- **right-arrow-flashing.** Merge right represented by an arrow pattern (e.g. '-->') that flashes on/off.
- **right-arrow-sequential.** Merge right represented by an arrow pattern (e.g. '-->') that is displayed in a progressing sequence (e.g. '>' '->' '-->' or '-' '--' '-->').
- **right-chevron-static.** Merge right represented by a pattern of chevrons (e.g. '>>>') that does not flash or move.
- **right-chevron-flashing.** Merge right represented by a pattern of chevrons (e.g. '>>>') that flashes on/off.
- **right-chevron-sequential.** Merge right represented by a pattern of chevrons that is displayed in a progressing sequence.
- **left-arrow-static.** Merge left represented by an arrow pattern (e.g. '<--') that does not flash or move.
- **left-arrow-flashing.** Merge left represented by an arrow pattern (e.g. '<--') that flashes on/off.
- **left-arrow-sequential.** Merge left represented by an arrow pattern (e.g. '<--') that is displayed in a progressing sequence (e.g. '<' '<-' '<--' or '-' '--' '<--').
- **left-chevron-static.** Merge left represented by a pattern of chevrons (e.g. '<<<') that does not flash or move.
- **left-chevron-flashing.** Merge left represented by a pattern of chevrons (e.g. '<<<') that flashes on/off.
- **left-chevron-sequential.** Merge left represented by a pattern of chevrons that is displayed in a progressing sequence.
- **bidirectional-arrow-static.** Split (merge left or right) represented by arrows pointing both left and right (e.g. '<-->') that does not flash or move.
- **bidirectional-arrow-flashing.** Split (merge left or right) represented by arrows pointing both left and right (e.g. '<-->') that flashes on/off.
- **line-flashing.** A flashing line or bar (e.g. '---'), indicating warning/caution, not a merge.
- **diamonds-alternating.** An alternating display of two diamond shapes (e.g. '◇ ◇'), indicating warning/caution, not a merge.
- **four-corners-flashing.** Four dots on the corners of the board which flash, indicating warning/caution, not a merge.
- **unknown.** The arrow board pattern is not known.

3.7.17 Enumeration of FieldDeviceType

The FieldDeviceType Enumerated Type enumerates all types of field devices described by the specification.
The following identifies the enumerations for FieldDeviceType.

- **arrow-board.** An electronic, connected arrow board which can display an arrow pattern to direct traffic. See ArrowBoard.
- **camera.** A camera device deployed in the field, capable of capturing still images. See Camera.
- **dynamic-message-sign.** An electronic traffic sign deployed on the roadway, used to provide information to travelers. See DynamicMessageSign.

- **flashing-beacon.** A flashing warning beacon used to supplement a temporary traffic control device. See FlashingBeacon.
- **hybrid-sign.** A message sign that contains both static text (e.g. on an aluminum board) along with a variable electronic message sign, used to provide information to travelers. See HybridSign.
- **location-marker.** Any GPS-enabled ITS device that is placed at a point on a roadway to mark a location (often the beginning or end of a road event). See LocationMarker.
- **traffic-sensor.** A device deployed on a roadway which captures traffic metrics such as speed, volume, and/or occupancy. See TrafficSensor.
- **traffic-signal.** A temporary traffic signal deployed on a roadway. See TrafficSignal.
- **roadside-unit.** A transceiver able to communicate with on-board units and other connected vehicle environment equipment.

3.7.18 Enumeration of FieldDeviceStatus

The FieldDeviceStatus enumerated type describes the operational status of a field device. The status indicates the health of the device.
The following identifies the enumerations for FieldDeviceStatus.

- **ok.** The device is turned on and working without issue.
- **warning.** The device is functional but is impaired or impacted in a way that is not critical to operation.
- **error.** The device is impaired such that it is not able to perform one or more necessary functions.
- **unknown.** The device's operational status is not known.

3.7.19 Enumeration of FlashingBeaconFunction

The FlashingBeaconFunction Enumerated Type describes a list of options for what a FlashingBeacon is being used to indicate.
The following identifies the enumerations for FlashingBeaconFunction.

- **vehicle-entering.** Vehicles are entering the roadway.
- **queue-warning.** There is a queue of vehicles.
- **reduced-speed.** There is a reduced speed limit.
- **workers-present.** There are workers present on or near the roadway.
- **other.** The FlashingBeacon is being used to indicate something other than any of the other values.

3.7.20 Enumeration of HybridSignDynamicMessageFunction

The HybridSignDynamicMessageFunction Enumerated Type describes options for the function of the dynamic message displayed by the electronic display on a HybridSign.
The following identifies the enumerations for HybridSignDynamicMessageFunction.

- **speed-limit.** The message is a speed limit.
- **travel-time.** The message is a travel time.
- **other.** The hybrid sign message function is not one of the other options described by this enumerated type.

3.7.21 Enumeration of MarkedLocationType

The MarkedLocationType enumerated type describes options for what a MarkedLocation can mark, such as the start or end of a work zone.
The following identifies the enumerations for MarkedLocationType.

- **afad.** An automatic flagger assistance device.

- **delineator.** A generic delineation point in a work zone. This value can be used for most types of marked locations that don't match any of the other values.
- **flagger.** A human who is directing traffic.
- **lane-shift.** A lane shift.
- **lane-closure.** One or more lanes are closed.
- **personal-device.** A connected device that is worn or carried by an individual worker in a work zone.
- **ramp-closure.** The start of a closed ramp onto or off a main road or highway.
- **road-closure.** The start of a closed road.
- **work-truck-with-lights-flashing.** A work truck with lights flashing, actively engaged in construction or maintenance activity on the roadway.
- **work-zone-start.** The start point of a work zone.
- **work-zone-end.** The end point of a work zone.
- **attenuator-vehicle.**
- **construction-vehicle.**
- **maintenance-vehicle.**
- **emergency-vehicle.**
- **stalled-or-disabled-vehicle.**
- **pavement-marking-vehicle.**
- **other.**

3.7.22 Enumeration of TrafficSignalMode

The TrafficSignalMode Enumerated Type describes the current operating mode of a TrafficSignal.
The following identifies the enumerations for TrafficSignalMode.

- **blank.** The signal is not displaying anything.
- **flashing-red.** The signal is in a flashing red state that could be part of startup or fault.
- **flashing-yellow.** The signal is in a flashing yellow state that could be part of startup or fault.
- **fully-actuated.** The signal is using an external trigger for all movements.
- **manual.** The signal is using a manual trigger.
- **pre-timed.** The signal is using a timed cycle.
- **semi-actuated.** The signal is using an external trigger only for the minor movements.
- **unknown.** The current operating mode is not known.

3.7.23 Enumeration of RoadsideUnitMessageTypes

The RoadsideUnitMessageTypes Enumerated Type describes the message types being broadcast by a RoadsideUnit.
The following identifies the enumerations for RoadsideUnitMessageTypes.

- **rsm.** The RSU is broadcasting RSM messages.
- **tim.** The RSU is broadcasting TIM messages.
- **spat.** The RSU is broadcasting SPaT messages.
- **map.** The RSU is broadcasting MAP messages.
- **other.** The RSU is broadcasting messages other than the options listed.

3.8 Direction Requirements

The Direction includes the following data definition.

3.8.1 Enumeration of Direction

The Direction Enumerated Type describes the direction of a roadway. The values are based on the standard naming for US roadways and indicates the direction of the traffic flow regardless of the real heading angle of the roadway.
The following identifies the enumerations for Direction.

- **northbound.** Road flow is in the northbound direction
- **eastbound.** Road flow is in the eastbound direction
- **southbound.** Road flow is in the southbound direction
- **westbound.** Road flow is in the westbound direction
- **inner-loop.** Road flow is on the inner loop of a ring road or beltway. In countries that drive on the right side of the road, this is the clockwise direction.
- **outer-loop.** Road flow is on the outer loop of a ring road or beltway. In countries that drive on the right side of the road, this is the counter-clockwise direction.
- **undefined.** Road flow does not have a signed direction. For a RoadEventFeature, the first and last coordinates in the feature's geometry represent the beginning and end of the road event in the direction of travel it impacts.
- **unknown.** Road flow may have a signed direction, but the affected direction of travel is not known

Additional Information
The 'Direction' enumerated type values were based on the TMDD Link-alignment Enumeration, which contains the following values:

- northbound (1)
- eastbound (2)
- southbound (3)
- westbound (4)
- inner-loop (5)
- outer-loop (6)

3.8.2 Reserved for Future Requirements

Reserved for future use.

3.9 BoundingBox Requirements

The BoundingBox includes the following data definition.

3.9.1 Contents of BoundingBox

See RFC 7946 Section 5.

3.9.2 Reserved for Future Requirements

Reserved for future use.

3.10 Protocol Requirements List (PRL)

The PRL described in this document maps the needs identified in Section 2 to the requirements defined in Section 3. The PRL can be used by the following:

a) A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation
b) The device manufacturer and user, as a detailed indication of the capabilities of the implementation

c) A user, as a basis for initially checking the potential interoperability with another implementation
d) A tester, as a checklist to compare against a specification and provide basis for test planning

3.10.1 Notation [Informative]

The following notations and symbols are used to indicate status and conditional status in the PRL. Not all of these notations and symbols may be used within this implementation guide.

3.10.1.1 Conformance Symbols

The symbols in

Table 2 are used to indicate status under the Conformance column in the PRL.

Table 2. Conformance Symbols

Symbol	Status
M	Mandatory
M.#	Support of every item of the group labeled by the same numeral # is required, but only one is active at a time
O	Optional
O.# (range)	Part of an option group. Support of the number of items indicated by the '(range)' is required from all options labeled with the same numeral #
C	Conditional
NA	Not-applicable (i.e., logically impossible in the scope of the standard)
X	Excluded or prohibited

The O.# (range) notation is used to show a set of selectable options (e.g., O.2 (1..*) would indicate that one or more of the option group 2 options shall be implemented). Two-character combinations are used for dynamic requirements. In this case, the first character refers to the static (implementation) status, and the second refers to the dynamic (use); thus, "MO" means "mandatory to be implemented, optional to be used."

3.10.1.2 Conditional Status Notation

The predicate notations in Table 3 may be used.

Table 3. Conditional Status Notation

Predicate	Notation
<predicate>:	This notation introduces a single item that is conditional on the <predicate>.
<predicate>::	This notation introduces a table or a group of tables, all of which are conditional on the <predicate>.
(predicate)	This notation introduces the first occurrence of the predicate. The feature associated with this notation is the base feature for all options that have this predicate in their conformance column.

The <predicate>: notation means that the status following it applies only when the PRL states that the feature or features identified by the predicate are supported. In the simplest case, <predicate> is the

identifying tag of a single PRL item. The <predicate> notation may precede a table or group of tables in a section or subsection. When the group predicate is true then the associated section shall be completed. The symbol <predicate> also may be a Boolean expression composed of several indices. "AND," "OR," and "NOT" shall be used to indicate the Boolean logical operations.

The predicates used in this standard map to the sections indicated in Table 4.

Table 4. Predicate Mapping

Predicate	Section
RefPost	Mandatory if reference_post is selected: 3.6.2 f) 3.6.3 f)3.7.3 n)
WorkerMethod	Mandatory if value is selected: 3.6.11 b)
ResValue	Mandatory if value is selected: 3.6.9 c)
ImgURL	Mandatory if image_url is selected. 3.7.5 c)
VideoURL	Mandatory if video_url is selected. 3.7.5 e)

3.10.1.3 Support Column Symbols

The Support column in the PRL can be used by a procurement specification to identify the required features for the given procurement or by an implementer to identify which features have been implemented. In either case, the user circles the appropriate answer (Yes, No, or N/A) in the support column. When a user circles YES for an optional requirement, the requirement becomes mandatory for the procurement specification.

Table 5. Support Column Entries

Entry	Identifier
Yes	Supported by the implementation
No	Not supported by the implementation
N/A	Not applicable

3.10.2 Instructions for Completing the PRL [Informative]

In the 'Support' column, each response shall be selected either from the indicated set of responses (for example: Yes / No / NA), or it shall reference additional items that are to be attached (for example, list of traffic signal controllers to be supported by an implementation). If a conditional requirement is inapplicable, use the Not Applicable (NA) choice.

NOTE: A specification can allow for flexibility in a deliverable by leaving the selection in the Support column blank for a given row.

3.10.2.1 Conformance Definition

To claim "Conformance" to this standard and guide, the deployers shall minimally fulfill the mandatory requirements as identified in the PRL.

NOTE: The reader and user of this standard and guide is advised that 'conformance' should not be confused with 'compliance' to a specification. The CWZ Standard and Implementation Guide is as broad as possible to allow a very simple CWZ deployment to be 'conformant.' If an agency specification needs to identify the requirements of a particular project, the specification writer is advised to match the requirements of a project with the corresponding standardized requirements defined in this standard and guide to achieve interoperability. This means that requirements defined as 'optional' in the PRL might need to be selected in a specification (in effect made 'mandatory' for the project-specific specification).

NOTE: Off-the-shelf interoperability and interchangeability can only be obtained through well-documented features broadly supported by the industry as a whole. Designing a system that uses features not defined in a standard or not typically deployed in combination with one another inhibits the goals of interoperability and interchangeability, especially if the documentation of these features is not available for distribution to system integrators. Standards allow the use of additional features to support innovation, which is constantly needed within the industry; but users should be aware of the risks involved with using such features.

3.10.3 Protocol Requirements List Table

In addition to the Conformance column and the Support column which were discussed in Sections 3.10.1.1 and 3.10.1.3, the additional columns in the PRL table contains columns for the Need ID, Need, Req ID, Requirements, and the Additional Specifications column. These are described as follows:

a) **Need ID** - the number assigned to the user need statement. The needs are defined within Section 2 and the PRL is based upon the user needs within that Section.
b) **Need** – a short descriptive title identifying the user need.
c) **Req ID** – the number assigned to the requirement statement. The requirements are defined within Section 3 and the PRL references the traces from needs to these requirements.
d) **Requirement** – a short descriptive title identifying the requirement.
e) **Conformance** – identifies whether the requirement is mandatory, optional, and any conformance dependencies.
f) **Support** – is used by specification developers to identify whether the requirement should be supported.
g) **Additional Specifications** - identifies other requirements to satisfy, including user selectable range values. The "Additional Specifications" column may (and should) be used by a procurement specification to provide additional notes and requirements for the product to be procured or may be used by an implementer to provide any additional details about the implementation. In some cases, default text already exists in this field, which the user should complete to fully specify the equipment. However, additional text can be added to this field as needed to fully specify a feature.

3.10.4 Table 6. Protocol Requirements List

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
2.5.1	**Architectural Needs**					
2.5.1.1	**Compatibility with the WZDx Specification**					
		3.2	**Architectural Requirements**			
		3.2.1	**Compatibility with the WZDx Specification**	M	Yes	
		3.2.2	**GeoJSON Data Format**	M	Yes	
		3.2.3	**GeoJSON Data Validation**	M	Yes	
		3.2.4	**Business Rules**	**M**	**Yes**	
		3.2.4.1	Event Segments Follow Lane Geometry Changes	M	Yes	
		3.2.4.2	WorkZoneRoadEvent Lanes	M	Yes	
		3.2.4.3	Lane Order	M	Yes	
		3.2.4.4	Data Source ID Referential Integrity	M	Yes	
		3.2.4.5	UTC Date-Time Format Specification	M	Yes	
		3.2.4.6	UUID Format Specification	M	Yes	
		3.5.1	**Contents of FeedInfo**			
		3.5.1 f)	version	M	Yes	
		3.3	**Data Exchange Requirements**			
		3.3.1	**Exchange WorkZoneFeed Information**			
		3.3.1.1	Send WorkZoneFeed Information Upon Request	M	Yes	
		3.3.2	**Exchange DeviceFeed Information**			
		3.3.2.1	Send DeviceFeed Information Upon Request	M	Yes	
		3.4	**WorkZoneFeed Requirements**			
		3.4.1	**Contents of WorkZoneFeed**			
		3.4.1 a)	feed_info	M	Yes	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.4.1 b)	type	M	Yes	
		3.4.1 c)	features	M	Yes	
		3.4.1 d)	bbox	O	Yes / No	
		3.5	**FeedInfo Requirements**			
		3.5.1	**Contents of FeedInfo**			
		3.5.1 a)	publisher	M	Yes	
		3.5.1 b)	contact_name	O	Yes / No	
		3.5.1 c)	contact_email	O	Yes / No	
		3.5.1 d)	update_frequency	O	Yes / No	
		3.5.1 e)	update_date	M	Yes	
		3.5.1 f)	version	M	Yes	
		3.5.1 g)	license	O	Yes / No	
		3.5.1 h)	data_sources	M	Yes	
		3.5.2	**Contents of FeedDataSource**			
		3.5.2 a)	data_source_id	M	Yes	
		3.5.2 b)	organization_name	M	Yes	
		3.5.2 c)	contact_name	O	Yes / No	
		3.5.2 d)	contact_email	O	Yes / No	
		3.5.2 e)	update_frequency	M	Yes	
		3.5.2 f)	update_date	M	Yes	
		3.6	**RoadEventFeature Requirements**			
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 a)	id	M	Yes	
		3.6.1 b)	type	M	Yes	
		3.6.1 c)	properties	M	Yes	
		3.6.1 d)	geometry	M	Yes	
		3.6.1 e)	bbox	O	Yes / No	
		3.6.2	**Contents of WorkZoneRoadEvent**			

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.2 a)	core_details	M	Yes	
		3.6.2 b)	beginning_cross_street	O	Yes / No	
		3.6.2 c)	ending_cross_street	O	Yes / No	
		3.6.2 d)	beginning_reference_post	O	Yes / No	
		3.6.2 e)	ending_reference_post	O	Yes / No	
		3.6.2 f)	reference_post_unit	RefPost:O	Yes / No	
		3.6.2 g)	is_start_position_verified	M	Yes	
		3.6.2 h)	is_end_position_verified	M	Yes	
		3.6.2 i)	start_date	M	Yes	
		3.6.2 j)	end_date	M	Yes	
		3.6.2 k)	is_start_date_verified	M	Yes	
		3.6.2 l)	is_end_date_verified	M	Yes	
		3.6.2 m)	work_zone_type	O	Yes / No	
		3.6.2 n)	vehicle_impact	M	Yes	
		3.6.2 o)	location_method	M	Yes	
		3.6.2 p)	worker_presence	O	Yes / No	
		3.6.2 q)	reduced_speed_limit_kph	O	Yes / No	
		3.6.2 r)	restrictions	O	Yes / No	
		3.6.2 s)	types_of_work	O	Yes / No	
		3.6.2 t)	lanes	O	Yes / No	
		3.6.2 u)	impacted_cds_curb_zones	O	Yes / No	
		3.6.3	**Contents of DetourRoadEvent**			
		3.6.3 a)	core_details	M	Yes	
		3.6.3 b)	beginning_cross_street	O	Yes / No	
		3.6.3 c)	ending_cross_street	O	Yes / No	
		3.6.3 d)	beginning_reference_post	O	Yes / No	
		3.6.3 e)	ending_reference_post	O	Yes / No	
		3.6.3 f)	reference_post_unit	RefPost:O	Yes / No	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.3 g)	start_date	M	Yes	
		3.6.3 h)	end_date	M	Yes	
		3.6.3 i)	is_start_date_verified	M	Yes	
		3.6.3 j)	is_end_date_verified	M	Yes	
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 a)	data_source_id	M	Yes	
		3.6.4 b)	event_type	M	Yes	
		3.6.4 c)	related_road_events	O	Yes / No	
		3.6.4 d)	road_names	M	Yes	
		3.6.4 e)	direction	M	Yes	
		3.6.4 f)	name	O	Yes / No	
		3.6.4 g)	description	O	Yes / No	
		3.6.4 h)	creation_date	O	Yes / No	
		3.6.4 i)	update_date	O	Yes / No	
		3.6.5	**Enumeration of LocationMethod**	**NA**		
		3.6.6	**Contents of RelatedRoadEvent**			
		3.6.6 a)	type	M	Yes	
		3.6.6 b)	id	M	Yes	
		3.6.7	**Contents of TypeOfWork**			
		3.6.7 a)	type_name	M	Yes	
		3.6.7 b)	is_architectural_change	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 b)	status	M	Yes	
		3.6.8 c)	type	M	Yes	
		3.6.8 e)	restrictions	O	Yes / No	
		3.6.9	**Contents of Restriction**			
		3.6.9 a)	type	M	Yes	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.9 b)	value	O	Yes / No	
		3.6.9 c)	unit	ResValue:O	Yes / No	
		3.6.10	**Contents of CdsCurbZonesReference**			
		3.6.10 a)	cds_curb_zone_ids	M	Yes	
		3.6.10 b)	cds_curbs_api_url	M	Yes	
		3.6.11	**Contents of WorkerPresence**			
		3.6.11 a)	are_workers_present	M	Yes	
		3.6.11 b)	method	O	Yes / No	
		3.6.11 c)	worker_presence_last_confirmed_date	O	Yes / No	
		3.6.11 d)	confidence	O	Yes / No	
		3.6.12	**Enumeration of EventType**	**NA**		
		3.6.13	**Enumeration of WorkZoneType**	**NA**		
		3.6.14	**Enumeration of VehicleImpact**	**NA**		
		3.6.15	**Enumeration of RestrictionType**	**NA**		
		3.6.16	**Enumeration of WorkTypeName**	**NA**		
		3.6.17	**Enumeration of LaneStatus**	**NA**		
		3.6.18	**Enumeration of LaneType**	**NA**		
		3.6.19	**Enumeration of UnitOfMeasurement**	**NA**		
		3.6.20	**Enumeration of WorkerPresenceMethod**	**NA**		
		3.6.21	**Enumeration of WorkerPresenceDefinition**	**NA**		
		3.6.22	**Enumeration of WorkerPresenceConfidence**	**NA**		
		3.6.23	**Enumeration of RelatedRoadEventType**	**NA**		
		3.7	**DeviceFeed Requirements**			
		3.7.1	**Contents of DeviceFeed**			
		3.7.1 a)	feed_info	M	Yes	
		3.7.1 b)	type	M	Yes	
		3.7.1 c)	features	M	Yes	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.7.1 d)	bbox	O	Yes / No	
		3.7.2	**Contents of FieldDeviceFeature**			
		3.7.2 a)	id	M	Yes	
		3.7.2 b)	type	M	Yes	
		3.7.2 c)	properties	M	Yes	
		3.7.2 d)	geometry	M	Yes	
		3.7.2 e)	bbox	O	Yes / No	
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 a)	device_type	M	Yes	
		3.7.3 b)	data_source_id	M	Yes	
		3.7.3 c)	device_status	M	Yes	
		3.7.3 d)	update_date	M	Yes	
		3.7.3 e)	has_automatic_location	M	Yes	
		3.7.3 f)	road_direction	O	Yes / No	
		3.7.3 g)	road_names	O	Yes / No	
		3.7.3 h)	name	O	Yes / No	
		3.7.3 i)	description	O	Yes / No	
		3.7.3 j)	status_messages	O	Yes / No	
		3.7.3 k)	is_moving	O	Yes / No	
		3.7.3 l)	road_event_ids	O	Yes / No	
		3.7.3 m)	reference_post	O	Yes / No	
		3.7.3 n)	reference_post_unit	RefPost:O	Yes / No	
		3.7.3 o)	make	O	Yes / No	
		3.7.3 p)	model	O	Yes / No	
		3.7.3 q)	serial_number	O	Yes / No	
		3.7.3 r)	firmware_version	O	Yes / No	
		3.7.3 s)	velocity_kph	O	Yes / No	
		3.7.3 t)	is_in_transport_position	O	Yes / No	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.7.4	**Contents of ArrowBoard**			
		3.7.4 a)	core_details	M	Yes	
		3.7.4 b)	pattern	M	Yes	
		3.7.5	**Contents of Camera**			
		3.7.5 a)	core_details	M	Yes	
		3.7.5 b)	image_url	O	Yes / No	
		3.7.5 c)	is_image_url_public	O	Yes / No	
		3.7.5 d)	image_timestamp	ImgURL:O	Yes / No	
		3.7.5 e)	video_url	O	Yes / No	
		3.7.5 f)	is_video_url_public	O	Yes / No	
		3.7.5 g)	video_update_frequency	VideoUrl:O	Yes / No	
		3.7.6	**Contents of DynamicMessageSign**			
		3.7.6 a)	core_details	M	Yes	
		3.7.6 b)	message_multi_string	M	Yes	
		3.7.7	**Contents of FlashingBeacon**			
		3.7.7 a)	core_details	M	Yes	
		3.7.7 b)	function	M	Yes	
		3.7.7 c)	is_flashing	O	Yes / No	
		3.7.7 d)	sign_text	O	Yes / No	
		3.7.8	**Contents of HybridSign**			
		3.7.8 a)	core_details	M	Yes	
		3.7.8 b)	dynamic_message_function	M	Yes	
		3.7.8 c)	dynamic_message_text	O	Yes / No	
		3.7.8 d)	static_sign_text	O	Yes / No	
		3.7.9	**Contents of LocationMarker**			
		3.7.9 a)	core_details	M	Yes	
		3.7.9 b)	marked_locations	M	Yes	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.7.10	**Contents of MarkedLocation**			
		3.7.10 a)	type	M	Yes	
		3.7.10 b)	road_event_id	O	Yes / No	
		3.7.11	**Contents of TrafficSensor**			
		3.7.11 a)	core_details	M	Yes	
		3.7.11 b)	collection_interval_start_date	M	Yes	
		3.7.11 c)	collection_interval_end_date	M	Yes	
		3.7.11 d)	average_speed_kph	O	Yes / No	
		3.7.11 e)	volume_vph	O	Yes / No	
		3.7.11 f)	occupancy_percent	O	Yes / No	
		3.7.11 g)	lane_data	O	Yes / No	
		3.7.12	**Contents of TrafficSensorLaneData**			
		3.7.12 a)	lane_order	M	Yes	
		3.7.12 b)	road_event_id	O	Yes / No	
		3.7.12 c)	average_speed_kph	O	Yes / No	
		3.7.12 d)	volume_vph	O	Yes / No	
		3.7.12 e)	occupancy_percent	O	Yes / No	
		3.7.13	**Contents of TrafficSignal**			
		3.7.13 a)	core_details	M	Yes	
		3.7.13 b)	mode	M	Yes	
		3.7.16	**Enumeration of ArrowBoardPattern**	**NA**		
		3.7.17	**Enumeration of FieldDeviceType**	**NA**		
		3.7.18	**Enumeration of FieldDeviceStatus**	**NA**		
		3.7.19	**Enumeration of FlashingBeaconFunction**	**NA**		
		3.7.20	**Enumeration of HybridSignDynamicMessageFunction**	**NA**		
		3.7.21	**Enumeration of MarkedLocationType**	**NA**		
		3.7.22	**Enumeration of TrafficSignalMode**	**NA**		

