

Vehicle-to-Infrastructure (V2I) Safety Applications

Performance Requirements, Vol. 4, Reduced Speed Zone Warning with Lane Closure (RSZW/LC)

www.its.dot.gov/index.htm

Final Report — August 2015

FHWA-JPO-16-251



U.S. Department of Transportation

Produced by Battelle Memorial Institute under DTFH61-12-D-00040
U.S. Department of Transportation
Federal Highway Administration Office of Safety Research and Development

Notice

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The U.S. Government is not endorsing any manufacturers, products, or services cited herein and any trade name that may appear in the work has been included only because it is essential to the contents of the work.

Source: Bottom left cover image courtesy of the University of