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.8	**Direction Requirements**			
		3.8.1	**Enumeration of Direction**	**NA**		
		3.9	**BoundingBox Requirements**			
		3.9.1	**Contents of BoundingBox**	**O**		
2.5.1.2	**GeoJSON Data Exchange**					
2.5.1.2.1	**Poll for Data**					
		3.3.1.1	Send WorkZoneFeed Information Upon Request	M	Yes	
		3.3.2.1	Send DeviceFeed Information Upon Request	M	Yes	
2.5.1.3	**GeoJSON Data Format**					
		3.2.3	**GeoJSON Data Format**	M	Yes	
2.5.1.4	**GeoJSON Data Validation**					
		3.2.4	**GeoJSON Data Validation**	M	Yes	
2.5.1.5	**Frequency of Updates**					
		3.5.2	**Contents of FeedDataSource**	M	Yes	
		3.5.2 e)	update_frequency	M	Yes	
		3.5.2 f)	update_date	M	Yes	
2.5.1.6	**UTC Date-Time Format Specification**					
		3.2.4.5	UTC Date-Time Format Specification	M	Yes	
2.5.2	**Data Exchange Needs**					
2.5.2.1	**Zone Metadata**					
2.5.2.1.1	Zone Data Standard Version					
		3.5.1	**Contents of FeedInfo**			
		3.5.1 f)	version	M	Yes	
2.5.2.1.2	Zone Identifier					

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
2.5.2.1.2.1	Support Zone Identifier for Zones					
		3.2.4.4	Data Source ID Referential Integrity	M	Yes	
		3.2.4.6	UUID Format Specification	M	Yes	
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 a)	id	M	Yes	
2.5.2.1.2.2	Support Unique Zone Identifiers					
		3.2.4.6	UUID Format Specification	M	Yes	
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 a)	id	M	Yes	
2.5.2.1.2.3	Support Unique Zone Group Identifiers					
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 c)	project_id	O	Yes / No	
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 m)	project_id	O	Yes / No	
2.5.2.1.2.4	Zone Identifier for VRUs, Devices, Work Zone Vehicles, Lanes, Speed Limit Zones					
		3.2.4.6	UUID Format Specification	M	Yes	
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 a)	id	M	Yes	
2.5.2.1.3	Zone Activity Type					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 s)	types_of_work	O	Yes / No	
2.5.2.1.4	Zone Data Timestamp					
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 h)	creation_date	O	Yes / No	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.4 i)	update_date	O	Yes / No	
2.5.2.1.5	Zone Data Source					
		3.2.4.4	Data Source ID Referential Integrity	M	Yes	
		3.5.1	**Contents of FeedInfo**			
		3.5.1 h)	data_sources	M	Yes	
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 a)	data_source_id	M	Yes	
2.5.2.2	**Zone Location**					
2.5.2.2.1	Zone Geometry					
		3.2.4.1	Event Segments Follow Attribute Changes	M	Yes	
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 d)	geometry	M	Yes	
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 g)	is_start_position_verified	M	Yes	
		3.6.2 h)	is_end_position_verified	M	Yes	
2.5.2.3	**Zone Schedule**					
2.5.2.3.1	Date Times					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 i)	start_date	M	Yes	
		3.6.2 j)	end_date	M	Yes	
		3.6.2 k)	is_start_date_verified	M	Yes	
		3.6.2 l)	is_end_date_verified	M	Yes	
2.5.2.4	**Zone Segmentation**					
2.5.2.4.1	Geometry					
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 c)	project_id	O	Yes / No	
		3.7.3	**Contents of FieldDeviceCoreDetails**			

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.7.3 m)	project_id	O	Yes / No	
2.5.2.4.2	Date Times					
		3.6.4	**Contents of RoadEventCoreDetails**			
		3.6.4 c)	project_id	O	Yes / No	
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 m)	project_id	O	Yes / No	
2.5.2.5	**Zone Status**					
2.5.2.5.1	Is Active					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 k)	is_start_date_verified	M	Yes	
		3.6.2 l)	is_end_date_verified	M	Yes	
2.5.2.5.2	Length					
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 d)	geometry	M	Yes	Calculated using coordinate information contained in the linestring
2.5.2.5.3	Number of Lanes Open					
		3.6.8	**Contents of Lane**			
		3.6.8 b)	status	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
2.5.2.5.4	Ad-hoc (Unscheduled/Unplanned)					
		3.6.14	**Enumeration of VehicleImpact**			
		3.6.15	**Enumeration of RestrictionType**			
2.5.2.5.5	Is Rolling/Moving					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 m)	work_zone_type	O	Yes / No	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.13	**Enumeration of WorkZoneType**			
2.5.2.6	**Zone Lanes**					
2.5.2.6.1	Numbering and Identification					
		3.2.4.2	WorkZoneRoadEvent Lanes	M	Yes	
2.5.2.6.1.1	Nationally Consistent Method of Lane Numbering					
		3.2.4.3	Lane Order	M	Yes	
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
2.5.2.6.1.2	Lane Numbering is Left-to-Right or Right-to-Left					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
2.5.2.6.2	Lane Type					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 c)	type	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
		3.6.18	**Enumeration of LaneType**			
2.5.2.6.2.1	Lane is Drivable					
		3.6.2	**Contents of WorkZoneRoadEvent**			

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 c)	type	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
		3.6.18	**Enumeration of LaneType**			
2.5.2.6.2.2	Special Use Lane					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 c)	type	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
		3.6.18	**Enumeration of LaneType**			
2.5.2.6.2.3	Reversible Lane					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 c)	type	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
		3.6.18	**Enumeration of LaneType**			
2.5.2.6.3	CVE Roadside Safety Applications					
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 d)	geometry	M	Yes	
		3.7.14	**Contents of RoadsideUnit**			
		3.7.14 b)	message_types	O	Yes / No	
2.5.2.6.4	Lane Tapers					

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
		3.2.4.1	Event Segments Follow Lane Geometry Changes	M	Yes	
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 n)	vehicle_impact	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
2.5.2.6.5	Lane Closure Status					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 t)	lanes	O	Yes / No	
		3.6.8	**Contents of Lane**			
		3.6.8 a)	order	M	Yes	
		3.6.8 b)	status	M	Yes	
		3.6.17	**Enumeration of LaneStatus**			
2.5.2.7	**Zone Speed Limit**					
2.5.2.7.1	Position/Geometry					
		3.6.1	**Contents of RoadEventFeature**			
		3.6.1 d)	geometry	M	Yes	
2.5.2.7.2	Speed Limit Change					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 q)	reduced_speed_limit_kph	O	Yes / No	
2.5.2.8	**Zone Traffic Data**					
2.5.2.8.1	Speed, Volume, and Occupancy					
		3.7.11	**Contents of Traffic Sensor**			
		3.7.11 d)	average_speed_kph	O	Yes / No	
		3.7.11 e)	volume_vph	O	Yes / No	
		3.7.11 f)	occupancy_percent	O	Yes / No	
2.5.2.8.2	Queue Warning					
		3.7.17	**Enumeration of FlashingBeaconFunction**			

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
2.5.2.9	**Zone Device**					
2.5.2.9.1	Inventory and Status					
		3.7.2	**Contents of FieldDeviceFeature**			
		3.7.2 d)	geometry	M	Yes	
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 a)	device_type	M	Yes	
		3.7.3 c)	device_status	M	Yes	
		3.7.3 l)	road_event_ids	O	Yes / No	
		3.7.17	**Enumeration of FieldDeviceType**			
		3.7.18	**Enumeration of FieldDeviceStatus**			
		3.7.21	**Enumeration of MarkedLocationType**			
2.5.2.9.2	Location Marker Type					
		3.7.21	**Enumeration of MarkedLocationType**			
2.5.2.9.3	Device Type					
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 a)	device_type	M	Yes	
		3.7.17	**Enumeration of FieldDeviceType**			
2.5.2.9.4	Position/Geometry					
		3.7.2	**Contents of FieldDeviceFeature**			
		3.7.2 d)	geometry	M	Yes	
2.5.2.9.5	Device Status					
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 c)	device_status	M	Yes	
		3.7.18	**Enumeration of FieldDeviceStatus**			
2.5.2.9.6	Zone Identifier					
		3.7.3	**Contents of FieldDeviceCoreDetails**			
		3.7.3 l)	road_event_ids	O	Yes / No	

PROTOCOL REQUIREMENTS LIST						
Need ID	**Need**	**Req ID**	**Requirement**	**Conformance**	**Support**	**Additional Specifications**
2.5.2.10	**Zone VRU Device**					
2.5.2.10.1	Worker Presence Status/Activity					
		3.6.2	**Contents of WorkZoneRoadEvent**			
		3.6.2 o)	worker_presence	O	Yes / No	
		3.6.11	**Contents of WorkerPresence**			
		3.6.11 a)	are_workers_present	M	Yes	
		3.6.11 b)	method	O	Yes / No	
		3.6.11 c)	worker_presence_last_confirmed_date	O	Yes / No	
		3.6.11 d)	confidence	O	Yes / No	
		3.6.11 e)	definition	O	Yes / No	
		3.6.11 f)	other_method	WorkerMethod:O	Yes / No	
2.5.2.10.2	VRU Position/Geometry					
		3.7.2	**Contents of FieldDeviceFeature**			
		3.7.2 d)	Geometry	M	Yes	
		3.7.21	**Enumeration of MarkedLocationType**			
2.5.2.11	**Zone Work Vehicle Device**					
2.5.2.11.1	Vehicle Type					
		3.7.21	**Enumeration of MarkedLocationType**			
2.5.2.11.2	Vehicle Position					
		3.7.2	**Contents of FieldDeviceFeature**			
		3.7.2 d)	geometry	M	Yes	
		3.7.21	**Enumeration of MarkedLocationType**			

Section 4
System Interface Design Details: Data Exchange Dialogs

4.1 Introduction [Informative]

This section specifies the data exchange dialogs to be used with this standard.

4.2 Poll for Data Dialog

The Poll for Data Dialog is an HTTP-based mechanism used to transfer work zone information across a system interface. The subsections below enumerates the referenced standards and role of the standard specified for the Poll for Data Dialog.

4.2.1 GeoJSON Format – Geospatial Data Interchange Format based on JSON

The IETF RFC 7946 The GeoJSON Format is a normative reference of this standard.

The IETF RFC 7946 abstract contains the following definition.

> "GeoJSON is a geospatial data interchange format based on JavaScript Object Notation (JSON). It defines several types of JSON objects and the manner in which they are combined to represent data about geographic features, their properties, and their spatial extents. GeoJSON uses a geographic coordinate reference system, World Geodetic System 1984, and units of decimal degrees."

GeoJSON is the data format for the Work Zone Feed and Device Feed.

4.2.2 JSON - JavaScript Object Notation

The IETF RFC 8259 The JavaScript Object Notation (JSON) Data Interchange Format, also known as ISO/IEC 21778:2017 is a normative reference of this standard.

The IETF RFC 8259 abstract contains the following definition.

> "JavaScript Object Notation (JSON) is a lightweight, text-based, language-independent data interchange format. It was derived from the ECMAScript Programming Language Standard. JSON defines a small set of formatting rules for the portable representation of structured data.

The Work Zone Feed and Device Feed data are in JSON format, and can be validated with a JSON Schema.

4.2.3 HTTP - HyperText Transfer Protocol

The IETF RFC 9110 HTTP Semantics is a normative reference of this standard. The IETF RFC 9110 HTTP contains requirements and design that includes HTTP over TLS, a type of secure messaging protocol.

The IETF RFC 9110 abstract contains the following definition.

> "The Hypertext Transfer Protocol (HTTP) is a stateless application-level protocol for distributed, collaborative, hypertext information systems. This document describes the overall architecture of HTTP, establishes common terminology, and defines aspects of the protocol that are shared by all versions. In this definition are core protocol elements, extensibility mechanisms, and the "http" and "https" Uniform Resource Identifier (URI) schemes.

HTTP is used to securely transmit Work Zone Feed and Device Feed data between two systems.

4.2.4 URI – Uniform Resource Identifier

The IETF RFC 3986 Uniform Resource Identifier (URI): Generic Syntax is a normative reference of this standard.

The IETF RFC 3986 abstract contains the following definition.

> "A Uniform Resource Identifier (URI) is a compact sequence of characters that identifies an abstract or physical resource. This specification defines the generic URI syntax and a process for resolving URI references that might be in relative form, along with guidelines and security considerations for the use of URIs on the Internet. The URI syntax defines a grammar that is a superset of all valid URIs, allowing an implementation to parse the common components of a URI reference without knowing the scheme-specific requirements of every possible identifier. This specification does not define a generative grammar for URIs; that task is performed by the individual specifications of each URI scheme.

As described in Section 2.7.3 Operational Policies and Constraints – Uniform Resource Identifiers, each feed provider defines their own URI based on their operational policies. It is the expectation of this standard that the URI defined by a data feed provider conform with IETF RFC 3986.

Section 5
System Interface Design Details: Data Concepts

5.1 Introduction [Informative]

This section specifies the Work Zone and Device Feed JSON Schemas.

5.2 WorkZoneFeed Schema

```
{
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/WorkZoneFeed.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "CWZ v1.0 Work Zone Feed",
  "description": "The GeoJSON output of a CWZ Work Zone Feed v1.0.",
  "type": "object",
  "required": ["feed_info", "type", "features"],
```

5.2.1 Properties

```
  "properties": {
```

5.2.1.1 feed_info

```
    "feed_info": {
      "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/FeedInfo.json"
    },
```

5.2.1.2 type

```
    "type": {
      "description": "The GeoJSON type.",
      "enum": ["FeatureCollection"]
    },
```

5.2.1.3 features

```
    "features": {
      "description": "An array of GeoJSON Feature objects which represent CWZ
road events.",
      "type": "array",
      "items": {
        "allOf": [
          {
            "properties": {
              "properties": {
                "properties": {
```

```
                "core_details": {
                  "properties": {
                    "event_type": {
                      "enum": ["work-zone", "detour"]
                    }
                  },
                  "required": ["event_type"]
                }
              },
              "required": ["core_details"]
            }
          },
          "required": ["properties"]
        },
        {
          "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/RoadEventFeature.json"
        }
      ]
    }
  },
```

5.2.1.4 bbox

```
  "bbox": {
    "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/BoundingBox.json"
  }
 }
}
```

5.3 FeedInfo Schema

```
{
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/FeedInfo.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "CWZ Feed Information",
  "description": "Describes CWZ feed header information such as metadata, contact
information, and data sources.",
  "type": "object",
  "required": [
    "publisher",
    "update_frequency",
    "update_date",
    "version",
    "license",
    "data_sources"
```

```
  ],
```

5.3.1 Properties

```
  "properties": {
```

5.3.1.1 publisher

```
    "publisher": {
      "description": "The organization responsible for publishing the feed.",
      "type": "string"
    },
```

5.3.1.2 contact_name

```
    "contact_name": {
      "description": "The name of the individual or group responsible for the
data feed.",
      "type": "string"
    },
```

5.3.1.3 contact_email

```
    "contact_email": {
      "description": "The email address of the individual or group responsible
for the data feed.",
      "type": "string",
      "format": "email"
    },
```

5.3.1.4 update_frequency

```
    "update_frequency": {
      "description": "The frequency in seconds at which the data feed is
updated.",
      "type": "integer",
      "minimum": -1
    },
```

5.3.1.5 update_date

```
    "update_date": {
      "description": "The UTC date and time when the GeoJSON file (representing
the instance of the feed) was generated.",
      "type": "string",
      "format": "date-time"
    },
```

5.3.1.6 version

```
    "version": {
      "description": "The CWZ specification version used to create the data feed,
in 'major.minor' format.",
      "type": "string",
```

```
      "pattern": "^(0|[1-9][0-9]*)\\.(0|[1-9][0-9]*)$"
    },
```

5.3.1.7 license

```
    "license": {
      "description": "The URL of the license that applies to the data in the CWZ
feed. This *must* be the string
\"https://creativecommons.org/publicdomain/zero/1.0/\".",
      "enum": [
        "https://creativecommons.org/publicdomain/zero/1.0/"
      ]
    },
```

5.3.1.8 data_sources

```
    "data_sources": {
      "description": "A list of specific data sources for the road event data in
the feed.",
      "type": "array",
      "items": {
        "$ref": "#/definitions/FeedDataSource"
      },
      "minItems": 1
    }
  },
```

5.3.2 Definitions

```
  "definitions": {
```

5.3.2.1 FeedDataSource

```
    "FeedDataSource": {
      "title": "CWZ Feed Data Source",
      "description": "Describes information about a specific data source used to
build the work zone data feed.",
      "type": "object",
      "required": [
        "data_source_id",
        "organization_name",
        "update_frequency",
        "update_date"
      ],
      "properties": {
```

5.3.2.1.1 data_source_id

```
        "data_source_id": {
          "description": "Unique identifier for the organization providing work
zone data. This identifier is a Universally Unique IDentifier (UUID) as defined
in [RFC 4122](https://datatracker.ietf.org/doc/html/rfc4122).",
```

```
          "type": "string"
        },
```

5.3.2.1.2 organization_name

```
        "organization_name": {
          "description": "The name of the organization for the authoritative
source of the work zone data.",
          "type": "string"
        },
```

5.3.2.1.3 contact_name

```
        "contact_name": {
          "description": "The name of the individual or group responsible for the
data source.",
          "type": "string"
        },
```

5.3.2.1.4 contact_email

```
        "contact_email": {
          "description": "The email address of the individual or group
responsible for the data source.",
          "type": "string",
          "format": "email"
        },
```

5.3.2.1.5 update_frequency

```
        "update_frequency": {
          "description": "The frequency in seconds at which the data source is
updated.",
          "type": "integer",
          "minimum": -1
        },
```

5.3.2.1.6 update_date

```
        "update_date": {
          "description": "The UTC date and time when the data source was last
updated.",
          "type": "string",
          "format": "date-time"
        }
      }
    }
  }
}
```

5.4 RoadEventFeature Schema

```
{
```

```
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/RoadEventFeature.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "Road Event Feature (GeoJSON Feature)",
  "description": "The container object for a specific CWZ road event; an instance
of a GeoJSON Feature.",
  "type": "object",
  "required": ["id","type","properties","geometry"],
```

5.4.1 Properties

```
  "properties": {
```

5.4.1.1 id

```
    "id": {
      "description": "A unique identifier issued by the data feed provider to
identify the CWZ road event. This identifier is a Universally Unique IDentifier
(UUID) as defined in [RFC 4122](https://datatracker.ietf.org/doc/html/rfc4122).",
      "type": "string"
    },
```

5.4.1.2 type

```
    "type": {
      "description": "The GeoJSON object type; must be 'Feature'.",
      "enum": ["Feature"]
    },
```

5.4.1.3 properties

```
    "properties": {
      "type": "object",
      "properties": {
        "core_details": {
          "$ref": "#/definitions/RoadEventCoreDetails"
        }
      },
      "required": ["core_details"],
      "oneOf": [
        {
          "$ref": "#/definitions/WorkZoneRoadEvent"
        },
        {
          "$ref": "#/definitions/DetourRoadEvent"
        }
      ]
    },
```

5.4.1.4 geometry

```
    "geometry": {
```

```
      "oneOf": [
        {
          "$ref": "https://geojson.org/schema/LineString.json"
        },
        {
          "$ref": "https://geojson.org/schema/Point.json"
        }
      ]
    },
```

5.4.1.5 bbox

```
    "bbox": {
      "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/BoundingBox.json"
    }
  },
```

5.4.2 Definitions

```
  "definitions": {
```

5.4.2.1 WorkZoneRoadEvent

```
    "WorkZoneRoadEvent": {
      "title": "Work Zone Road Event",
      "description": "Describes a work zone road event including where, when, and
what activities are taking place within a work zone on a roadway.",
      "type": "object",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "event_type": {
                  "const": "work-zone"
                }
              },
              "required": ["event_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details",
            "is_start_position_verified",
            "is_end_position_verified",
            "start_date",
```

```
            "end_date",
            "is_start_date_verified",
            "is_end_date_verified",
            "vehicle_impact",
            "location_method"
          ],
          "dependencies": {
            "beginning_reference_post": ["reference_post_unit"],
            "ending_reference_post": ["reference_post_unit"]
          },
          "properties": {
```

5.4.2.1.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/RoadEventCoreDetails"
            },
```

5.4.2.1.2 beginning_cross_street

```
            "beginning_cross_street": {
              "description": "Name or number of the nearest cross street along
the roadway where the event begins.",
              "type": "string"
            },
```

5.4.2.1.3 ending_cross_street

```
            "ending_cross_street": {
              "description": "Name or number of the nearest cross street along
the roadway where the event ends.",
              "type": "string"
            },
```

5.4.2.1.4 beginning_reference_post

```
            "beginning_reference_post": {
              "description": "The linear distance measured against a reference
post marker along a roadway where the event begins.",
              "type": "number",
              "minimum": 0
            },
```

5.4.2.1.5 ending_reference_post

```
            "ending_reference_post": {
              "description": "The linear distance measured against a reference
post marker along a roadway where the event ends.",
              "type": "number",
              "minimum": 0
            },
```

5.4.2.1.6 reference_post_unit

```
            "reference_post_unit ": {
              "description": "The unit used for reference post.",
              "$ref": "#/definitions/UnitOfMeasurement"
            },
```

5.4.2.1.7 is_start_position_verified

```
            "is_start_position_verified": {
              "description": "Indicates if the start position (first geometric
coordinate pair) is based on actual reported data from a GPS-equipped device that
measured the location of the start of the work zone.",
              "type": "boolean"
            },
```

5.4.2.1.8 is_end_position_verified

```
            "is_end_position_verified": {
              "description": "Indicates if the end position (last geometric
coordinate pair) is based on actual reported data from a GPS-equipped device that
measured the location of the end of the work zone.",
              "type": "boolean"
            },
```

5.4.2.1.9 start_date

```
            "start_date": {
              "description": "The UTC date and time (formatted according to RFC
3339, Section 5.6) when the road event begins (e.g. 2020-11-03T19:37:00Z).",
              "type": "string",
              "format": "date-time"
            },
```

5.4.2.1.10 end_date

```
            "end_date": {
              "description": "The UTC date and time (formatted according to RFC
3339, Section 5.6) when the road event ends (e.g. 2020-11-03T19:37:00Z).",
              "type": "string",
              "format": "date-time"
            },
```

5.4.2.1.11 is_start_date_verified

```
            "is_start_date_verified": {
              "description": "Indicates if work has been confirmed to have
started, such as from a person or field device.",
              "type": "boolean"
            },
```

5.4.2.1.12 is_end_date_verified

```
            "is_end_date_verified": {
```

```
            "description": "Indicates if work has been confirmed to have ended,
such as from a person or field device.",
            "type": "boolean"
          },
```

5.4.2.1.13 work_zone_type

```
          "work_zone_type": {
            "description": "The type of work zone road event.",
            "$ref": "#/definitions/WorkZoneType"
          },
```

5.4.2.1.14 vehicle_impact

```
          "vehicle_impact": {
            "$ref": "#/definitions/VehicleImpact"
          },
```

5.4.2.1.15 location_method

```
          "location_method": {
            "$ref": "#/definitions/LocationMethod"
          },
```

5.4.2.1.16 worker_presence

```
          "worker_presence": {
            "$ref": "#/definitions/WorkerPresence"
          },
```

5.4.2.1.17 reduced_speed_limit_kph

```
          "reduced_speed_limit_kph": {
            "description": "If applicable, the reduced speed limit posted
within the road event, in kilometers per hour.",
            "type": "number",
            "minimum": 0
          },
```

5.4.2.1.18 restrictions

```
          "restrictions": {
            "description": "A list of zero or more restrictions applying to the
road event.",
            "type": "array",
            "items": {
              "$ref": "#/definitions/Restriction"
            }
          },
```

5.4.2.1.19 types_of_work

```
          "types_of_work": {
```

```
              "description": "A list of the types of work being done in a road
event.",
              "type": "array",
              "items": {
                "$ref": "#/definitions/TypeOfWork"
              }
            },
```

5.4.2.1.20 lanes

```
            "lanes": {
              "description": "A list of individual lanes within a road event
(roadway segment).",
              "type": "array",
              "items": {
                "$ref": "#/definitions/Lane"
              }
            },
```

5.4.2.1.21 impacted_cds_curb_zones

```
            "impacted_cds_curb_zones": {
               "description": "A list of references to external CDS Curb Zones
impacted by the work zone.",
               "type": "array",
               "items": {
                  "$ref": "#/definitions/CdsCurbZonesReference"
              }
            }
          }
        }
      ]
    },
```

5.4.2.2 DetourRoadEvent

```
    "DetourRoadEvent": {
      "title": "Detour Road Event",
      "description": "Describes a detour on a roadway.",
      "type": "object",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "event_type": {
                  "const": "detour"
                }
              },
```

```
            "required": ["event_type"]
          }
        },
        "required": ["core_details"]
      },
      {
        "required": [
          "core_details",
          "start_date",
          "end_date",
          "is_start_date_verified",
          "is_end_date_verified"
        ],
        "dependencies": {
          "beginning_reference_post": ["reference_post_unit"],
          "ending_reference_post": ["reference_post_unit"]
        },
        "properties": {
```

5.4.2.2.1 core_details

```
          "core_details": {
            "$ref": "#/definitions/RoadEventCoreDetails"
          },
```

5.4.2.2.2 beginning_cross_street

```
          "beginning_cross_street": {
            "description": "Name or number of the nearest cross street along
the roadway where the event begins.",
            "type": "string"
          },
```

5.4.2.2.3 ending_cross_street

```
          "ending_cross_street": {
            "description": "Name or number of the nearest cross street along
the roadway where the event ends.",
            "type": "string"
          },
```

5.4.2.2.4 beginning_reference_post

```
          "beginning_reference_post": {
            "description": "The linear distance measured against a reference
post marker along a roadway where the event begins.",
            "type": "number",
            "minimum": 0
          },
```

5.4.2.2.5 ending_reference_post

```
            "ending_reference_post": {
              "description": "The linear distance measured against a reference
post marker along a roadway where the event ends.",
              "type": "number",
              "minimum": 0
            },
```

5.4.2.2.6 reference_post_unit

```
            "reference_post_unit": {
              "description": "The unit used for reference post.",
              "$ref": "#/definitions/UnitOfMeasurement"
            },
```

5.4.2.2.7 start_date

```
            "start_date": {
              "description": "The UTC date and time (formatted according to RFC
3339, Section 5.6) when the road event begins (e.g. 2020-11-03T19:37:00Z).",
              "type": "string",
              "format": "date-time"
            },
```

5.4.2.2.8 end_date

```
            "end_date": {
              "description": "The UTC date and time (formatted according to RFC
3339, Section 5.6) when the road event ends (e.g. 2020-11-03T19:37:00Z).",
              "type": "string",
              "format": "date-time"
            },
```

5.4.2.2.9 is_start_date_verified

```
            "is_start_date_verified": {
              "description": "Indicates if the detour has been confirmed to have
started, such as from a person or device in the field or a report from a traffic
management center.",
              "type": "boolean"
            },
```

5.4.2.2.10 is_end_date_verified

```
            "is_end_date_verified": {
              "description": "Indicates if the detour has been confirmed to have
ended, such as from a person or device in the field or a report from a traffic
management center.",
              "type": "boolean"
            }
          }
        }
```

```
      ]
    },
```

5.4.2.3 RoadEventCoreDetails

```
    "RoadEventCoreDetails": {
      "title": "Road Event Core Details",
      "description": "The core details of an event occurring on a roadway (i.e. a
road event) that is shared by all types of road events.",
      "type": "object",
      "required": [
        "data_source_id",
        "event_type",
        "road_names",
        "direction"
      ],
      "properties": {
```

5.4.2.3.1 data_source_id

```
        "data_source_id": {
          "description": "Identifies the data source from which the road event
data is sourced from.",
          "type": "string"
        },
```

5.4.2.3.2 event_type

```
        "event_type": {
          "$ref": "#/definitions/EventType"
        },
```

5.4.2.3.3 related_road_events

```
        "related_road_events": {
          "description": "A list describing one or more road events which are
related to this road event, such as a work zone project it is part of or another
road event that occurs before or after it in sequence.",
          "type": "array",
          "items": {
            "$ref": "#/definitions/RelatedRoadEvent"
          }
        },
```

5.4.2.3.4 project_id

```
        "project_id": {
          "description": " An identifier for the project that the event is part
of. A project is the highest-level representation of an area where road work
takes place and may cover multiple roadways if adjacent or intersecting. A
project will contain one or more RoadEventFeatures. This project ID does not
correspond to an object in a WorkZoneFeed. It is used to group events (and
```

```
devices, see FieldDeviceCoreDetails). This identifier is a Universally Unique
IDentifier (UUID) as defined in RFC 4122 to guarantee uniqueness between feeds
and over time.",
          "type": "string"
        },
```

5.4.2.3.5 road_names

```
        "road_names": {
          "description": "A list of publicly known names of the road on which the
event occurs. This may include the road number designated by a jurisdiction such
as a county, state or interstate (e.g. I-5, VT 133).",
          "type": "array",
          "minItems": 1,
          "items": {
            "type": "string"
          }
        },
```

5.4.2.3.6 direction

```
        "direction": {
          "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/Direction.json"
        },
```

5.4.2.3.7 name

```
        "name": {
          "description": "A human-readable name for the road event.",
          "type": "string"
        },
```

5.4.2.3.8 description

```
        "description": {
          "description": "Short free text description of the road event.",
          "type": "string"
        },
```

5.4.2.3.9 creation_date

```
        "creation_date": {
          "description": "The UTC date and time (formatted according to RFC 3339,
Section 5.6) when the road event was created (e.g. 2020-11-03T19:37:00Z).",
          "type": "string",
          "format": "date-time"
        },
```

5.4.2.3.10 update_date

```
        "update_date": {
```

```
          "description": "The UTC date and time (formatted according to RFC 3339,
Section 5.6) when any information in the RoadEventFeature (including child
objects) that the RoadEventCoreDetails applies to was most recently updated or
confirmed as up to date.",
          "type": "string",
          "format": "date-time"
        }
      }
    },
```

5.4.2.4 LocationMethod

```
    "LocationMethod": {
      "title": "Location Method Enumerated Type",
      "description": "The typical method used to locate the beginning and end of
a work zone impact area.",
      "enum": [
        "channel-device-method",
        "sign-method",
        "junction-method",
        "other",
        "unknown"
      ]
    },
```

5.4.2.5 RelatedRoadEvent

```
    "RelatedRoadEvent": {
      "title": "RelatedRoadEvent",
      "description": "Identifies a road event that is related to the road event
that the RelatedRoadEvent object occurs on.",
      "type": "object",
      "required": ["type", "id"],
      "properties": {
```

5.4.2.5.1 type

```
        "type": {
          "description": "The type of road event being identified, such as
another sequence of related work zones, a detour, or next road event in
sequence.",
          "$ref": "#/definitions/RelatedRoadEventType"
        },
```

5.4.2.5.2 id

```
        "id": {
          "description": "An identifier for the related road event by the type
property.",
          "type": "string"
```

```
        }
      }
    },
```

5.4.2.6 TypeOfWork

```
    "TypeOfWork": {
      "title": "Type of Work",
      "description": "A description of the type of work being done in a road
event and an indication of if that work will result in an architectural change to
the roadway.",
      "type": "object",
      "required": ["type_name"],
      "properties": {
```

5.4.2.6.1 type_name

```
        "type_name": {
          "$ref": "#/definitions/WorkTypeName"
        },
```

5.4.2.6.2 is_architectural_change

```
        "is_architectural_change": {
          "description": "A flag indicating whether the type of work will result
in an architectural change to the roadway.",
          "type": "boolean"
        }
      }
    },
```

5.4.2.7 Lane

```
    "Lane": {
      "title": "Lane",
      "description": "An individual lane within a road event.",
      "type": "object",
      "required": ["order", "status", "type"],
      "properties": {
```

5.4.2.7.1 order

```
        "order": {
          "description": "The position (index) of the lane in sequence on the
roadway, where '1' represents the left-most lane.",
          "type": "integer",
          "minimum": 1
        },
```

5.4.2.7.2 status

```
        "status": {
          "$ref": "#/definitions/LaneStatus"
```

```
        },
```

5.4.2.7.3 type

```
        "type": {
          "$ref": "#/definitions/LaneType"
        },
```

5.4.2.7.4 restrictions

```
        "restrictions": {
          "description": "A list of zero or more restrictions specific to the
lane.",
          "type": "array",
          "items": {
            "$ref": "#/definitions/Restriction"
          }
        }
      },
```

5.4.2.8 Restriction

```
    "Restriction": {
      "title": "Restriction",
      "description": "A restriction on a roadway or lane, including type and
value.",
      "type": "object",
      "required": ["type"],
      "dependencies": {
        "value": ["unit"]
      },
      "properties": {
```

5.4.2.8.1 type

```
        "type": {
          "$ref": "#/definitions/RestrictionType"
        },
```

5.4.2.8.2 value

```
        "value": {
          "type": "number"
        },
```

5.4.2.8.3 unit

```
        "unit": {
          "$ref": "#/definitions/UnitOfMeasurement"
        }
      }
    },
```

5.4.2.9 CdsCurbZonesReference

```
    "CdsCurbZonesReference": {
      "title": "CdsCurbZonesReference",
      "description": "A reference to one or more CDS curb zones that are impacted
by road work.",
      "type": "object",
      "required": ["cds_curb_zone_ids", "cds_curbs_api_url"],
      "properties": {
```

5.4.2.9.1 cds_curb_zone_ids

```
        "cds_curb_zone_ids": {
           "description": "A list of CDS Curb Zone ids.",
           "type": "array",
           "items": {
              "type": "string"
           }
        },
```

5.4.2.9.2 cds_curbs_api_url

```
        "cds_curbs_api_url": {
          "description": "An identifier for the source of the requested CDS
Curbs API.",
          "type": "string",
          "format": "uri"
        }
      }
  },
```

5.4.2.10 WorkerPresence

```
    "WorkerPresence": {
      "title": "Worker Presence",
      "description": "Information about the presence of workers in the work zone
event area.",
      "type": "object",
      "required": ["are_workers_present"],
      "properties": {
```

5.4.2.10.1 are_workers_present

```
        "are_workers_present": {
          "description": "Whether workers are present in the work zone event
area, following the definition provided in the 'definition' property on the
WorkerPresence object.",
          "type": "boolean"
        },
```

5.4.2.10.2 method

```
        "method": {
```

```
          "$ref": "#/definitions/WorkerPresenceMethod"
        },
```

5.4.2.10.3 worker_presence_last_confirmed_date

```
        "worker_presence_last_confirmed_date": {
          "description": "The UTC date and time at which the presence of workers
was last confirmed.",
          "type": "string",
          "format": "date-time"
        },
```

5.4.2.10.4 confidence

```
        "confidence": {
          "$ref": "#/definitions/WorkerPresenceConfidence"
        },
```

5.4.2.10.5 definition

```
        "definition": {
          "description": "A list of situations in which workers are considered to
be present in the jurisdiction of the data provider.",
          "type": "array",
          "items": {
            "$ref": "#/definitions/WorkerPresenceDefinition"
          },
          "uniqueItems": true
        },
```

5.4.2.10.6 other_method

```
        "other_method": {
          "description": "Provides more information about how worker presence in
a work zone event area is determined when method enumeration selected is
'other'.",
          "type": "string"
        }
      }
    },
```

5.4.2.11 EventType

```
    "EventType": {
      "title": "Road Event Type Enumerated Type",
      "description": "The type of CWZ road event.",
      "enum": ["work-zone", "detour"]
    },
```

5.4.2.12 WorkZoneType

```
    "WorkZoneType": {
      "title": "Work Zone Type Enumerated Type",
```

```
      "description": "The type of work zone road event.",
      "enum": ["static", "moving", "planned-moving-area"]
    },
```

5.4.2.13 VehicleImpact

```
    "VehicleImpact": {
      "title": "Vehicle Impact Enumerated Type",
      "description": "The impact to vehicular lanes along a single road in a
single direction.",
      "enum": ["all-lanes-closed", "some-lanes-closed", "all-lanes-open",
"alternating-one-way", "some-lanes-closed-merge-left", "some-lanes-closed-merge-
right", "all-lanes-open-shift-left", "all-lanes-open-shift-right", "some-lanes-
closed-split", "flagging", "temporary-traffic-signal", "unknown"]
    },
```

5.4.2.14 RestrictionType

```
    "RestrictionType": {
      "title": "Restriction Type Enumerated Type",
      "description": "The type of vehicle restriction on a roadway.",
      "enum": [
        "local-access-only",
        "no-trucks",
        "travel-peak-hours-only",
        "hov-3",
        "hov-2",
        "no-parking",
        "reduced-width",
        "reduced-height",
        "reduced-length",
        "reduced-weight",
        "axle-load-limit",
        "gross-weight-limit",
        "towing-prohibited",
        "permitted-oversize-loads-prohibited",
        "no-passing"
      ]
    },
```

5.4.2.15 WorkTypeName

```
    "WorkTypeName": {
      "title": "Work Type Name Enumerated Type",
      "description": "A high-level text description of the type of work being
done in a road event.",
      "enum": [
        "non-encroachment",
        "minor-road-defect-repair",
```

```
        "roadside-work",
        "overhead-work",
        "below-road-work",
        "barrier-work",
        "surface-work",
        "painting",
        "roadway-relocation",
        "roadway-creation"
      ]
    },
```

5.4.2.16 LaneStatus

```
    "LaneStatus": {
      "title": "Lane Status Enumerated Type",
      "description": "The status of the lane for the traveling public.",
      "enum": ["open", "closed", "shift-left", "shift-right", "merge-left",
"merge-right", "alternating-flow"]
    },
```

5.4.2.17 LaneType

```
    "LaneType": {
      "title": "Lane Type Enumerated Type",
      "description": "An indication of the type of lane or shoulder.",
      "enum": [
        "general",
        "exit-lane",
        "exit-ramp",
        "entrance-lane",
        "entrance-ramp",
        "sidewalk",
        "bike-lane",
        "shoulder",
        "parking",
        "median",
        "two-way-center-turn-lane"
      ]
    },
```

5.4.2.18 UnitOfMeasurement

```
    "UnitOfMeasurement": {
      "title": "Unit of Measurement Enumerated Type",
      "description": "Unit of measurement, used when providing a unit to
accompany a value.",
      "enum": ["feet", "inches", "centimeters", "pounds", "tons", "kilograms",
"miles", "kilometers"]
    },
```

5.4.2.19 WorkerPresenceMethod

```
    "WorkerPresenceMethod": {
      "title": "Worker Presence Method Enumerated Type",
      "description": "Describes methods for how worker presence in a work zone
event area is determined.",
      "enum": [
        "camera-monitoring",
        "maintenance-vehicle-present",
        "wearables-present",
        "mobile-device-present",
        "check-in-app",
        "check-in-verbal",
        "other"
      ]
    },
```

5.4.2.20 WorkerPresenceDefinition

```
    "WorkerPresenceDefinition": {
      "title": "Worker Presence Definition Enumerated Type",
      "description": "Situations in which workers may be considered present in a
work zone.",
      "enum": [
        "workers-in-work-zone-working",
        "workers-in-work-zone-not-working",
        "mobile-equipment-in-work-zone-moving",
        "mobile-equipment-in-work-zone-not-moving",
        "fixed-equipment-in-work-zone",
        "humans-behind-barrier",
        "humans-in-right-of-way"
      ]
    },
```

5.4.2.21 WorkerPresenceConfidence

```
    "WorkerPresenceConfidence": {
      "title": "Worker Presence Confidence Enumerated Type",
      "description": "A high-level description of the feed publisher's confidence
in the reported WorkerPresence value of are_workers_present.",
      "enum": [
        "low",
        "medium",
        "high"
      ]
    },
```

5.4.2.22 RelatedRoadEventType

```
    "RelatedRoadEventType": {
```

```
      "title": "Related Road Event Type Enumerated Type",
      "description": "Describes how a road event is related to the road event
that the RelatedRoadEvent object occurs on.",
      "enum": [
        "first-in-sequence",
        "next-in-sequence",
        "first-occurrence",
        "next-occurrence",
        "related-work-zone",
        "related-detour",
        "planned-moving-operation",
        "active-moving-operation"
      ]
    }
  }
}
```

5.5 DeviceFeed Schema

```
{
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/DeviceFeed.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "CWZ v1.0 DeviceFeed",
  "description": "The GeoJSON output of a CWZ Device Feed v1.0.",
  "type": "object",
  "required": ["feed_info", "type", "features"],
```

5.5.1 Properties

```
  "properties": {
```

5.5.1.1 feed_info

```
    "feed_info": {
      "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/FeedInfo.json"
    },
```

5.5.1.2 type

```
    "type": {
      "description": "The GeoJSON type.",
      "enum": ["FeatureCollection"]
    },
```

5.5.1.3 features

```
    "features": {
      "description": "An array of GeoJSON Feature objects which represent field
devices deployed in a work zone.",
      "type": "array",
```

```
      "items": {
        "$ref": "#/definitions/FieldDeviceFeature"
      }
    },
```

5.5.1.4 bbox

```
    "bbox": {
      "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/BoundingBox.json"
    }
  },
```

5.5.2 Definitions

```
  "definitions": {
```

5.5.2.1 FieldDeviceFeature

```
    "FieldDeviceFeature": {
      "title": "Field Device Feature (GeoJSON Feature)",
      "description": "The GeoJSON feature container for a CWZ field device.",
      "type": "object",
      "required": ["id","type","properties","geometry"],
      "properties": {
```

5.5.2.1.1 id

```
        "id": {
          "description": "A unique identifier issued by the data feed provider to
identify the field device. This identifier is a Universally Unique IDentifier
(UUID) as defined in [RFC 4122](https://datatracker.ietf.org/doc/html/rfc4122).",
          "type": "string"
        },
```

5.5.2.1.2 type

```
        "type": {
          "description": "The GeoJSON object type; must be 'Feature'.",
          "enum": ["Feature"]
        },
```

5.5.2.1.3 properties

```
        "properties": {
          "type": "object",
          "properties": {
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            }
          },
          "required": ["core_details"],
          "oneOf": [
```

```
            {
              "$ref": "#/definitions/ArrowBoard"
            },
            {
              "$ref": "#/definitions/Camera"
            },
            {
              "$ref": "#/definitions/DynamicMessageSign"
            },
            {
              "$ref": "#/definitions/FlashingBeacon"
            },
            {
              "$ref": "#/definitions/HybridSign"
            },
            {
              "$ref": "#/definitions/LocationMarker"
            },
            {
              "$ref": "#/definitions/RoadsideUnit"
            },
            {
              "$ref": "#/definitions/TrafficSensor"
            },
            {
              "$ref": "#/definitions/TrafficSignal"
            }
          ]
        },
```

5.5.2.1.4 geometry

```
        "geometry": {
          "oneOf": [
            {
              "$ref": "https://geojson.org/schema/Point.json"
            }
          ]
        },
```

5.5.2.1.5 bbox

```
        "bbox": {
          "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/BoundingBox.json"
        }
      }
    },
```

5.5.2.2 FieldDeviceCoreDetails

```
    "FieldDeviceCoreDetails": {
      "title": "Field Device Core Details",
      "description": "The core details—both configuration and current state—of a
field device that are shared by all types of field devices.",
      "type": "object",
      "required": [
        "device_type",
        "data_source_id",
        "device_status",
        "update_date",
        "has_automatic_location"
      ],
      "dependencies": {
        "reference_post": ["reference_post_unit"]
      },
      "properties": {
```

5.5.2.2.1 device_type

```
        "device_type": {
          "$ref": "#/definitions/FieldDeviceType"
        },
```

5.5.2.2.2 data_source_id

```
        "data_source_id": {
          "description": "Identifies the data source from which the field device
information is sourced from.",
          "type": "string"
        },
```

5.5.2.2.3 device_status

```
        "device_status": {
          "$ref": "#/definitions/FieldDeviceStatus"
        },
```

5.5.2.2.4 update_date

```
        "update_date": {
          "description": "The UTC date and time (formatted according to RFC 3339,
Section 5.6) when any information in the FieldDeviceFeature (including child
objects) that the FieldDeviceCoreDetails applies to was most recently updated or
confirmed as up to date.",
          "type": "string",
          "format": "date-time"
        },
```

5.5.2.2.5 has_automatic_location

```
        "has_automatic_location": {
```

```
          "description": "A yes/no value indicating if the field device location
(parent FieldDeviceFeature's geometry) is determined automatically from an
onboard GPS (true) or manually set/overridden (false).",
          "type": "boolean"
        },
```

5.5.2.2.6 road_direction

```
        "road_direction": {
          "$ref": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/Direction.json",
          "description": "The direction of the road that the field device is on.
This value indicates the direction of the traffic flow of the road, not a real
heading angle."
        },
```

5.5.2.2.7 road_names

```
        "road_names": {
          "description": "A list of publicly known names of the road on which the
field device is located. This may include the road number designated by a
jurisdiction such as a county, state or interstate (e.g. I-5, VT 133).",
          "type": "array",
          "minItems": 1,
          "items": {
            "type": "string"
          }
        },
```

5.5.2.2.8 name

```
        "name": {
          "type": "string",
          "description": "A human-readable name for the field device."
        },
```

5.5.2.2.9 description

```
        "description": {
          "type": "string",
          "description": "A description of the field device."
        },
```

5.5.2.2.10 status_messages

```
        "status_messages": {
          "type": "array",
          "description": "A list of messages associated with the device's status,
if applicable. Used to provide additional information about the status such as
specific warning or error message.",
          "items": {
            "type": "string"
```

```
        }
      },
```

5.5.2.2.11 is_moving

```
      "is_moving": {
        "type": "boolean",
        "description": "A yes/no value indicating if the device is actively
moving (not statically placed) as part of a mobile work zone operation."
      },
```

5.5.2.2.12 road_event_ids

```
      "road_event_ids": {
        "type": "array",
        "description": "A list of one or more IDs of a RoadEventFeatures that
the device is associated with.",
        "items": {
          "type": "string"
        }
      },
```

5.5.2.2.13 project_id

```
      "project_id": {
        "type": "string",
        "description": " An identifier for the project that the device is
associated with. A project is the highest-level representation of an area where
road work takes place and may cover multiple roadways if adjacent or
intersection. This project ID does not correspond to an object in a WorkZoneFeed.
It is used to group devices (and events, see RoadEventCoreDetails)."
      },
```

5.5.2.2.14 reference_post

```
      "reference_post": {
        "type": "number",
        "description": "The linear distance measured against a reference post
marker along a roadway where the device is located."
      },
```

5.5.2.2.15 reference_post_unit

```
      "reference_post_unit": {
        "description": "The unit used for reference post.",
        "$ref": "#/definitions/UnitOfMeasurement"
      },
```

5.5.2.2.16 make

```
      "make": {
        "type": "string",
```

```
          "description": "The make or manufacturer of the device."
        },
```

5.5.2.2.17 model

```
        "model": {
          "type": "string",
          "description": "The model of the device."
        },
```

5.5.2.2.18 serial_number

```
        "serial_number": {
          "type": "string",
          "description": "The serial number of the device."
        },
```

5.5.2.2.19 firmware_version

```
        "firmware_version": {
          "type": "string",
          "description": "The version of firmware the device is using to
operate."
        },
```

5.5.2.2.20 velocity_kph

```
        "velocity_kph": {
          "type": "number",
          "description": "The velocity of the device in kilometers per hour."
        },
```

5.5.2.2.21 is_in_transport_position

```
            "is_in_transport_position": {
              "type": "boolean",
              "description": "A yes/no value indicating if the device is in the
stowed/transport position (true) or deployed/upright position (false)."
            }


      }
    },
```

5.5.2.3 ArrowBoard

```
    "ArrowBoard": {
      "title": "Arrow Board Field Device",
      "description": "An electronic, connected arrow board which can display an
arrow pattern to direct traffic.",
      "type": "object",
      "allOf": [
        {
          "properties": {
```

```
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "arrow-board"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details",
            "pattern"
          ],
          "properties": {
```

5.5.2.3.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.3.2 pattern

```
            "pattern": {
              "$ref": "#/definitions/ArrowBoardPattern"
            }
          }
        }
      ]
    },
```

5.5.2.4 Camera

```
    "Camera": {
      "title": "Camera Field Device",
      "description": "A camera device deployed in the field, capable of capturing
still images.",
      "type": "object",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "camera"
                }
```

```
            },
            "required": ["device_type"]
          }
        },
        "required": ["core_details"]
      },
      {
        "required": [
          "core_details"
        ],
        "dependencies": {
          "image_url": ["image_timestamp"],
          "video_url": ["video_update_frequency"]
        },
        "properties": {
```

5.5.2.4.1 core_details

```
          "core_details": {
            "$ref": "#/definitions/FieldDeviceCoreDetails"
          },
```

5.5.2.4.2 image_url

```
          "image_url": {
            "type": "string",
            "format": "uri",
            "description": "A URL pointing to an image file for the camera
video."
          },
```

5.5.2.4.3 is_image_url_public

```
          "is_image_url_public": {
            "type": "boolean",
            "description": "Identifies whether image_url is publicly
accessible."
          },
```

5.5.2.4.4 image_timestamp

```
          "image_timestamp": {
            "type": "string",
            "format": "date-time",
            "description": "The UTC date and time when the image was captured."
          },
```

5.5.2.4.5 video_url

```
          "video_url": {
            "type": "string",
```

```
              "format": "uri",
              "description": "A URL pointing to a video file for the camera
video."
            },
```

5.5.2.4.6 is_video_url_public

```
            "is_video_url_public": {
              "type": "boolean",
              "description": "Identifies whether video_url is publicly
accessible."
            },
```

5.5.2.4.7 video_update_frequency

```
            "video_update_frequency": {
              "description": "The frequency at which the video feed is updated,
in seconds.",
              "type": "integer",
              "minimum": -1
            }
          }
        }
      ]
    },
```

5.5.2.5 DynamicMessageSign

```
    "DynamicMessageSign": {
      "title": "Dynamic Message Sign Field Device",
      "description": "An electronic traffic sign deployed on the roadway, used to
provide information to travelers.",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "dynamic-message-sign"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
```

```
            "core_details",
            "message_multi_string"
          ],
          "properties": {
```

5.5.2.5.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.5.2 message_multi_string

```
            "message_multi_string": {
              "type": "string",
              "description": "A MULTI-formatted string describing the message
currently posted to the sign."
            }
          }
        }
      ]
    },
```

5.5.2.6 FlashingBeacon

```
    "FlashingBeacon": {
      "title": "Flashing Beacon Field Device",
      "description": "A flashing warning beacon used to supplement a temporary
traffic control device.",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "flashing-beacon"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details",
            "function"
          ],
          "properties": {
```

5.5.2.6.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.6.2 function

```
            "function": {
              "$ref": "#/definitions/FlashingBeaconFunction"
            },
```

5.5.2.6.3 is_flashing

```
            "is_flashing": {
              "type": "boolean",
              "description": "A yes/no value indicating if the flashing beacon is
currently in use and flashing."
            },
```

5.5.2.6.4 sign_text

```
            "sign_text": {
              "type": "string",
              "description": "The text on the sign the beacon is mounted on, if
applicable."
            }
          }
        }
      ]
    },
```

5.5.2.7 HybridSign

```
    "HybridSign": {
      "title": "Hybrid Sign Field Device",
      "description": "A hybrid sign that contains static text (e.g. on an
aluminum sign) along with a single electronic message display, used to provide
information to travelers.",
      "type": "object",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "hybrid-sign"
                }
              },
              "required": ["device_type"]
            }
```

```
        },
        "required": ["core_details"]
      },
      {
        "required": [
          "core_details",
          "dynamic_message_function"
        ],
        "properties": {
```

5.5.2.7.1 core_details

```
          "core_details": {
            "$ref": "#/definitions/FieldDeviceCoreDetails"
          },
```

5.5.2.7.2 dynamic_message_function

```
          "dynamic_message_function": {
            "$ref": "#/definitions/HybridSignDynamicMessageFunction"
          },
```

5.5.2.7.3 dynamic_message_text

```
          "dynamic_message_text": {
            "type": "string",
            "description": "A text representation of the message currently
posted to the dynamic electronic component of the hybrid sign."
          },
```

5.5.2.7.4 static_sign_text

```
          "static_sign_text": {
            "type": "string",
            "description": "The static text on the non-electronic component of
the hybrid sign."
          }
        }
      }
    ]
  },
```

5.5.2.8 LocationMarker

```
  "LocationMarker": {
    "title": "Location Marker Field Device",
    "description": "Any GPS-enabled ITS device that is placed at a point on a
roadway to dynamically know the location of something (often the beginning or end
of a work zone).",
    "type": "object",
    "allOf": [
      {
```

```
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "location-marker"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": ["core_details", "marked_locations"],
          "properties": {
```

5.5.2.8.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.8.2 marked_locations

```
            "marked_locations": {
              "type": "array",
              "minItems": 1,
              "items": {
                "$ref": "#/definitions/MarkedLocation"
              }
            }
          }
        }
      ]
    },
```

5.5.2.9 MarkedLocation

```
    "MarkedLocation": {
      "title": "Marked Location",
      "description": "Describes a specific location where a LocationMarker is
placed, such as the start or end of a work zone road event.",
      "required": ["type"],
      "properties": {
```

5.5.2.9.1 type

```
        "type": {
          "$ref": "#/definitions/MarkedLocationType"
        },
```

5.5.2.9.2 road_event_id

```
        "road_event_id": {
          "type": "string",
          "description": "The ID of a RoadEventFeature that the MarkedLocation
applies to."
        }
      }
    },
```

5.5.2.10 TrafficSensor

```
    "TrafficSensor": {
      "title": "Traffic Sensor Field Device",
      "description": "A traffic sensor deployed on a roadway which captures
traffic metrics (e.g. speed, volume, occupancy) over a collection interval.",
      "type": "object",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "traffic-sensor"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details",
            "collection_interval_start_date",
            "collection_interval_end_date"
          ],
          "properties": {
```

5.5.2.10.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.10.2 collection_interval_start_date

```
            "collection_interval_start_date": {
              "type": "string",
              "format": "date-time",
```

```
            "description": "The UTC date and time where the TrafficSensor data
collection started. The averages and totals contained in the TrafficSensor data
apply to the inclusive interval of 'collection_interval_start_date' to
'collection_interval_end_date'."
          },
```

5.5.2.10.3 collection_interval_end_date

```
          "collection_interval_end_date": {
            "type": "string",
            "format": "date-time",
            "description": "The UTC date and time where the TrafficSensor data
collection ended. The averages and totals contained in the TrafficSensor data
apply to the inclusive interval of 'collection_interval_start_date' to
'collection_interval_end_date'."
          },
```

5.5.2.10.4 average_speed_kph

```
          "average_speed_kph": {
            "type": "number",
            "minimum": 0,
            "description": "The average speed of vehicles across all lanes over
the collection interval in kilometers per hour."
          },
```

5.5.2.10.5 volume_vph

```
          "volume_vph": {
            "type": "number",
            "minimum": 0,
            "description": "The rate of vehicles passing by the sensor during
the collection interval in vehicles per hour."
          },
```

5.5.2.10.6 occupancy_percent

```
          "occupancy_percent": {
            "type": "number",
            "minimum": 0,
            "description": "The percent of time the roadway section monitored
by the sensor was occupied by a vehicle over the collection interval."
          },
```

5.5.2.10.7 lane_data

```
          "lane_data": {
            "type": "array",
            "items": {
              "$ref": "#/definitions/TrafficSensorLaneData"
            }
          }
```

```
        }
      }
    ]
  },
```

5.5.2.11 TrafficSensorLaneData

```
  "TrafficSensorLaneData": {
    "title": "Traffic Sensor Lane Data",
    "description": "Data for a single lane measured by a TrafficSensor deployed
on the roadway.",
    "required": [
      "lane_order"
    ],
    "properties": {
```

5.5.2.11.1 lane_order

```
      "lane_order": {
        "type": "integer",
        "minimum": 1,
        "description": "The lane's position in sequence on the roadway."
      },
```

5.5.2.11.2 road_event_id

```
      "road_event_id": {
        "type": "string",
        "description": "The ID of a RoadEventFeature that the measured lane
occurs in."
      },
```

5.5.2.11.3 average_speed_kph

```
      "average_speed_kph": {
        "type": "number",
        "minimum": 0,
        "description": "The average speed of traffic in the lane over the
collection interval (in kilometers per hour)."
      },
```

5.5.2.11.4 volume_vph

```
      "volume_vph": {
        "type": "number",
        "minimum": 0,
        "description": "The rate of vehicles passing by the sensor in the lane
during the collection interval (in vehicles per hour)."
      },
```

5.5.2.11.5 occupancy_percent

```
      "occupancy_percent": {
```

```
          "type": "number",
          "minimum": 0,
          "description": "The percent of time the lane monitored by the sensor
was occupied by a vehicle over the collection interval."
        }
      }
    },
```

5.5.2.12 TrafficSignal

```
    "TrafficSignal": {
      "title": "Traffic Signal",
      "description": "Describes a temporary traffic signal deployed on a
roadway.",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "traffic-signal"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details",
            "mode"
          ],
          "properties": {
```

5.5.2.12.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.12.2 mode

```
            "mode": {
              "$ref": "#/definitions/TrafficSignalMode"
            }
          }
        }
```

```
      ]
    },
```

5.5.2.13 RoadsideUnit

```
    "RoadsideUnit": {
      "title": "Roadside Unit",
      "description": "Describes a roadside unit deployed on a roadway.",
      "allOf": [
        {
          "properties": {
            "core_details": {
              "properties": {
                "device_type": {
                  "const": "roadside-unit"
                }
              },
              "required": ["device_type"]
            }
          },
          "required": ["core_details"]
        },
        {
          "required": [
            "core_details"
          ],
          "properties": {
```

5.5.2.13.1 core_details

```
            "core_details": {
              "$ref": "#/definitions/FieldDeviceCoreDetails"
            },
```

5.5.2.13.2 message_types

```
            "message_types": {
              "description": "A list of message types being broadcast by a
RoadsideUnit.",
              "type": "array",
              "items": {
                "$ref": "#/definitions/RoadsideUnitMessageTypes"
              },
              "uniqueItems": true
            }
          }
        }
      ]
    },
```

5.5.2.14 UnitOfMeasurement

```
    "UnitOfMeasurement": {
      "title": "Unit of Measurement Enumerated Type",
      "description": "Unit of measurement, used when providing a unit to
accompany a value.",
      "enum": ["feet", "inches", "centimeters", "pounds", "tons", "kilograms",
"miles", "kilometers"]
    },
```

5.5.2.15 ArrowBoardPattern

```
    "ArrowBoardPattern": {
      "title": "Arrow Board Pattern Enumerated Type",
      "description": "A list of options for the posted pattern on an
ArrowBoard.",
      "enum": [
        "blank",
        "right-arrow-static",
        "right-arrow-flashing",
        "right-arrow-sequential",
        "right-chevron-static",
        "right-chevron-flashing",
        "right-chevron-sequential",
        "left-arrow-static",
        "left-arrow-flashing",
        "left-arrow-sequential",
        "left-chevron-static",
        "left-chevron-flashing",
        "left-chevron-sequential",
        "bidirectional-arrow-static",
        "bidirectional-arrow-flashing",
        "line-flashing",
        "diamonds-alternating",
        "four-corners-flashing",
        "unknown"
      ]
    },
```

5.5.2.16 FieldDeviceType

```
    "FieldDeviceType": {
      "title": "Field Device Type Enumerated Type",
      "description": "The type of field device.",
      "enum": [
        "arrow-board",
        "camera",
        "dynamic-message-sign",
```

```
        "flashing-beacon",
        "hybrid-sign",
        "location-marker",
        "traffic-sensor",
        "traffic-signal",
        "roadside-unit"
      ]
    },
```

5.5.2.17 FieldDeviceStatus

```
    "FieldDeviceStatus": {
      "title": "Field Device Status Enumerated Type",
      "description": "The operational status of a field device.",
      "enum": ["ok", "warning", "error", "unknown"]
    },
```

5.5.2.18 FlashingBeaconFunction

```
    "FlashingBeaconFunction": {
      "title": "Flashing Beacon Function Enumerated Type",
      "description": "Options for what a FlashingBeacon is being used to
indicate.",
      "enum": ["vehicle-entering", "queue-warning", "reduced-speed", "workers-
present", "other"]
    },
```

5.5.2.19 HybridSignDynamicMessageFunction

```
    "HybridSignDynamicMessageFunction": {
      "title": "Hybrid Sign Dynamic Message Function Enumerated Type",
      "description": "Options for the function of the dynamic message displayed
by the electronic display on a HybridSign.",
      "enum": ["speed-limit", "travel-time", "other"]
    },
```

5.5.2.20 MarkedLocationType

```
    "MarkedLocationType": {
      "title": "Marked Location Type Enumerated Type",
      "description": "Options for what a MarkedLocation can mark, such as the
start or end of a road event.",
      "enum": [
        "afad",
        "delineator",
        "flagger",
        "lane-shift",
        "lane-closure",
        "personal-device",
        "ramp-closure",
```

```
        "road-closure",
        "work-truck-with-lights-flashing",
        "work-zone-start",
        "work-zone-end",
        "attenuator-vehicle",
        "construction-vehicle",
        "maintenance-vehicle",
        "emergency-vehicle",
        "stalled-or-disabled-vehicle",
        "pavement-marking-vehicle",
        "other"
      ]
    },
```

5.5.2.21 TrafficSignalMode

```
    "TrafficSignalMode": {
      "title": "Traffic Signal Mode Enumerated Type",
      "description": "Describes the current operating mode of a TrafficSignal.",
      "enum": [
        "blank",
        "flashing-red",
        "flashing-yellow",
        "fully-actuated",
        "manual",
        "pre-timed",
        "semi-actuated",
        "unknown"
      ]
    },
```

5.5.2.22 RoadsideUnitMessageTypes

```
    "RoadsideUnitMessageTypes": {
      "title": "Roadside Unit Message Types Enumerated Type",
      "description": "Describes the message types being broadcast by a
RoadsideUnit.",
      "enum": [
        "rsm",
        "tim",
        "spat",
        "map",
        "other"
      ]
    }
  }
}
```

5.6 Direction Schema


```
{
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/Direction.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "Direction Enumerated Type",
  "description": "The direction of a road based on standard naming for US roads;
indicates the direction the traffic flow not the real heading angle.",
  "enum": ["northbound", "eastbound", "southbound", "westbound", "inner-loop",
"outer-loop", "undefined", "unknown"]
}
```


5.7 BoundingBox Schema


```
{
  "$id": "https://raw.githubusercontent.com/ite-
org/cwz/main/schemas/1.0/BoundingBox.json",
  "$schema": "http://json-schema.org/draft-07/schema#",
  "title": "GeoJSON Bounding Box",
  "description": "Information on the coordinate range for a Geometry, Feature, or
FeatureCollection.",
  "type": "array",
  "minItems": 4,
  "items": {
    "type": "number"
  }
}
```

Annex A
Requirements Traceability Matrix

A.1 Notation [Informative]

A.1.1 Requirement Columns

The requirements are defined within Section 3 and the RTM is based upon the requirements within that section. The section number and the functional requirement name are indicated within these columns.

A.1.2 Design Details

The "Design Details" column either provides a hyperlinked reference to a section number where the design details are defined within Section 4 and Section 5, provides an external, normative reference that provides the details on how to fulfill the requirement, or indicates "No Further Design Details" because no additional design information is necessary (i.e., the requirement is self-explanatory).

A.1.3 Additional Specifications

The "Additional Specifications" column may be used to provide additional notes and requirements or may be used by an implementer to provide any additional details about the implementation.

A.1.4 Instructions for Completing the RTM [Informative]

To find the conformant design content for a requirement, search for the requirement identification (section) number or requirement under the appropriate column. Next to the functional requirements column are columns that define the conformant design details that fulfills the requirement. The columns either reference a section within this standard describing how the requirement is to be fulfilled; points a normative reference describing how to fulfill the requirement; or indicates "No Further Design Details" because no additional design information is necessary. The "Additional Specifications" column provides additional notes or details about the design content.

A.2 Requirements Traceability Matrix Table

Table 7. Requirements Traceability Matrix

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
3.2	**Architectural Requirements**					
3.2.1	**Compatibility with the WZDx Specification**	**4.2**	**Dialog**			
3.2.2	**GeoJSON Data Format**		Message	5.2	WorkZoneFeed Schema	See 4.2.1, 4.2.2
			Message	5.5	DeviceFeed Schema	See 4.2.1, 4.2.2
3.2.3	**GeoJSON Data Validation**		Message	5.2	WorkZoneFeed Schema	See 4.2.1, 4.2.2
			Message	5.5	DeviceFeed Schema	See 4.2.1, 4.2.2
3.2.4	**Business Rules**	**NA**				
3.3	**Data Exchange Requirements**					
3.3.1	**Exchange WorkZoneFeed Information**					
3.3.1.1	Send WorkZoneFeed Information Upon Request	4.2	Dialog	5.2	WorkZoneFeed Schema	See 4.2.3, 4.2.4
3.3.2	**Exchange DeviceFeed Information**					
3.3.2.1	Send DeviceFeed Information Upon Request	4.2	Dialog	5.5	DeviceFeed Schema	See 4.2.3, 4.2.4
3.4	**WorkZoneFeed Requirements**		**Message**	**5.2**	**WorkZoneFeed Schema**	
3.4.1	**Contents of WorkZoneFeed**		**Data Frame**	**5.2.1**	**Properties**	
a)	feed_info		Data Frame	5.2.1.1	feed_info	
b)	type		Data Element	5.2.1.2	type	
c)	features		Data Frame	5.2.1.3	features	
d)	bbox		Data Frame	5.2.1.4	bbox	
3.5	**FeedInfo Requirements**			**5.3**	**FeedInfo Schema**	
3.5.1	**Contents of FeedInfo**		**Data Frame**	**5.3.1**	**Properties**	
a)	publisher		Data Element	5.3.1.1	publisher	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
b)	contact_name		Data Element	5.3.1.2	contact_name	
c)	contact_email		Data Element	5.3.1.3	contact_email	
d)	update_frequency		Data Element	5.3.1.4	update_frequency	
e)	update_date		Data Element	5.3.1.5	update_date	
f)	version		Data Element	5.3.1.6	version	
g)	license		Data Element	5.3.1.7	license	
h)	data_sources		Data Frame	5.3.1.8	data_sources	
3.5.2	**Contents of FeedDataSource**		**Data Frame**	**5.3.2.1**	**FeedDataSource**	
a)	data_source_id		Data Element	5.3.2.1.1	data_source_id	
b)	organization_name		Data Element	5.3.2.1.2	organization_name	
c)	contact_name		Data Element	5.3.2.1.3	contact_name	
d)	contact_email		Data Element	5.3.2.1.4	contact_email	
e)	update_frequency		Data Element	5.3.2.1.5	update_frequency	
f)	update_date		Data Element	5.3.2.1.6	update_date	
3.6	**RoadEventFeature Requirements**			**5.4**	**RoadEventFeature Schema**	
3.6.1	**Contents of RoadEventFeature**		**Data Frame**	**5.4.1**	**Properties**	
a)	id		Data Element	5.4.1.1	id	
b)	type		Data Element	5.4.1.2	type	
c)	properties		Data Frame	5.4.1.3	properties	
d)	geometry		Data Frame	5.4.1.4	geometry	
e)	bbox		Data Frame	5.4.1.5	bbox	
3.6.2	**Contents of WorkZoneRoadEvent**		**Data Frame**	**5.4.2.1**	**WorkZoneRoadEvent**	
a)	core_details		Data Frame	5.4.2.1.1	core_details	
b)	beginning_cross_street		Data Element	5.4.2.1.2	beginning_cross_street	
c)	ending_cross_street		Data Element	5.4.2.1.3	ending_cross_street	
d)	beginning_reference_post		Data Element	5.4.2.1.4	beginning_reference_post	
e)	ending_reference_post		Data Element	5.4.2.1.5	ending_reference_post	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
f)	reference_post_unit		Data Element	5.4.2.1.6	reference_post_unit	
g)	is_start_position_verified		Data Element	5.4.2.1.7	is_start_position_verified	
h)	is_end_position_verified		Data Element	5.4.2.1.8	is_end_position_verified	
i)	start_date		Data Element	5.4.2.1.9	start_date	
j)	end_date		Data Element	5.4.2.1.10	end_date	
k)	is_start_date_verified		Data Element	5.4.2.1.11	is_start_date_verified	
l)	is_end_date_verified		Data Element	5.4.2.1.12	is_end_date_verified	
m)	work_zone_type		Data Element	5.4.2.1.13	work_zone_type	
n)	vehicle_impact		Data Element	5.4.2.1.14	vehicle_impact	
o)	location_method		Data Element	5.4.2.1.15	location_method	
p)	worker_presence		Data Element	5.4.2.1.16	worker_presence	
q)	reduced_speed_limit_kph		Data Element	5.4.2.1.17	reduced_speed_limit_kph	
r)	restrictions		Data Frame	5.4.2.1.18	restrictions	
s)	types_of_work		Data Frame	5.4.2.1.19	types_of_work	
t)	lanes		Data Frame	5.4.2.1.20	lanes	
u)	impacted_cds_curb_zones		Data Frame	5.4.2.1.21	impacted_cds_curb_zones	
3.6.3	**Contents of DetourRoadEvent**		**Data Frame**	**5.4.2.2**	**DetourRoadEvent**	
a)	core_details		Data Frame	5.4.2.2.1	core_details	
b)	beginning_cross_street		Data Element	5.4.2.2.2	beginning_cross_street	
c)	ending_cross_street		Data Element	5.4.2.2.3	ending_cross_street	
d)	beginning_reference_post		Data Element	5.4.2.2.4	beginning_reference_post	
e)	ending_reference_post		Data Element	5.4.2.2.5	ending_reference_post	
f)	reference_post_unit		Data Element	5.4.2.2.6	reference_post_unit	
g)	start_date		Data Element	5.4.2.2.7	start_date	
h)	end_date		Data Element	5.4.2.2.8	end_date	
i)	is_start_date_verified		Data Element	5.4.2.2.9	is_start_date_verified	
j)	is_end_date_verified		Data Element	5.4.2.2.10	is_end_date_verified	
3.6.4	**Contents of RoadEventCoreDetails**		**Data Frame**	**5.4.2.3**	**RoadEventCoreDetails**	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
a)	data_source_id		Data Element	5.4.2.3.1	data_source_id	
b)	event_type		Data Element	5.4.2.3.2	event_type	
c)	related_road_events		Data Frame	5.4.2.3.3	related_road_events	
d)	project_id		Data Frame	5.4.2.3.4	project_id	
e)	road_names		Data Frame	5.4.2.3.5	road_names	
f)	direction		Data Element	5.4.2.3.6	direction	
g)	name		Data Element	5.4.2.3.7	name	
h)	description		Data Element	5.4.2.3.8	description	
i)	creation_date		Data Element	5.4.2.3.9	creation_date	
j)	update_date		Data Element	5.4.2.3.10	update_date	
3.6.5	**Enumeration of LocationMethod**		**Data Element**	**5.4.2.4**	**LocationMethod**	
3.6.6	**Contents of RelatedRoadEvent**		**Data Frame**	**5.4.2.5**	**RelatedRoadEvent**	
a)	type		Data Element	5.4.2.5.1	type	
b)	id		Data Element	5.4.2.5.2	id	
3.6.7	**Contents of TypeOfWork**		**Data Frame**	**5.4.2.6**	**TypeOfWork**	
a)	type_name		Data Element	5.4.2.6.1	type_name	
b)	is_architectural_change		Data Element	5.4.2.6.2	is_architectural_change	
3.6.8	**Contents of Lane**		**Data Frame**	**5.4.2.7**	**Lane**	
a)	order		Data Element	5.4.2.7.1	order	
b)	status		Data Element	5.4.2.7.2	status	
c)	type		Data Element	5.4.2.7.3	type	
d)	restrictions		Data Frame	5.4.2.7.4	restrictions	
3.6.9	**Contents of Restriction**		**Data Frame**	**5.4.2.8**	**Restriction**	
a)	type		Data Element	5.4.2.8.1	type	
b)	value		Data Element	5.4.2.8.2	value	
c)	unit		Data Element	5.4.2.8.3	unit	
3.6.10	**Contents of CdsCurbZonesReference**		**Data Frame**	**5.4.2.9**	**CdsCurbZonesReference**	
a)	cds_curb_zone_ids		Data Frame	5.4.2.9.1	cds_curb_zone_ids	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
b)	cds_curbs_api_url		Data Element	5.4.2.9.2	cds_curbs_api_url	
3.6.11	**Contents of WorkerPresence**		**Data Frame**	**5.4.2.10**	**WorkerPresence**	
a)	are_workers_present		Data Element	5.4.2.10.1	are_workers_present	
b)	method		Data Element	5.4.2.10.2	method	
c)	worker_presence_last_confirmed_date		Data Element	5.4.2.10.3	worker_presence_last_confirmed_date	
d)	confidence		Data Element	5.4.2.10.4	confidence	
e)	definition		Data Frame	5.4.2.10.5	definition	
f)	other_method		Data Element	5.4.2.10.6	other_method	
3.6.12	**Enumeration of EventType**		**Data Element**	**5.4.2.11**	**EventType**	
3.6.13	**Enumeration of WorkZoneType**		**Data Element**	**5.4.2.12**	**WorkZoneType**	
3.6.14	**Enumeration of VehicleImpact**		**Data Element**	**5.4.2.13**	**VehicleImpact**	
3.6.15	**Enumeration of RestrictionType**		**Data Element**	**5.4.2.14**	**RestrictionType**	
3.6.16	**Enumeration of WorkTypeName**		**Data Element**	**5.4.2.15**	**WorkTypeName**	
3.6.17	**Enumeration of LaneStatus**		**Data Element**	**5.4.2.16**	**LaneStatus**	
3.6.18	**Enumeration of LaneType**		**Data Element**	**5.4.2.17**	**LaneType**	
3.6.19	**Enumeration of UnitOfMeasurement**		**Data Element**	**5.4.2.18**	**UnitOfMeasurement**	
3.6.20	**Enumeration of WorkerPresenceMethod**		**Data Element**	**5.4.2.19**	**WorkerPresenceMethod**	
3.6.21	**Enumeration of WorkerPresenceDefinition**		**Data Element**	**5.4.2.20**	**WorkerPresenceDefinition**	
3.6.22	**Enumeration of WorkerPresenceConfidence**		**Data Element**	**5.4.2.21**	**WorkerPresenceConfidence**	
3.6.23	**Enumeration of RelatedRoadEventType**		**Data Element**	**5.4.2.22**	**RelatedRoadEventType**	
3.7	**DeviceFeed Requirements**		**Message**	**5.5**	**DeviceFeed Schema**	
3.7.1	**Contents of DeviceFeed**		**Data Frame**	**5.5.1**	**Properties**	
a)	feed_info		Data Frame	5.5.1.1	feed_info	
b)	type		Data Element	5.5.1.2	type	
c)	features		Data Frame	5.5.1.3	features	
d)	bbox		Data Frame	5.5.1.4	bbox	
3.7.2	**Contents of FieldDeviceFeature**		**Data Frame**	**5.5.2.1**	**FieldDeviceFeature**	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
a)	id		Data Element	5.5.2.1.1	id	
b)	type		Data Element	5.5.2.1.2	type	
c)	properties		Data Frame	5.5.2.1.3	properties	
d)	geometry		Data Frame	5.5.2.1.4	geometry	
e)	bbox		Data Frame	5.5.2.1.5	bbox	
3.7.3	**Contents of FieldDeviceCoreDetails**		**Data Frame**	**5.5.2.2**	**FieldDeviceCoreDetails**	
a)	device_type		Data Element	5.5.2.2.1	device_type	
b)	data_source_id		Data Element	5.5.2.2.2	data_source_id	
c)	device_status		Data Element	5.5.2.2.3	device_status	
d)	update_date		Data Element	5.5.2.2.4	update_date	
e)	has_automatic_location		Data Element	5.5.2.2.5	has_automatic_location	
f)	road_direction		Data Element	5.5.2.2.6	road_direction	
g)	road_names		Data Frame	5.5.2.2.7	road_names	
h)	name		Data Element	5.5.2.2.8	name	
i)	description		Data Element	5.5.2.2.9	description	
j)	status_messages		Data Frame	5.5.2.2.10	status_messages	
k)	is_moving		Data Element	5.5.2.2.11	is_moving	
l)	road_event_ids		Data Frame	5.5.2.2.12	road_event_ids	
m)	project_id		Data Element	5.5.2.2.13	project_id	
n)	reference_post		Data Element	5.5.2.2.14	reference_post	
o)	reference_post_unit		Data Element	5.5.2.2.15	reference_post_unit	
p)	make		Data Element	5.5.2.2.16	make	
q)	model		Data Element	5.5.2.2.17	model	
r)	serial_number		Data Element	5.5.2.2.18	serial_number	
s)	firmware_version		Data Element	5.5.2.2.19	firmware_version	
t)	velocity_kph		Data Element	5.5.2.2.20	velocity_kph	
u)	is_in_transport_posision		Data Element	5.5.2.2.21	is_in_transport_position	
3.7.4	**Contents of ArrowBoard**		**Data Frame**	**5.5.2.3**	**ArrowBoard**	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
a)	core_details		Data Frame	5.5.2.3.1	core_details	
b)	pattern		Data Element	5.5.2.3.2	Pattern	
3.7.5	**Contents of Camera**		**Data Frame**	**5.5.2.4**	**Camera**	
a)	core_details		Data Frame	5.5.2.4.1	core_details	
b)	image_url		Data Element	5.5.2.4.2	image_url	
c)	Is_image_url_public		Data Element	5.5.2.4.3	is_image_url_public	
d)	image_timestamp		Data Element	5.5.2.4.4	image_timestamp	
e)	video_url		Data Element	5.5.2.4.5	video_url	
f)	Is_video_url_public		Data Element	5.5.2.4.6	is_video_url_public	
g)	video_update_frequency		Data Element	5.5.2.4.7	video_update_frequency	
3.7.6	**Contents of DynamicMessageSign**		**Data Frame**	**5.5.2.5**	**DynamicMessageSign**	
a)	core_details		Data Frame	5.5.2.5.1	core_details	
b)	message_multi_string		Data Element	5.5.2.5.2	message_multi_string	
3.7.7	**Contents of FlashingBeacon**		**Data Frame**	**5.5.2.6**	**FlashingBeacon**	
a)	core_details		Data Frame	5.5.2.6.1	core_details	
b)	function		Data Element	5.5.2.6.2	Function	
c)	is_flashing		Data Element	5.5.2.6.3	is_flashing	
d)	sign_text		Data Element	5.5.2.6.4	sign_text	
3.7.8	**Contents of HybridSign**		**Data Frame**	**5.5.2.7**	**HybridSign**	
a)	core_details		Data Frame	5.5.2.7.1	core_details	
b)	dynamic_message_function		Data Element	5.5.2.7.2	dynamic_message_function	
c)	dynamic_message_text		Data Element	5.5.2.7.3	dynamic_message_text	
d)	static_sign_text		Data Element	5.5.2.7.4	static_sign_text	
3.7.9	**Contents of LocationMarker**		**Data Frame**	**5.5.2.8**	**LocationMarker**	
a)	core_details		Data Frame	5.5.2.8.1	core_details	
b)	marked_locations		Data Frame	5.5.2.8.2	marked_locations	
3.7.10	**Contents of MarkedLocation**		**Data Frame**	**5.5.2.9**	**MarkedLocation**	
a)	type		Data Element	5.5.2.9.1	Type	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
b)	road_event_id		Data Element	5.5.2.9.2	road_event_id	
3.7.11	**Contents of TrafficSensor**		**Data Frame**	**5.5.2.10**	**TrafficSensor**	
a)	core_details		Data Frame	5.5.2.10.1	core_details	
b)	collection_interval_start_date		Data Element	5.5.2.10.2	collection_interval_start_date	
c)	collection_interval_end_date		Data Element	5.5.2.10.3	collection_interval_end_date	
d)	average_speed_kph		Data Element	5.5.2.10.4	average_speed_kph	
e)	volume_vph		Data Element	5.5.2.10.5	volume_vph	
f)	occupancy_percent		Data Element	5.5.2.10.6	occupancy_percent	
g)	lane_data		Data Frame	5.5.2.10.8	lane_data	
3.7.12	**Contents of TrafficSensorLaneData**		**Data Frame**	**5.5.2.11**	**TrafficSensorLaneData**	
a)	lane_order		Data Element	5.5.2.11.1	lane_order	
b)	road_event_id		Data Element	5.5.2.11.2	road_event_id	
c)	average_speed_kph		Data Element	5.5.2.11.3	average_speed_kph	
d)	volume_vph		Data Element	5.5.2.11.4	volume_vph	
e)	occupancy_percent		Data Element	5.5.2.11.5	occupancy_percent	
3.7.13	**Contents of TrafficSignal**		**Data Frame**	**5.5.2.12**	**TrafficSignal**	
a)	core_details		Data Frame	5.5.2.12.1	core_details	
b)	mode		Data Element	5.5.2.12.2	mode	
3.7.14	**Contents of RoadsideUnit**		**Data Frame**	**5.5.2.13**	**RoadsideUnit**	
a)	core_details		Data Frame	5.5.2.13.1	core_details	
b)	message_types		Data Frame	5.5.2.13.2	message_types	
3.7.15	**Enumeration of UnitOfMeasurement**		**Data Element**	**5.5.2.14**	**UnitOfMeasurement**	
3.7.16	**Enumeration of ArrowBoardPattern**		**Data Element**	**5.5.2.15**	**ArrowBoardPattern**	
3.7.17	**Enumeration of FieldDeviceType**		**Data Element**	**5.5.2.16**	**FieldDeviceType**	
3.7.18	**Enumeration of FieldDeviceStatus**		**Data Element**	**5.5.2.17**	**FieldDeviceStatus**	
3.7.19	**Enumeration of FlashingBeaconFunction**		**Data Element**	**5.5.2.18**	**FlashingBeacon**	
3.7.20	**Enumeration of HybridSignDynamicMessageFunction**		**Data Element**	**5.5.2.19**	**HybridSignDynamicMessageFunction**	
3.7.21	**Enumeration of MarkedLocationType**		**Data Element**	**5.5.2.20**	**MarkedLocationType**	

REQUIREMENTS TRACEABILITY MATRIX						
Req ID	**Requirement**	**Dialog ID**	**Data Concept Type**	**Data Concept ID**	**Data Concept Name**	**Additional Specifications**
3.7.22	**Enumeration of TrafficSignalMode**		**Data Element**	**5.5.2.21**	**TrafficSignalMode**	
3.7.23	**Enumeration of RoadsideUnitMessageTypes**		**Data Element**	**5.5.2.22**	**RoadsideUnitMessageTypes**	
3.8	**Direction Requirements**			**5.6**	**Direction Schema**	
3.8.1	**Enumeration of Direction**		**Data Element**	**5.6**	**Direction Schema**	
3.9	**BoundingBox Requirements**			**5.7**	**BoundingBox Schema**	
3.9.1	**Contents of BoundingBox**		**Data Frame**	**5.7**	**BoundingBox Schema**	

Annex B

Connected Work Zones Guidance Needs [Informative]

This section covers potential Guidance Needs of CWZ Deployers and is organized into sub-sections as follows:

- Challenges to Developing a CWZ Program
- Technical/Deployment Challenges
- Data Quality Challenges
- Training and Retraining
- Data Aggregation and The Future of Feed Registries
- Now You're Ready! Setting up a Work Zone Feed.

The intended audience for this section on Guidance is the collective group of stakeholders, including: IOOs, integrators, developers, contractors, equipment vendors, and third party organizations typically involved in a connected work zone deployment.

Developing a comprehensive guide about how to deploy connected work zones from concept to deployment is beyond the scope of this effort. What we can do is develop topic areas to guide the reader of things to consider that will help them conceptualize, build stakeholder involvement, provide training for new skills and knowledge, engineer, design, deploy, and test interoperable connected work zones.

B.1 Guidance Needs - Challenges to Developing a CWZ Program

B.1.1 Guidance Needs - Getting Started with CWZs

Before jumping in and getting started with implementing CWZs, deployers need a plan and a program. This section outlines some of the considerations when putting together a program to address deploying CWZs.

To gain experience and to help pull together the various stakeholders and separate aspects of CWZ, deployers may want to consider, as part of their program, deploying one or more pilot projects. Significant effort and commitment is required to acquire the experience necessary to manage a continuing program of projects to provide accurate and reliable connected work zones.

Deployers should also consider putting together an educational and training element as part of their CWZ program to fill the need for new information, new knowledge, new practices, and new skillsets needed to build CWZs, from start to finish. In doing so, you will have helped the industry to satisfy the need for more and better ways to share knowledge and experience about deploying connected work zones.

The transportation industry is currently working on new approaches (many untried or with only preliminary results) to identify the technologies that work best from a transportation operations viewpoint. The paragraphs below identify challenges you may encounter during your journey to deploy CWZs.

Technology is not the bottleneck, but rather new practices need to be adopted by CWZ deployers stating the tasks and rules that each stakeholder organization must put into place. Developing and institutionalizing these new practices, together with a training program, is the true bottleneck.

That said, because some of the technologies may be new to those involved in CWZ deployments, staff at stakeholder organizations need an understandable architecture, described in layperson terms, that will help them to define a CWZ technology program and good project definitions, where a good project definition provides insight into the rationale for doing the project, for example, improve safety in work zones, provide a basis for training, gain experience, etc.

Set expectations: Often, deploying a first CWZ pilot project may not provide additional information beyond what is provided from a 511 traveler information system, or an ATMS reporting information on construction. However, this example drives home that it may be necessary to build a business case for CWZs that goes beyond today's typical 511 or ATMS system.

After approving contracts and selecting contractors, IOOS don't usually know where their work zones are or when they are active. The biggest challenge today in connected work zones is knowing when the CWZ is active, and where it is located. Building a coalition of IOOs, or perhaps regional IOOs, device and equipment manufacturers, and contractors is key to enable quality and timely work zone information dissemination that will result in lives saved—both work zone workers and drivers passing through work zones.

The broader benefits of CWZs, related to driver and worker safety, can be stated through the following objectives:

- CWZs will identify in near real-time when a CWZ is active;
- CWZs will idenfity locations of work zones: where the work zone starts and ends, approach(es) start and end, truck early-merge locations, taper locations, speed limit reduction zones, worker presence, etc., all able to be reported in near real-time.

The data and work flow needs for your program will be shaped depending on what you intend to do.

Leverage the consensus flow that works for your organization and for your pilot projects. For example, smart devices are commonly used in large projects, but not so much for smaller scale projects. The general goals of coalition building, experience, and experimentation remain the same, though the results may be more or less visible to the casual observer.

Ultimately, your program and experience from pilot projects will enable you to “connect the dots” so you implement a data and work flow that gathers and disseminates work zone data that is beneficial for your specific needs, and the needs of your end-users.

B.1.2 Guidance Needs - Cross-cutting Organizational Challenges

CWZ stakeholders, whether in separate organizations or within the same organization, have different priorities and missions, which may present a challenge when trying to reach agreement on direction and detail.

Stakeholder participation is key to success, and it is important to realize this while gaining early buy-in and commitment from partners. One of the key benefits of pilot projects is building relationships that enable CWZs. Cultivating partnerships is just as important, if not more so, than developing the technical requirements for a CWZ.

In addition, CWZ deployers need a champion that can articulate and balance the goals of numerous stakeholder organizations, including: IOOs, integrators, contractors, equipment vendors, and third parties.

Additional considerations when building organizational relationships include:

- Developing CWZs may involve cross-cutting needs for your organization, and involve multiple departments that may not usually share information about construction projects or work zones.
- Roles and Responsibilities: Deployers will need to define who has what roles, and identify the potential benefits of each role to motivate continued participation.

B.1.3 Guidance Needs - Explaining the Benefits of CWZs

CWZ deployers need guidance on how to explain the benefits of connected work zones (and deployment options) to potential project stakeholders.

Generally, explaining the technology is straight-forward to understand, however, the complexities of deployment required to enable connected work zones that provide accurate, timely, and reliable information is not well understood and the degree of experience varies with each stakeholder.

While the broad benefits related to safety and efficiency improvements are easy to understand, some organizations may need to seek expertise in understanding which technologies and strategies will work best for their particular organization, and which technologies and strategies correlate with the safety improvements they value most.

B.2 Guidance Needs - Technical/Deployment Challenges

B.2.1 Guidance Needs - Lack of Real Time Information about Work Zone Location and Status

While CWZ deployers may have information available about work zones and the road activity that supports them, they often do not have information on the specifics of dates, times, and location of work zones, nor real-time status of activity. What is required, however, to enable safety and trip-planning improvements, is for CWZ deployers to identify with a high degree of certainty what is happening now, and where it is happening, with regards to work zones.

Short-term projects present a new set of challenges as these are not scheduled in advance. In addition, these jobs involve setting up a work zone for only a short period of time and may be rolling/moving. For example, a municipality may set up a work zone and shut down of a lane for 6 hours for a roadway repair, or in the case of a utility, shutting down a local street for 2 to 4 hours to safely enable a repair.

Electronic work zone equipment with communications to enable awareness of status, location, and description may help to solve the problem of asserting real-time information about work zone activity. While electronic work zone equipment that are communications enabled (referred to as “IOT devices”) are suitable as a solution, they are not predominantly used today. CWZ deployers may consider the approach of having a work zone worker use a phone app or laptop to enter the data to fill the information gap between an IOT-device and a non-communications enabled device. The rationale for the approach of involving workers to do data entry is that the value of using traditional equipment (enhanced with data entry performed by a work zone worker) is very high or equal to that of data sourced from automated digital IOT-type devices (such as a smart sign).

In addition, determining the frequency of updates, involves balancing the cost of communications against the benefits of more frequently available updates. This is especially true for rolling/moving work zones.

B.2.2 Guidance Needs – Limited Coverage and Participation of Potential CWZ Operators

One question that might arise in the mind of a reader is, “how will we incorporate all levels of transportation agencies and work zone deployers – counties, cities, states?” For example, just looking at counties in the US, one can estimate 3000+ organizations. Or in the case of utility companies and other private organizations that have work zones, we can quickly estimate that the number of CWZ deployers could number into the many thousands.

Looking specifically at state and large metropolitan area DOTs, we can arrive at anecdotal evidence that in general, the smaller the project, and the lower the volume of traffic on the roadway, the more likely that the work zone is ad-hoc and uses traditional equipment with no communications ability, where a simple permit provides an approximate area and period of duration.

B.2.3 Guidance Needs - High-Level Deployment Considerations

B.2.3.1 Project Definition

When considering projects, CWZ deployers have a range of options to consider ranging from large projects, small projects, and ad-hoc projects (e.g., unplanned, utility work). Developing a project definition depends on a number of factors, such as internal relationships between departments in your organization, what department will be the project lead, whether connected work zone equipment needs to be specified

in an RFP, and deciding what contractors will need to do to set up, move, and maintain a connected work zone.

It may be possible to start with small projects that are completely internal to an organization, or even ad-hoc projects, where some aspect of connected work zones and equipment are deployed, tested, and evaluated. This potential research phase will not put the deployer in the limelight; it will allow a deployer to gain knowledge through touch and feel.

Another consideration when deciding on projects to pursue is that CWZs require set-up / take-down time, and therefore may be more appropriate for a larger project. That said, ad-hoc and shorter-term work zone projects make up an overwhelming percentage of work zones deployed.

Most important is developing a sense for what the deployer hopes to accomplish (goals) together with objectives and milestones to show progress toward the goals.

B.2.3.2 Engineering Specifications

While the focus of this document is on system architecture and interface designs to support interoperability, it is important to state awareness of processes and reference documentation (e.g., MUTCD, HCM, NCHRP 350) that are required for conformance and the development of engineering specifications. For example, such as when defining approaches, taper segments, and details related to placement of equipment.

It is necessary to involve roadway/roadwork engineering professionals when specifying connected work zones. These professionals can help identify what activities need to take place and what locations associated with the work zone need to be marked.

B.2.3.3 System Architecture and Interface Design

One best practice for implementation of an interface based on this standard is to develop a system architecture, a high-level design showing the components that make up a system, and their interfaces.

Deploying CWZs presents challenges when implementing key parts of the system architecture, and deployers should be prepared to reach out to their organization's IT department.

Key design issues related to deploying a system architecture to satisfy the needs of CWZs are discussed below.

- Frequency of Updates. A key consideration in designing and deploying a system interface is how often the data should be generated and whether your deployment will support change-driven (update-driven) communications. The type of information will drive how often a device needs to communicate information. For example, the device marking location of the start of a work zone may not need to communicate frequently.
- Security-Trust. Deployers need to know who is authorized to request work zone information. One potential solution is to use an API key as part of the request. A deployer provides an API key to anyone who is authorized to make a data request. Another issue is how to determine whether the providers of work zone information are trusted sources. One potential solution is the use of electronically signed certificates from the provider. If a CWZ deployer is looking to deploy equipment for Connected Vehicles, then the devices and computing systems used in the CWZ may need to become part of the SCMS that enables communications with consumers in a secure way.
- Network Connection Management. Deployers need to know that the equipment used in a connected work zone are connected to the work zone center. Connection management includes verification that components are able to communicate with each other, and in the case of a connection fault, providing alarms and notifications so components can act in a predicted way to deal with the loss of one or more system components.

- Interface Design Specification. A frequently used term to describe a system interface is Interface Control Document (ICD). An ICD is deployer-specific. One resource for developing ICDs is IEEE Std 1016-1998.
- Testing. Deployers need to verify that the component interfaces of a CWZ conform with standards and comply with deployer's specifications. Testing can be done in a laboratory environment, in a small field setting, or as part of regular maintenance of a system. For more information on Testing, see IEEE Std 829-2008.
- Data Archiving. Many agencies have expressed interest in being able to do analysis of historical information. Deployers may want to consider archiving connected work zone data to conduct metric-based historical analysis. In this case, it will be necessary to address storage requirements.
- Data Inputs and Sources. Deployers need to identify which data sets need to be ingested into a work zone information feed.

B.2.3.4 Configuring CWZ Components – Devices, VRUs, Work Vehicles, Lanes, etc.

Deployers need guidance on how to properly configure work zone equipment. Configuration of work zone equipment (devices, work zone vehicles, and on VRUs) is a challenge. Several aspects of equipment configuration are identified below.

Deployers may need a mechanism for assigning identifiers to equipment. Equipment in CWZs need to know what work zone they are associated with, what type of equipment they are, and their geographic position, to name a few items. Some equipment may be able to automatically self-configure, but some may require someone to enter this configuration information.

Deployers may need some way to define work zone information, such as how to define lane closures, taper start and end points, number of lanes to taper, and direction of taper. In addition, similar handling may be required for speed reduction zones, work zone approaches, etc.

B.2.3.5 Connected Vehicle (CV) Environment Deployments

The factors described below apply to any alternative for deploying CWZs. For each factor, a brief discussion as it pertains to CV environments is described.

- Power Consumption. CV devices currently consume more power than a typical communications-enabled work zone device such as an arrow board. Engineering the power requirements for a set of CV devices should be a factor when considering alternatives.
- Time to Configure. Deploying RSUs and other CV requires preparation. Deployers will need to factor in time for setting up CV equipment for ad-hoc and short-term jobs.
- Lane Geometry / MAP message. Need to develop a MAP message when deploying CV equipment in a work zone. It is also necessary to keep in mind that there is no current standard for dealing with roadway sections, i.e., zones. The MAP message has been deployed for intersection-oriented applications.
- Cost. CWZ deployers considering CV technologies may want to include cost as a factor when considering alternatives.
- Positioning / RTCM Message. Deployers will need to identify there positioning accuracy needs and determine how best to deploy RTCM. Currently, there are alternative methods for deploying RTCM networks/devices and consistency is a factor across the nation.

B.2.4 Guidance Needs - Applying ITS Standards

Work zones show up in multiple ITS standards. While standards are good, applying multiple ITS standards and keeping up with their progress to address growing needs can be tricky. We explore two issues below and discuss:

1) approaches to keeping up with the development and progress of ITS standards, and
2) approaches to using multiple ITS standards in CWZ deployments.

B.2.4.1 Guidance Needs - Keeping up with the Development and Progress of ITS Standards

Connected work zones crosscut into many areas where standardization efforts have been applied, including: traffic management, work zone equipment, and connected vehicle environments. As CWZs have evolved, so have standards: new standards emerge, and existing standards are being updated.

Specific challenges for CWZ deployers includes identifying which standards to support; for developers, keeping up with standards updates is a challenge as they will need to support all versions.

B.2.4.2 Guidance Needs – Using Multiple Standards in a CWZ Deployment

As stated previously, the topic of work zones is included in multiple standards. One of the objectives of this document is look at relevant standards and provide technical guidance where applicable on applying multiple ITS standards, including the following:

- Work Zone Data Exchange (WZDx) Specification. The objective is that this standard and guidance will, based on consensus working group input, provide a design that is backward compatible with the WZDx specification.
- ngTMDD. The ngTMDD standard provides a data dictionary that was developed concurrently with this CWZ standard. Sharing of work zone information between work zones and centers is facilitated with a common data dictionary.
- SAE J2945/4. Compatibility with the Roadside Safety Message (RSM) in terms of enumerated lists and guidance on mapping from this standard to the J2945/4 RSM where needed. We anticipate that the J2945/4 standard will replace and resolve ambiguities in deployments that are using the SAE J2735 Roadside Safety Message and/or Traveler Information Message.

Deployers that will be working with CWZs long-term may consider becoming part of the standards development process to track and influence the standards related to CWZs.

B.3 Guidance Needs - Data Quality Challenges

B.3.1 Guidance Needs - Inconsistent Data and Quality from Data Providers

Currently, data provided as work zone information depends a on the producer of the information and what data is available.

Not all roads are the same when it comes to available work zone information. But generally:

- Planned work zone information is available for larger roadways, and larger construction projects.
- Smaller roadways, smaller projects, and utility companies do not track and therefore do not have much, if any, electronic data for their work zones.

B.3.2 Guidance Needs - Map Accuracy

In addition, there are limitations on the accuracy of map data from publicly available sources and low-cost GNSS. Overall, CWZ deployers do not have the resources to make and measure high-definition map data. Currently, this is not a major concern, as OEMs are developing their own high-definition maps, tailored to each OEM's applications. Development of this standard has taken needs into account to reflect the detail CWZ deployers need to send to an OEMs backoffice. For the most part, CWZ deployers will not need to provide lane-specific work zone geometry, other than for their own purposes and for general data sharing of geographic data sets with the public and internally.

B.3.3 Guidance Needs - Verification & Validation

CWZ deployers need to develop a process / work flow to validate that their work zone information feed is current and correct. This includes the following:

- CWZ deployers need to validate that work zone technologies are in place and functional.
- CWZ deployers need to assess and verify the reliability and availability (uptime) of devices in the work zone. For example, testing a device may entail running tests over a period of time. This may require a CWZ deployer may need to have the device remain dark (to travelers), but accessible to be monitored for the purposes of test from a remote location.

- CWZ deployers need to assess and verify the reliability and availability (uptime) for their work zone information feeds used by external centers, third parties, and the public.

B.4 Guidance Needs - Training and Re-training

B.4.1 Guidance Needs - Emerging Technologies & Methods of Data Acquisition

CWZ deployers will need to factor in the additional time necessary to bring on-board all parties that will be involved in a deployment.

- C/AV User Needs. Deployers need guidance to develop pilots for C/AV implementations that satisfy the needs of end-users.
- Best Practices. Deployers need to know about best practices for deployment of the new technologies and methods for real-time WZ data acquisition.
- Data Quality. Deployers need to understand how to verify the accuracy and currency of work zone information (e.g. to verify the geometry of the work zone) and that status information is accurate and up-to-date.
- Training Resources. Provide links to research and documentation.
- Lab and Training Environment. Deployers may want to establish a lab and/or training facility to allow hands-on training on equipment and for conducting lab testing of CWZs in controlled environments.

B.4.2 Guidance Needs - Developing New Skills

Deployers should consider developing a training program as part of their overall CWZ deployment program, to provide the knowledge and skills necessary to enable staff to develop work zones.

A representative example of types of new skills organized by staff/labor category is shown below.

- Project Managers. Need to understand the benefits of CWZ deployments. For example, CWZs provide traveler information which leads to mobility and safety benefits.
- Contractors and Field Staff. More training is required for work zone workers. For example, how to setup, configure, and take down equipment. Training on Connected Arrow Boards or Dynamic Message Signs are ways to get started with a training program.
- Roadway Engineers. Need to understand what are best practices for engineering design of CWZs that use a hybrid of traditional equipment and newer technologies.
- System Architects. Generally, a high-level architecture of a connected work zone can be understood by experienced ITS professionals. CWZ deployers may need to assist staff who do not understand the architectural details of how connected work zones are put together..
- System Integrators. There is a lack of knowledge by deployers/agencies about how to fill in the work zone data if they do not have it.

B.5 Guidance Needs - Data Aggregation and The Future of Feed Registries

A common need of regions such as a metropolitan area or a rural state is to aggregate—collect, harmonize, and redistribute—data into a regional view of transportation information. In our case, the focus would be regional work zone information.

Currently, as part of the WZDx initiative, there is a data registry that enables discovery of WZDx data sources.

The fate of the WZDx feed registry is uncertain, and therefore, regions may decide to develop their own discovery mechanism or create a data hub to maintain the work zone information in a historical context.

Listed below are some things to consider if this path suits the needs of regional stakeholders.

- Benefits. One benefit regions may consider is that a feed registry can be used to promote safety for work zone workers and the driving public.
- Unique IDs. For the purposes of aggregating data, regions will likely need some mechanism for assigning unique identifiers for work zones in the region.

- Who maintains and pays for upkeep. The public sector will need to find a funding source, while the private sector would need to make a business case and identify how to monetize the data feed. We don't look at this as a conflict of interest as much as a difference in approach to satisfy the need for high quality work zone information for a region.

B.6 Guidance Needs - Assess Your Readiness to Deploy CWZs

Hopefully, this section of the standard and guide has provided readers with high-level information about how to assess a deployers readiness to deploy connected work zones using this standard.

CWZ deployers need software that can help track the complexity of data and interrelationships that define a work zone: locations, lane details and configurations, schedules, devices, vehicles, VRUs, traffic flow, etc. Each CWZ deployer will need to assess what they do have in terms of systems and available data. For example, a potential deployer may have legacy implementations that they can use as a starting point, such as an ATMS or 511 system.

B.7 Guidance Needs - Leverage What Others Have Started

Leverage what others have done before. One method is to download some WZDx data, which can be input directly into a GIS. Then, revisit this Guide and Standard to review topics that may help you plan your CWZ Program.

Annex C
Guidance for Deployments Involving Connected Vehicle Environment Work Zone-related Standards [Informative]

This annex provides guidance for CWZ deployers who may need to use this standard in addition to other standards related with the Connected Vehicle Environment.

C.1 Physical Architecture - CVE Compatibility Roadside Safety Message

The figure below provides a context for the use of CWZ WorkZoneFeed and DeviceFeed together with other standards of the Connected Vehicle Environment.

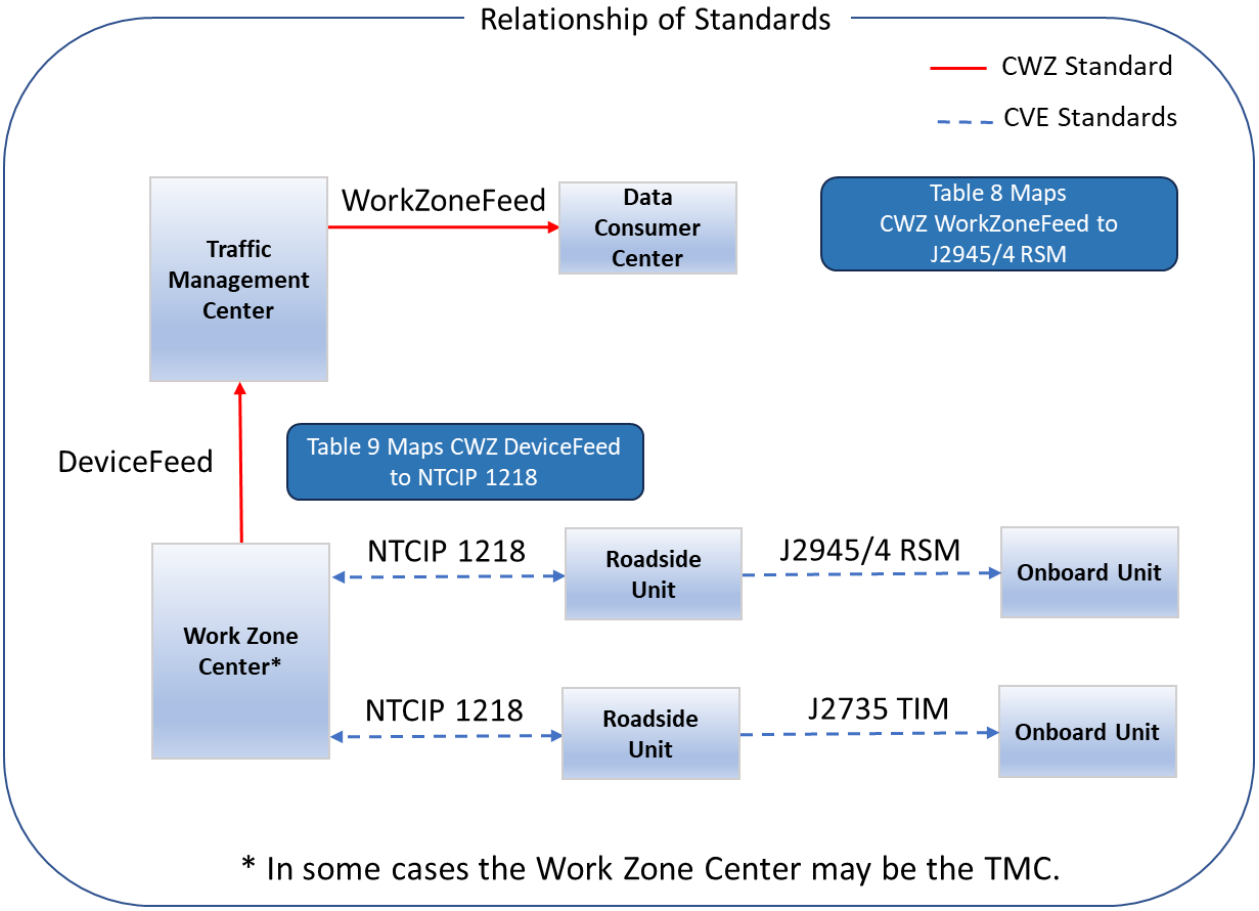
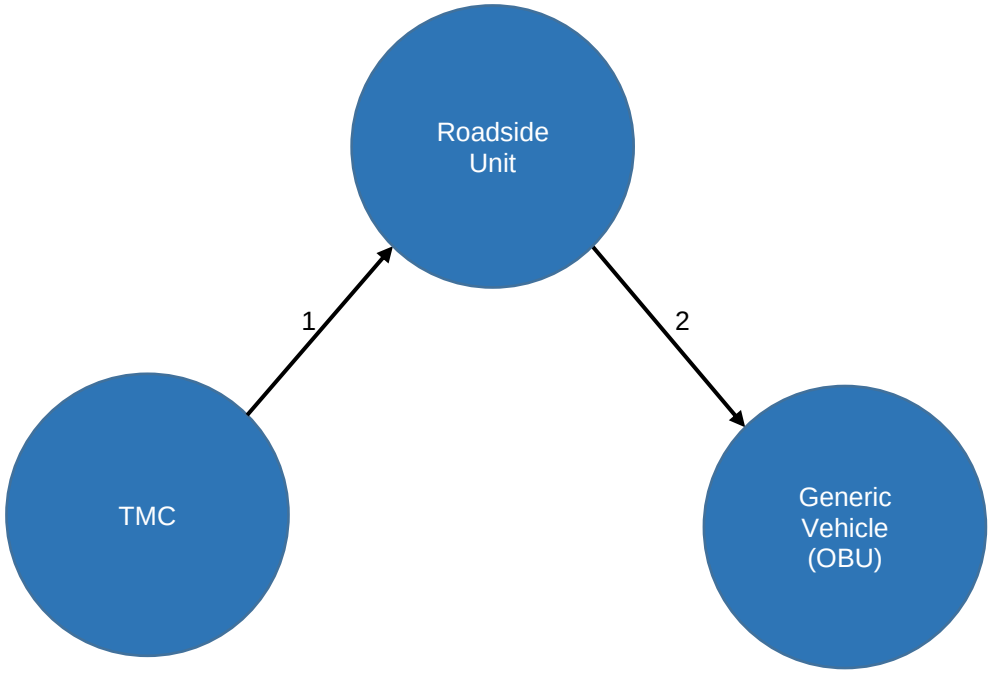


Figure 5. Physical Architecture: Connected Vehicle Environment Roadside Safety Application

Note: Describing how to configure an RSU using NTCIP 1218 is out of scope of this project.

C.2 Operational Scenario - CVE Compatibility Roadside Safety Message

Title	Connected Vehicle Environment Compatibility – Roadside Safety Message
Problem Aspect	Work zones RSUs may provide messages using the connected vehicle environment standards to communicate with connected vehicle OBUs.
Description	The traffic management center may want to broadcast roadside safety messages to drivers in connected vehicles. This can be done with an RSU in the work zone. Possible messages may be a reduced speed zone warning or lane closure information.
Pre-Conditions	• The traffic management center is connected to the connected vehicle environment (C-V2X/DSRC/other). • The RSU is configured using communications standard NTCIP 1218. • RSU is configured to broadcast the Roadside Safety Message per communications standard J2945/4.
Optional Diagram	
Narrative and Sequence of Steps	1) The TMC transmits an NTCIP 1218 message to the RSU to configure the RSU to send Roadside Safety Messages (RSM) to the OBU. 2) The RSU transmits an J2945/4 RSM message to the OBU.
End Conditions or State	CVs (OBUs in vehicles) receive Roadside Safety Message from the RSU so that the driver may be alerted.

C.3 Design Guidance – WorkZoneFeed and SAE J2945/4 Compatibility

The information below is a preliminary recommendations of the CWZ WG.

Table 8. Mapping of CWZ WorkZoneFeed Data Concepts to SAE J2945/4 Data Concepts

CWZ WorkZoneFeed Data Concept	SAE J2945/4 Data Concept	Additional Information and Notes
	3.5.1 Message Content and Structure Requirements	
5.4 RoadEventFeature 5.4.1.1 id	3.5.2 Event Identification In this case the event is the work zone.	
5.4.2.1 WorkZoneRoadEvent 5.4.2.3 RoadEventCoreDetails	3.5.3 Event Context	
5.4.2.3 RoadEventCoreDetails 5.4.2.3.2 event_type work-zone detour	3.5.3.1 Event Type (Section G.2 Cause code) ITISGroup-Closures (3)	
5.4.2.1 WorkZoneRoadEvent 5.4.2.1.18 types_of_work 5.4.2.7.1 type_name maintenance, minor-road-defect-repair, roadside-work, overhead-work below-road-work barrier-work surface-work painting roadway-relocation roadway-creation	3.5.3.2 Event Subtype (Section G.2 Subcause code) accident (513) closed-to-traffic (769) closed-ahead (771) closed-intermittently (772) closed-for-repairs (773) closed-for-the-season (774) blocked (775) blocked-ahead (776) reduced-to-one-lane (777) reduced-to-two-lanes (778) reduced-to-three-lanes (779) collapse (780) road-construction (1025) major-road-construction (1026) long-term-road-construction (1027) construction-work (1028)	A recommendation is provided in Annex D. There are challenges to providing a one-to-one mapping between the CWZ elements and those of SAE. The current state of the practice in some DOTs is to use a script that contains an algorithm to translate between the values shown in the columns at right. Currently, agencies have different and potentially conflicting approaches to expressing the information about a work zone using the SAE ITIS codes as described the center column.

CWZ WorkZoneFeed Data Concept	SAE J2945/4 Data Concept	Additional Information and Notes
	paving-operations (1029) work-in-the-median (1030) road-reconstruction (1031) opposing-traffic (1032) narrow-lanes (1033) construction-traffic-merging (1034) single-line-traffic-alternating-directions (1035) road-maintenance-operations (1036) road-marking-operations (1037) road-widening (1061)	
5.4 RoadEventFeature 5.4.1.4 geometry	3.5.4 Event Location	
	Reference Point	No direct translation
	Applicable Heading	Not a CWZ Standard data concept
5.4.1.4 geometry – LineString	Location Type = BroadPatch 5.2.24 DF_Path	
	3.5.5 Event Time	
5.4.2.1.8 start_date	3.5.1.1 Event Start Time – Planned Event	
5.4.2.1.8 start_date 5.4.2.1.10 is_start_date_verified	3.5.5.1.2 Event Start Time – Current Event	Potentially, 5.4.2.3.8 creation_date
5.4.2.1.9 end_date	3.5.5.2 Event End Time	
5.4.2.1.16 reduced_speed_limit_kph Speed limit units are in kilometers per hour	3.5.12.2 Reduced Speed Event Requirements - Speed Limit Units in meters per second	Requires conversion between kilometer-per-second and meter-per-second
5.4.2.8 Lane	3.5.12.3 Lane Closure Event Requirements	
5.4.2.8 Lane 5.4.2.8.1 order 5.4.2.8.2 status = open	3.5.12.3.1 Provide Number of Lanes Nominally Open	
5.4.2.8 Lane 5.4.2.8.1 order 5.4.2.8.2 status = closed	3.5.12.3.2 Provide Indication of the Close Lanes	
5.4.2.8 Lane 5.4.2.8.1 order order. Integer. 1 = left most lane	3.5.12.3.3 Provide Lane Closure Locations RSMLanePosition	There is direct alignment between the data concepts in both standards.

CWZ WorkZoneFeed Data Concept	SAE J2945/4 Data Concept	Additional Information and Notes
	- 5.5.7 DE_RSMLanePosition. Range (1..32). 1 is the left most lane.	

A couple of noteworthy items are presented below:

- The J2735 Sep 2023 version contains Section 5.17 Message: MSG_RoadSafetyMessage (RSM). The text in this section states that it is 'Reserved for future use.' The CWZ Working Group assumes that this section is a placeholder for the same RSM message as described in SAE J2945/4.
- At the time of this writing, the CWG Working Group has learned that at least one organization, Ohio DOT, is developing a guide for usage of the J2945/4 RSM.

C.4 Design Guidance – DeviceFeed and NTCIP 1218 Compatibility

The information below is a preliminary recommendations of the CWZ WG.

Table 9. Mapping of CWZ DeviceFeed Data Concepts to NTCIP 1218 Data Concepts

CWZ DeviceFeed Data Concept	NTCIP 1218 Data Concept	Additional Information and Notes
5.5.2.13 RoadSideUnit		
5.5.2.1 FieldDeviceFeature		
5.5.2.1.4 geometry	5.7.6 GNSS Reported Latitude 5.7.7 GNSS Reported Longitude	Value = GeoJSON type 'Point'
5.5.2.13.1 core_details		
5.5.2.2 FieldDeviceCoreDetails		
5.5.2.2.1 device_type		Value = 'roadside_unit'
5.5.2.2.2 data_source_id		Determined by data provider
5.5.2.2.3 device_status		Determined by data provider
5.5.2.2.4 update_date		Determined by data provider
5.5.2.2.5 has_automatic_location		Value = 'true'
5.5.2.13.2 message_types	5.4.2 Store and Repeat Table 5.4.2.2 Stored Message PSID	The Provider Service Identifier (PSID) is a reference to an application running on the roadside unit. The PSID may potentially be used to identify the type of message being broadcast by the RSU.

C.5 Discussion –SAE J2735 Traveler Information Message

One of the findings from discussions leading to development of this section by the CWZ Working Group is that there is a need for a national effort or standard to ensure consistent usage and interoperability of J2735 TIM messages as relates to Work Zones.

The current practice in several DOTs is the development of guidance on J2735 TIM message usage and deployment, as described below:

- Caltrans is developing a document “Connected Vehicle Traveler Information Guide”. The purpose of this document is to specify how to configure the J2735 TIM message from ITIS Codes.
- The ITIS Codes can be linked to graphics/icons and some of these graphics/icons may be in the MUTCD. The Caltrans guidance on J2735 TIM includes a mapping to the national MUTCD code, where applicable.
- Wyoming DOT (WyDOT) developed an early version of J2735 TIM message guidance as part of the Connected Vehicle Pilot Program.
- Colorado DOT has adopted and is following the guidance developed by WyDOT guidance.
- Michigan DOT broadcasts J2735 TIM from RSUs.

Annex D
Recommendations to SDOs [Informative]

This annex summarizes comments and recommendations by the CWZ Working Group or its task forces to Standards Development Organizations on existing standards that are referenced by this CWZ Implementation Guide and Standard.

D.1 SAE Recommendation jointly with ITE

1. The CWZ WG recommends that SAE, perhaps jointly with other organizations, develop a decision tree or algorithm for mapping between the CWZ WorkZoneFeed and the ITIS codes used by J2945/4, namely, the Event Subtypes of Event Type ITISGroup-Closures (3).
2. The CWZ WG recommends that SAE, perhaps jointly with other organizations, develop guidelines and standard for consistent usage and interoperability of J2735 TIM messages as relates to Work Zones.
3. The CWG WG suggests a technical review of how the vehicle communications standards should be implemented in the case of a vehicle receiving messages from two separate work zone in the same direction of travel e.g. on I-95 north a work zone exists from mile marker 88 to mile marker 90, and a separate work zone is set up from mile marker 91 to mile marker 92. While we expect that each work zone would have its' own unique identifier, we want to make sure that the vehicle communications standards can support a vehicle receiving messages about multiple work zones at the same time because the range of an RSU can be over 8,000 feet – presenting the possibility of a vehicle receiving messages from multiple work zones.

A more detailed analysis of items 1 and 2 above is contained in Annex C.

D.2 ITE Recommendation

D.2.1 ITE CAV Committee Role

The CWZ WG suggests that a group such as ITE's CAV Committee undertake the challenge of a technical review of the User Comment Draft, and provide a home for dealing with specific operational issues related to deployment of Connected Work Zones that are beyond the scope of this standard.

As described on ITE's web site, the scope of ITE's CAV Committee is stated below.

> "The ITE CAV Steering Committee within the Transportation Systems Management & Operations (TSM&O) Council is a multi-disciplinary cross-cutting steering committee intended to give every ITE Council a voice in the conversation concerning the future of connected & automated vehicles. This group will function as a clearinghouse for ideas, issues, and concerns – ensuring that every stakeholder group within ITE (as represented by the different councils) has an opportunity to contribute, while enhancing collaboration and communication for the very cross-cutting nature of this subject." [Source: https://www.ite.org/about-ite/councils/transportation-systems-management-operations/cav-steering-committee/]
>
> Add CWZ and ngTMDD harmonization.

Annex E
User Requests [Informative]

This annex identifies needs, requirements, and design details that were identified and considered by the CWZ Working Group or its task forces for this CWZ Implementation Guide and Standard, but were not included. The rationale on why these needs, requirements, and design details were not included is also provided. This section is included for consideration for future editions of the CWZ Implementation Guide and Standard.

E.1 User Requests - Needs

This sub-section identifies user needs that were identified and considered by the CWZ Working Group, but are not addressed by this CWZ Implementation Guide and Standard.

E.1.1 Tutorial – Data Exchange Roles and Mechanisms

2.4.3.1 Polling for Updates – An Alternative to Polling

Polling is easy to understand. An alternative to polling, referred to as *polling for updates*, allows Paula to make more efficient use of paper. With polling for updates, Chris polls for just the data that has changed in the last 12 hours (or some other specified time in the past).

One benefit of polling for updates is the result of smaller transmissions of data.

One disadvantage of polling for updates is that a data consumer may miss updates if the specified time in the past is incorrect.

2.4.3.2 Change-driven Updates Described as an Interaction Between Humans

With the change-driven updates mechanism, Paula only gives Chris the pages that have changed, and when they change. But that is really all that Chris needs to be able to update his data set so that it remains current with Paula's data. For the purposes of this tutorial, let's imagine that all the information you need for work zone information can be contained within a single page.

With change-driven updates, Chris shows up with a piece of paper that serves the purpose of authentication, but also contains Chris's work address. Let's imagine that mail service between Paula and Chris is practically instantaneous. When Paula detects a change, she edits the page to update her own data set (binder). Then Paula sends the page number and the page with the new updates to all data consumers, including Chris. Chris and Paula's data sets (binders) are in sync. In the case of multiple work zones with updates, data consumers, including Chris, will receive multiple pages.

One benefit of change-driven updates is the result in smaller transmissions of data. A secondary benefit is that change-driven data exchange architectures scale well, thus able to support growing numbers of data consumers and data providers.

One disadvantage is that it requires data consumers to have confidence that they have received every change that has occurred.

Rationale: CWZ WG Discussion.

- The Polling for Update and Change-driven update data exchange mechanisms have advantages and disadvantages for deployers. These disadvantages do not exist with the current Polling mechanism of WZDx. Developing a satisfactory design to overcome the disadvantages is a complex issue with many design considerations. It was the opinion of many in the WG to postpone a design for a future update of the CWZ Standard. Therefore, the materials leading to the design, including this tutorial, associated needs, operational scenario, and requirements have been relocated to this Annex for future consideration.

E.1.2 Architectural Needs

2.5.1.1 Architectural Need - Software and Documentation Repository

CWZ deployers need open and public access to open-source software and documentation. Currently, as of 2023, the WZDx provides an open Github repository. An open software and documentation repository enables potential CWZ deployers to inform themselves and gain experience to be able to participate in helping to develop, experiment, and/or apply this CWZ standard.

Rationale:

- As stated, this is a goal.
- The requirements developed from this need would not be testable.

2.5.1.2 Architectural Need - Compatibility with Existing and Emerging Standards

CWZ deployers may need to use multiple standards (e.g., J2945/4 RSM, TMDD, J2735 TIM & RSM, and WZDx). To the extent practical, the CWZ Standard will strive to arrive at consistency in data element definitions and enumerations to facilitate conversions necessary when moving data between formats governed by different standards. Where there is no consistency, the working group will provide guidance. For example, a mapping table to translate from one standard to another.

Rationale:

- The requirements developed from this need would not be testable.
- As stated, this need is a goal.

2.5.1.2.2 GeoJSON Data Exchange – Poll for Data Updates

CWZ deployers need to share work zone information updates only, given a point in time in the past, where work zone information is provided in the GeoJSON data format. Poll for Data Updates is a synchronous method of communications.

2.5.1.2.3 GeoJSON Data Exchange - Change-driven Updates

CWZ data providers need to share work zone information that sends asynchronous updates when data has changed, and only when it changes.

Rationale: CWZ WG Discussion.

- The Polling for Update and Change-driven update data exchange mechanisms have advantages and disadvantages for deployers. These disadvantages do not exist with the current Polling mechanism of WZDx. Developing a satisfactory design to overcome the disadvantages is a complex issue with many design considerations. It was the opinion of many in the WG to postpone a design for a future update of the CWZ Standard. Therefore, the materials leading to the design, including this tutorial, associated needs, and requirements have been relocated to this Annex for future consideration.

2.5.1.3 Architectural Need - Extensible Framework

This CWZ standardization effort will largely be based on what can be practically and currently collected from and by IOOs. The capabilities and data collection practices of IOOs will likely develop over time to reflect new practices. Therefore:

- CWZ deployers need a CWZ standard what will provide a consistent framework for data exchanges deployable today, while able to accommodate new needs that may arise over time.
- CWZ deployers need a CWZ standard that will extend to new areas and categories of disruptions.
- CWZ deployers need a CWZ standard that will extend to new areas and categories of VRUs.

Rationale:

- The requirements from this need overlap with the need for backward compatibility. Backward compatibility provides an extensible framework, as defined above.
- As stated, most of the content in this need is a goal.

2.5.1.5 Architectural Need - Time Source

Currently, devices use varying methods and time sources to determine time (for example, to generate a timestamp); some devices use the Network Time Protocol (NTP), while others depend on the time provided by a Global Navigation Satellite System (GNSS) receiver.

CWZ deployers need to maintain consistent time across various devices used in connected work zones.

Rationale:

- No requirements nor design were identified for this need by the CWZ WG.

2.5.1.6.2 Support Smaller, Condensed Packets of Information

The current JSON REST API provides all work zone activity for a particular data provider. The work zone information transferred, when saved, results in a GeoJSON file that can be viewed with off-the-shelf software, such as a GIS. One drawback of this approach is that the data transferred may be large and will likely not support the following:

- "over the air" interfaces, nor
- the transfer of real-time or near real-time information exchanges.

CWZ deployers need to support the exchange of smaller, condensed packets of information.

CWZ deployers need to support a mechanism for data exchanges as follows:

- Based on the exchange of smaller packets of information;
- Supports updates of single work zone information or subsets/fragments of work zone information (e.g., VRU locations, work vehicle, devices) without having to send information previously sent to a consumer where the data has remained static;
- Supports exchanges where the data provider is the initiator of the information exchange. The current JSON REST API is initiated by the data consumer, referred to as polling.

  Rationale: CWZ WG Discussion.

  - Proposed to remove these texts.
  - There was agreement to remove.
  - The focus (scope) of this standard is center to center (Work Zone Center to External Center).
  - The WZDx and this ConOps should not cover Work Zone Devices to Work Zone Center.
  - General agreement.
  - The scope does not include polling or control of devices from Work Zone Center.
  - It was agreed to keep the change-driven discussion, which is included in another need.

2.5.1.6.3 Support Confirmation Receipts

CWZ deployers need data exchanges to contain a confirmation receipt that documents proof of delivery when a data provider sends data to a data consumer.

Rationale: CWZ WG Discussion.

- Objective is to account for both delivery and confirmation of interpretation of the data.
- Want acknowledgement that all data items in the "transaction" were read successfully. This is important for security and liability reasons.

- Providers need a “key code” that authorizes the end-user's use of the data. This may be used as a confirmation that the end-user agrees to comply with an agreement.
- It was agreed that this is a big topic and should be moved to the parking lot.

2.5.1.9 Architectural Need - Goal / Mandatory and Optional Elements

CWZ deployers have the following concerns about mandatory and optional elements:

- Optional items in the CWZ standard makes designs incompatible;
- Optional data elements greatly affect the desired outcome of a common data structure to handle the content of work zone information;
- Stakeholders involved in standards development tend to make data elements optional when:
  - They cannot reach consensus agreement, or
  - They anticipate that they will not be able to provide the data specified by the standard.

CWZ deployers need greater consensus agreement on what is essential (i.e., mandatory).

CWZ deployers need to handle mandatory elements when data is not available so they can use a common data structure, even if the data is not available.

Rationale: CWZ WG Discussion.

- Agreed that this is a challenge, but untestable, and there is not process to support this goal.
- There is not much that can be done about this, and therefore should be removed from the standard.

2.5.1.10 Architectural Need - Goal / Machine Interpretable Data

CWZ deployers have systems that rely on data that does not require human interpretation of the data, such as free-form fields.

CWZ deployers need data as specified in the standard to be interpretable by machines.

Rationale:

- As stated this is a goal.
- The requirements developed from this need would not be testable.

2.5.1.11 Architectural Need – Goal / Data Structure

CWZ deployers have the following architectural design goals:

- Limit the use of 'choice' elements in the data structure that can enable multiple, if not infinite permutations of data structures, and non-interoperable designs, ambiguous interpretations of the data, and create errors in data interpretation.
- A flat data structure is better than a deeply-nested structure. The current data structure is tending toward becoming heavily nested. Moving forward, the CWZ Working Group should consider more favorable designs with a flatter structure.
- Enable an API to allow gathering of specific data for a CWZ.

CWZ deployers need a single, consistent data structure that handles multiple situations, across actor components, and designs.

Rationale: CWZ WG Discussion.

- The assertions are unproven and requirements developed from this need would not be testable.

- There is not much that can be done about this, there is much engineering judgement involved.
- This should be removed from the standard.

2.5.1.12 Architectural Need - Zone Data Quality and Validation
2.5.1.12.1.1 Criteria for a Defined Quality of Information
CWZ deployers need criteria for evaluating the quality of work zone data.

2.5.1.12.1.2 Support Information to Support Decision-making for Operations
CWZ data consumers need ~~accurate and correct~~ information to support decision-making for operations.

2.5.1.12.1.3 Support Accurate and Correct Information to Support Trip Planning
CWZ data consumers need ~~accurate and correct~~ information to support pre-trip route, and en-route trip planning.

Rationale: CWZ WG Discussion.
- If these are needs, will there be requirements and design to trace back to these needs. These items are not testable.
- If we use the term accurate, we need to specify how accurate.
- Equipment manufacturers do not typically provide information that is “interpreted”.

2.5.1.12.2 Architectural Need - Zone Data Quality - Position/Geometry is Correct
CWZ providers need to provide ~~correct and accurate~~ (the best the provider has available) zone geometry information when providing work zone information to data consumers.

Rationale: CWZ WG Discussion.
- If we use the term accurate, we need to specify how accurate.
- Some feed providers can only provide a single point.
- Define the source.
- As defined above, quality is untestable.

2.5.1.12.3 Architectural Need – Zone Data Quality – Time Work Zone is Active is Correct
CWZ providers need to provide ~~correct and accurate~~ ~~zone~~ active time information when providing work zone information to data consumers.

Rationale: As amended, this is a duplicate need.

2.5.1.13 Architectural Need - Security-Trust

2.5.1.13.1 Support Cyber Security
CWZ deployers need cyber security to be a vital element of the CWZ Standard architecture.

2.5.1.13.2 Verify Trusted Source of Information
CWZ deployers exchanging data need to verify whether a data provider is a trustworthy source. For example, one mechanism suggested by CWZ deployers is verification of a trusted source using security certificates and signing of data.

2.5.1.13.3 Verify Authentication for Access
CWZ data providers need a mechanism for authorizing of data consumers. For example, one mechanism suggested by CWZ deployers is that API keys are used in conjunction with the JSON REST API.

2.5.1.13.4 Support SCMS for Connected Vehicle Environment Deployments

CWZ deployers working in Connected Vehicle Environments need to access the SCMS for security services.

Rationale: These security needs were identified as an operational constraint and highly dependent on each agency's security policies, which are not subject to this standard.

2.5.1.15 Architectural Need – Feed Discovery

Potential CWZ data consumers need to know where to acquire work zone data being made available by data providers.

Rationale: This need, the need for a mechanism and supporting systems to enable feed discovery, is outside the scope of this system interface standard.

2.5.1.16 Architectural Need - Data Hub

CWZ deployers need a mechanism to allow aggregation of data from multiple or many data providers.

Rationale: This data hub need is outside the scope of this system interface standard, as we are not writing requirements for a data hub.

E.1.2.1 Architectural Needs – User Comment Draft Comments Received

The following comments were received during the User Comment Draft review.

- In certain implementations of a Data Consumer / Data Provider polling system, the Data Provider may need to limit the quantity of data provided in order to allow the Data Provider to ensure internal systems are not effectively shut down due to overloaded throughput (i.e. effectively a Denial of Service attack). Some Data Providers may have policies to mitigate potential Denial of Service failures on their internal systems. As is written, the CWZ Standard implies that all available work zone data will be provided by a Data Provider upon request from a Data Consumer via the Poll communication system. However, depending on the frequency at which a Data Consumer issues a Poll Request and/or the total quantity of available data, it may be overly burdensome to a Data Provider to respond with all of the available data to each request. A Best Practice method of handling this type of scenario is with an implementation of data pagination, whereby a segment of the total available data is provided to the Data Consumer along with a method for the Data Consumer to subsequently issue a new request for the next segment, continued until the Data Consumer eventually requests all available data segments. Such a mechanism allows a Data Provider to ensure that internal systems are provisioned to support a maximum quantity of data analysis, preparation, and transfer based upon the quantity of Data Consumers making Poll requests and the total quantity of available data.

- The ngTMDD has a new architectural need to support change-driven updates or event-driven updates. Designs developed by the ngTMDD may support the CWZ effort.

  Rationale: At this time, the ngTMDD design is underway, and it is unclear what direction the ngTMDD is going to take with respect to handling of Change-driven updates. Furthermore, it is unclear when the design effort will include handling of Change-driven updates.

- Currently, the ngTMDD is planning an update to the TMDD location referencing scheme (node, link, route) to support lane-level granularity for new objects such as "link lane status" that can share the status (i.e., open, closed, or restricted) of specific lanes on an approach to a work zone. With respect to developing applications that could inform motorist of which lanes are closed as they approach a work zone or other event, harmonization between CWZ (Section 3.6.17 Enumeration of LaneStatus) and ngTMDD lane status data concepts and objects would be beneficial.

Rationale: At this time, the ngTMDD design is underway, and it is unclear what direction the ngTMDD is going to take with respect to roadway and general geographic referencing. Furthermore, it is unclear whether the ngTMDD design will be compatible with the GeoJSON approach used in CWZ.

E.1.3 Data Exchange Needs

2.5.2.1.2 Zone Metadata - Zone Data Acknowledge Receipt
CWZ consumers need to provide a confirmation receipt as a proof of delivery of work zone data upon receipt of data from a CWZ data provider.

Rationale: CWZ WG Discussion.

- This is a receipt from the data consumer that the feed file was successfully read with no errors.
- This would be optional, depending on the consumer.
- This could be built on top of the API mechanism.
- It was agreed that this is a big topic and should be moved to the parking lot. There is an accompanying need.

2.5.2.1.5 Zone Metadata - GNSS Position Accuracy in meters
CWZ data providers need to provide the locational accuracy or method of location information acquisition to determine the accuracy of geographic information, in meters, when providing work zone information to data consumers.

A brief summary about the locational accuracy of work zone data collection methods are described below:

- IOOs typically use standard GNSS, which provides 5 to 7-meter accuracy.
- OEMs require high fidelity location data for lane determination. OEMs and navigation companies have digital maps with accuracies of approximately 10 centimeters. OEMs and navigation companies use LIDAR as measurement devices. OEMs state that this level of accuracy should not and does not have to be passed on to the IOOs.
- The accuracy of current GNSS on-board OEM vehicles (which relies on multiple GNSS devices on-board the vehicle) in open environments is about 2 meters. Therefore, vehicles cannot determine which lane they are in.
- Typical, standard GNSS cannot be used to acquire lane level detail of work zones. Therefore, creating lane-level geometry that depends on GNSS is unnecessary.
- Device manufacturers have stated that an arrow board will provide 2-meter accuracy.

Rationale: CWZ WG Discussion.

- It is not the intent of the standard to define a required level of accuracy for position data, which varies greatly.
- Most data providers cannot provide this right now. (DO NOT INCLUDE in the standard).

2.5.2.1.6 Zone Metadata - Zone Data Expiration End Date-Time
CWZ data providers need to provide zone data expiration date-time when providing work zone information to data consumers. Data consumers need to know the timeframe for which data is accurate and reliable, for example, to support decision-making.

Rationale: CWZ WG Discussion.

- No expiration date on DeviceFeed.
- It is better to use end_date for the WorkZoneFeed.
- Consensus is to remove this need.

2.5.2.2.2 Zone Alerts and Notifications – VRU Position/Geometry

CWZ deployers want to notify/alert drivers when their vehicle is approaching a VRU's location. CWZ deployers may provide wearable devices to VRUs that can be used to locate a VRU within a CWZ. Vehicles warn their driver upon approach to the CWZ.

CWZ data providers need to provide VRU position/geometry when providing work zone information to data consumers.

Rationale: CWZ WG Discussion.

- There are no alerts and notifications.
- This is a redundant need.
- Remove.

2.5.2.2.3 Zone Alerts and Notifications - Zone Status, Speed Limits, and Lane Shifts

CWZ deployers deploy devices that share status information to navigation companies automatically. Typical information sent includes: start of work zone, end of work zone, reduced speed limit zones, lane changes/shifts (and connections with arrow boards), and lane closures. Alerts show up in the navigation company's mobile applications or in OEMs' driver alert gadget.

CWZ data providers need to provide zone status, speed limit zones, speed limits, lane shifts, lane tapers, and direction of lane shift, number of lanes to taper, and lane closures when providing work zone information to data consumers.

Rationale: CWZ WG Discussion.

- There are no alerts and notifications.
- This is a redundant need.
- Remove.

2.5.2.2.4 Zone Alerts and Notifications - Intrusion Detection Geometry

CWZ deployers need work zone information to detect intrusions by vehicles into specific areas within the work zone. For example, areas where workers are present.

CWZ data providers need to provide notification alerts to drivers, VRUs, and work zone centers when intrusions are detected.

Rationale: CWZ WG Discussion.

- There are no alerts and notifications.
- This was determined to be out of scope.
- Keep for future consideration.

2.5.2.4.3 Zone Traffic - Crash Counts

2.5.2.4.3.1 Traffic Incident Management Performance Measures

CWZ deployers need to calculate incident durations related to crashes in a work zone consistent with the NOCOE Traffic Incident Management Performance Measures (TIM-PM) and Incident Timeline to assess the safety of work zone deployments.

2.5.2.4.3.2 Traffic Incident Type and Location

CWZ data providers need to provide crash information such as type and location when providing work zone information to work zone data consumers.

2.5.2.4.3.3 Crash Counts

CWZ data providers need to provide crash counts over a period of time when providing work zone information to work zone data consumers.

Rationale: CWZ WG Discussion.

- Data may come from:
  - Attenuators have crash counts.
  - Extract from CAN-bus data.
  - First responder records.
- Put in parking lot. There are different ways to get this information.

2.5.2.2.5 Zone Alerts and Notifications - Zone Identifier

CWZ data providers need to provide the zone identifier associated with zone alerts and notifications when providing work zone information to work zone data consumers.

2.5.2.3.6 Zone Status - Zone Identifier

CWZ data providers need to provide the zone identifier associated with zone status information when providing work zone information to work zone data consumers.

2.5.2.4.4 Zone Traffic - Zone Identifier

CWZ data providers need to provide the zone identifier associated with zone traffic information when providing work zone information to work zone data consumers.

2.5.2.5.6 Zone Lanes - Zone Identifier

CWZ data providers need to provide the zone identifier associated with zone lane information when providing work zone information to work zone data consumers.

2.5.2.6.3 Zone VRU – Zone Identifier

CWZ data providers need to provide the zone identifier associated with a VRU when providing work zone information to work zone data consumers.

2.5.2.7.3 Zone Work Vehicle - Zone Identifier

CWZ data providers need to provide the zone identifier associated with the work vehicle when providing work zone information to work zone data consumers.

2.5.2.9.2 Zone Schedule - Zone Identifier

CWZ data providers need to provide the zone identifier associated with the zone schedule information when providing work zone information to work zone data consumers.

2.5.2.10.3 Zone Speed Limit – Zone Identifier

CWZ data providers need to provide the zone identifier associated with the speed limit change information when providing work zone information to work zone data consumers.

Rationale: CWZ WG Discussion.

- Zone Identifiers are only needed for Devices to identify which zone the device is associated with.
  - VRU is covered under Device.
  - Work Vehicle is covered under Device.
- There is no need to identify zone identifiers for these attributes of work zones.
- Remove these identifiers.
- Separate need was identified to identify travel time through the zone, for example by blue-tooth devices.

E.1.4 Operational Scenarios

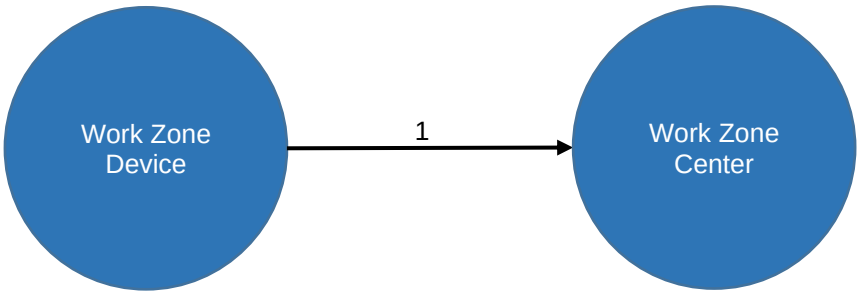
VRU Safety – Zone Intrusion Detection and Notification Alerts (OUT OF SCOPE)

Title	VRU Safety – Zone Intrusion Detection
Problem Aspect	A work zone may want a defined area to detect for vehicle intrusions for VRU safety.
Description	Work zone equipment may be set up to detect vehicle intrusions into the work zone to provide VRUs with enough warning to get to a safe location. Detection equipment may include sensors, and alerting equipment may include flashing beacons, VRU electronic safety vests, or personal devices (smartphone).
Pre-Conditions	• The area being monitored for vehicle intrusion is defined. • Work zone device(s) monitoring this defined area is/are set up. • The work zone device(s) is/are connected to the work zone center. • (optional) The work zone devices are connected to each other. • VRUs in the area are wearing smart vests or carry a personal device connected to the alerting equipment. • A work zone device detects an intrusion.
Optional Diagram	
Narrative and Sequence of Steps	1a) The work zone device sends an intrusion alert to the work zone VRU. 1b) The work zone device sends the intrusion information to the work zone center. 1c) (optional) The work zone device sends the intrusion information to other work zone device(s) such as a flashing beacon. 2) (optional) The work zone center sends the intrusion information to other work zone device(s).
End Conditions or State	VRUs are alerted of the intrusion with enough time to get to safety (through an audio/haptic/visual alert on their vest or personal device and/or flashing beacons), and the work zone center receives information about the intrusion.
Scenario Extension	This may apply to other VRUs with a smartphone application.

Rationale: CWZ WG Discussion.

- This scenario is out of scope of this standard and should be removed.

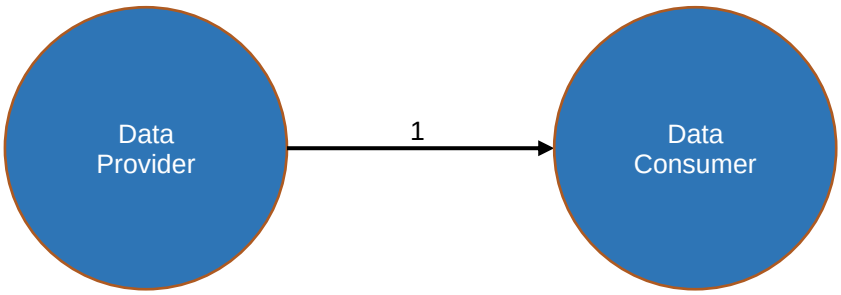
WZ Data Collection – From Devices (OUT OF SCOPE)

Title	WZ Data Collection – From Devices
Problem Aspect	A work zone center needs to collect information gathered by work zone devices.
Description	A connected work zone may require the use of devices that gather data such as GPS location or vehicle speeds. These devices may be directly connected to the work zone center for maximum utility. A device may be work zone equipment such as a camera or traffic sensor.
Pre-Conditions	The work zone device is powered on and configured. The work zone device is connected to the work zone center.
Optional Diagram	
Narrative and Sequence of Steps	The work zone device sends information to the work zone center continuously, periodically, or as relevant events happen.
End Conditions or State	The work zone center receives the data collected by the work zone device.
Scenario Extensions	This may also apply to work zone vehicles and VRUs.

Rationale: CWZ WG Discussion.

- This scenario is out of scope of this standard and should be removed.

2.6.6 Generic Work Zone Information Data Exchange (Change-driven Updates)

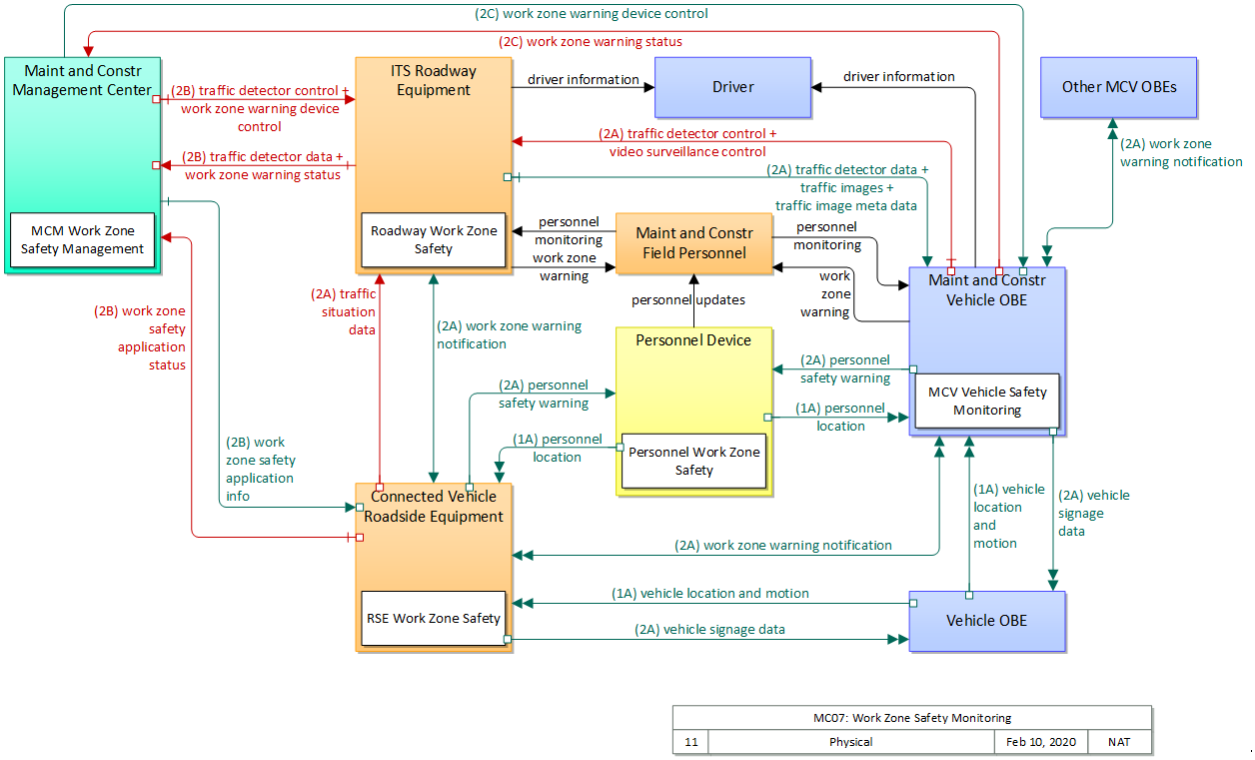
Title	Generic Work Zone Data Exchange (Change-driven Updates)
Problem Aspect	A data consumer has a prior data set of work zone information that needs to be updated. A data provider needs to send only information updates to allow the data consumer's data set to be current.
Description	When a data provider has new information, possibly due to an event, the data provider needs to update a data consumer with information to bring the data consumer's data set up-to-date. This may be a work zone needing to update a data consumer about a new vehicle or VRU position, or changes in speed limits within a zone.
Pre-Conditions	• The data consumer is an authorized connection to the data provider. • The data provider has new information that needs to be communicated to a data consumer.
Optional Diagram	
Narrative and Sequence of Steps	1) The data provider sends updated information to the data consumer.
End Conditions or State	The data consumer has up-to-date information about work zones and conditions.

Rationale: CWZ WG Discussion.

- The Polling for Update and Change-driven update data exchange mechanisms have advantages and disadvantages for deployers. These disadvantages do not exist with the current Polling mechanism of WZDx. Developing a satisfactory design to overcome the disadvantages is a complex issue with many design considerations. It was the opinion of many in the WG to postpone a design for a future update of the CWZ Standard. Therefore, the materials leading to the design, including this tutorial, associated needs, operational scenarios, and requirements have been relocated to this Annex for future consideration.

E.1.5 Relationship to ARC-IT

ARC-IT Work Zone Safety Monitoring Service Package [2.8.2] (OUT OF SCOPE)
MC07: Work Zone Safety Monitoring. This service package provides warnings to maintenance personnel within a work zone about potential hazards within the work zone. It enables vehicles or the infrastructure to provide warnings to workers in a work zone when a vehicle is moving in a manner that appears to create an unsafe condition (e.g., moving at high speed or entering the work zone).



ARC-IT – Work Zone Safety Service Package Diagram [Figure 6].

Rationale: CWZ WG Discussion.

- This portion of ARC-IT is out of scope of this standard and should be removed.

E.2 User Requests - Requirements

This sub-section identifies requirements that were identified and considered by the CWZ Working Group, but are not addressed in this CWZ Implementation Guide and Standard.

3.3.1.2 Send WorkZoneFeed Upon Request for Updates

A data provider shall send WorkZoneFeed information upon request for updates from a data consumer.

3.3.1.3 Send WorkZoneFeed Information Updates Upon Change of Information

A data provider shall send WorkZoneFeed updates to data consumers upon change in information.

3.3.2.2 Send DeviceFeed Upon Request for Updates

A data provider shall send DeviceFeed information upon request for updates from a data consumer.

3.3.2.3 Send DeviceFeed Information Updates Upon Change of Information

A data provider shall send DeviceFeed updates to data consumers upon change in information.

Rationale: CWZ WG Discussion.

- The Polling for Update and Change-driven update data exchange mechanisms have advantages and disadvantages for deployers. These disadvantages do not exist with the current Polling mechanism of WZDx. Developing a satisfactory design to overcome the disadvantages is a complex issue with many design considerations. It was the opinion of many in the WG to postpone a design for a future update of the CWZ Standard. Therefore, the materials leading to the design, including this tutorial, associated needs,

operational scenarios, and requirements have been relocated to this Annex for future consideration.

E.3 User Requests - Design Details

This sub-section identifies design details that were identified and considered by the CWZ Working Group, but are not addressed in this CWZ Implementation Guide and Standard.

E.4 User Requests – Guidance Needs

This sub-section identifies guidance needs that were identified and considered by the CWZ Working Group, but are not addressed in this CWZ Implementation Guide and Standard.

Guidance Needs - Contracting, Data Ownership, and Licensing [B.2]
CWZ deployers need guidance on how to develop contractor specs. For example, uptime requirements for contractors and penalties for downtime. Several IOOs are developing guidelines for testing connected work zone equipment; for example, equipment needs to pass a X-days of field test prior to using the device in an active work zone. These same IOOs, however, state that they are aware that some contractors will choose not to bid on the project due to the new testing requirements.

Guidance Needs - Roadway Construction Contractor Scopes do not Require the Provision of Electronic Work Zone Information and Status [B.2.1]
Device manufacturers work with IOOs and contractors to deploy electronic equipment to serve a host of needs, including safety applications, guidance for drivers to maneuver passage through a work zone, etc.

Contractors are not required by IOOs to deploy electronic field devices in work zones. Currently, the burden of communicating the benefits of connected work zones has traditionally fallen on the work zone device manufacturers, who are motivated to sell their equipment, and by some IOOs. Today, however, and moving forward, IOOs will need to take a larger role in communicating the benefits of CWZs within their own organizations, but also to assist with communicating the beneftis to their contractors that ultimately will become responsible for the day-to-day operation of connected work zones.

A few examples of the type of things that need to be stated in contract specs are described in the paragraphs below.

- the types of work zone equipment that needs to be planned, designed, engineered, and monitored;
- specifications so equipment is deployed correctly, accurately, and reliably;
- that workers need to use equipment to enable detection of worker presence and location within a work zone – workers may have wearable devices;
- where to positions location markers within the work zone;
- and, for connected vehicle deployments, the details of configuration of RSUs.

Contractor equipment need to be supported and tested to conform with standards for data communications. In addition, contractors may need to do data entry, keeping data available and up-to-date, based on real-time requirements.

Along with specifying contractual requirements, IOOs will need to enforce contractual requirements.

Guidance Needs - Data Ownership and Licensing [B.2.2]
The topics of data ownership and licensing are closely related, and discussed briefly, below.

Guidance Needs – Data Ownership [B.2.2.1]
In today's technology and data-driven environment, data is an asset and a source of intellectual property (IP) for data owners. Data owners add value to raw data through first acquiring the data, and then becoming responsible for maintenance, reliability, uptime, frequency of updates, and other quality factors.

Data owners seek to monetize their data IP, and can optimize and recoup their investment in value-added features, by limiting the usage and redistribution right of the data.

Data ownership may also apply when addressing the source of the data, i.e., the equipment used that generates the data. For example, contractors may feel that they are the owners of data, since the data is generated and collected from their vehicles, devices they own, and workers they employ.

Data owners have to deal with a number of legal issues—for example, the liability they absorb as contractors—that extends to sourcing data to the public sector or third parties, such as navigation and transportation service providers. It is important to note for an IOO whether to absorb the liability risk of CWZ data, since most IOOs pass on the general risk of work zones onto contractors.

Guidance Needs – Licensing [B.2.2.2]
One concern data owners have is determining who has rights to the data when it is aggregated. Limiting a data consumer's rights to redistribution of data protects data owners. Licensing the data provides clarification on restrictions related to the data's usage, and may include limited rights to re-distribute the data or to save the data for historical analysis purposes.

It is important for licensees, especially IOOs, to understand the constraints stated in a data license. CWZ deployers will need to think about their long-term goals to identify the impacts of the limitations and constraints that are enacted in a license. It is noteworthy that while accepting a license limits usage, it also limits exposure to liability risk.

Rationale: CWZ WG Discussion.

- There were questions about why this sections is in a standard.
- This is about contracting. Keep contracting out of this document.
- This section should not be contracting guidance.
- Perhaps re-characterize that what IOOs need is to establish a “pre-qualification” process.
- There was a suggestion to separate the discussion on Contracting from the discussion on Data Ownership and Licensing
- There was a question as to whether this would only apply to pilot projects.
- There was a suggestion that maybe a discussion about qualified products lists is better.
- There is a lot of equipment out there, and is being tested. Recommend that agencys accept testing done in other States.
- One issue is that if IOOs do not require (emphasis on the term require) the CWZ equipment, then this equipment will less likely be deployed in a WZ.
- One person suggested broadening the discussion to include all those that will benefit.
- There was a question as to why it is necessary to 'single out' IOOs in this section.
- Some IOOs are requiring the use of electronic work zone equipment.
- There was clarification that this section is not intending to mandate anything.
- One benefit is assisting with the inspection process. The equipment manufacturers can facilitate the process to verify the equipment is in fact working.
- It is important to show the value – e.g., to consumers, to OEMs – and that that value comes at an additional cost when you deploy electronic equipment.
- Many will shrug at the guidance and 'recommendations'. The goal should be for deployers to figure out how to make their data fit the requirements in the standard.
- We have to remember that each IOO is different, and they should not be lumped together.
- What's important is to focus not on the equipment, but rather on the work zone features required and data you need to collect and share. Let the features drive the equipment choices.
- There was some concern about why we are discussing Data Ownership and Licensing?

- One person offered an example: For DeviceFeed information, we (equipment vendor) need to specify ownership of the data, and the limitations of sharing the data with others. Typically, for IOOs, if the device feed matches a planned project then that becomes part of the agency's WZFeed, and that is the only data that the agency can distribute. For a navigation company, the agreement may be completely different.
- There was clarification that an agency's WZFeed is a public resource and should be freely available. All agreed.
- There was more concern about whether this topic should be included in this guidance.
- There was additional support for the statement that the WZFeed shall be freely available – and that this should be stated in an agreement.
- The WG collectively agreed to remove this section after much discussion.

Annex F
Listing of Differences between the CWZ Standard and the WZDX v4.2 Specification JSON Schemas [Informative]

This annex lists differences between the JSON Schemas contained in Section 5 of this standard and the WZDX v4.2 Specification JSON Schemas.

F.1 Differences Affecting Both the WorkZoneFeed and DeviceFeed

1. Replaced the use of GeoJSON ‘MultiPoint’ type with ‘Point’ as follows: The Geometry object's 'type' property MUST be LineString (RFC 7946 Section 3.1.4) or Point (RFC 7946 Section 3.1.2).
2. Changed ‘feed_info’ to required because ‘road_event_feed_info’ was deprecated.
3. Changed ‘update_frequency’ to required.
4. Changed ‘update_frequency’ minimum value ‘1’ to ‘-1’.
5. Changed ‘update_date’ to required.
6. Removed deprecated element ‘lrs_type’.
7. Removed deprecated element ‘lrs_url’.
8. Removed deprecated element ‘location_verify_method’.
9. Corrected typographical error of “verfied” to “verified” throughout.
10. Removed ‘restriction’ as an enumerated value of ‘EventType’.
11. Changed ‘milepost’ to ‘reference_post’ throughout.
12. Added ‘reference_post_unit’ element.
13. Updated the ‘reference_post_unit’ element to include ‘miles’.
14. Added Operational Policy and Constraint that states that the assignment of UUIDs is governed by the regulatory guidelines and policies of the data provider. For example, the assignment of uniform resource identifiers may be governed by policies to guarantee privacy. As a result, UUIDs may need to change over time.
15. Added Business Rule that states that all universally unique identifiers must comply with the UUID standard (RFC4122) reference.
16. Added ‘project_id’ element.

F.2 WorkZoneFeed Differences

1. Changed ‘is_start_position_verified’ to required.
2. Changed ‘is_end_position_verified’ to required.
3. Changed ‘is_start_date_verified’ to required.
4. Changed ‘is_end_date_verified’ to required.
5. Removed deprecated element ‘relationship’.
6. Removed deprecated element ‘lane_number’.
7. Removed deprecated enumeration ‘SpatialVerification’.
8. Removed deprecated enumeration ‘TimeVerification’.
9. Removed deprecated enumeration ‘EventStatus’.
10. Changed WorkTypeName enumeration text “maintenance” to “non-encroachment”.
11. Removed deprecated enumerated item ‘center-left-turn-lane’ from ‘LaneType’.

F.3 DeviceFeed Differences

1. Removed deprecated element ‘is_moving’.
2. Removed enumerated item ‘road-event-start’ from ‘MarkedLocationType’
3. Removed enumerated item ‘road-event-end’ from ‘MarkedLocationType’.
4. Removed deprecated enumerated item ‘temporary-traffic-signal’ from ‘MarkedLocationType’.
5. Added new enumerated items for vehicle types and ‘other’ to ‘MarkedLocationType’.

6. Added enumerated item ‘pavement-marking-vehicle’ to ‘MarkedLocationType’.
7. Added ‘is_in_transport_position’ to FieldDeviceCoreDetails to reflect that other devices (in addition to the ArrowBoard device) may have the characteristic of being in transport position.
8. Removed ‘is_in_transport_position’ from ArrowBoard device.
9. Added ‘is_image_url_public’ to contents of the Camera device.
10. Added ‘video_url’ to contents of the Camera device.
11. Added ‘is_video_url_public’ to contents of the Camera device.
12. Added ‘video_update_frequency’ element to contents of Camera device to reflect how often video is updated.
13. Added ‘travel_time_sec’ element to contents of TrafficSensor device.
14. Added ‘travel_time_sec’ to contents of TrafficSensorLaneData.
15. Added ‘RoadsideUnit’ as a new device.
16. Added ‘roadside-unit’ enumerated item to ‘FieldDeviceType’.
17. Added element ‘message_types’ to identify message being broadcast by an RSU (e.g., RSM, TIM, SPaT, MAP). Added enumerated list of potential RSU messages that could be broadcast.

§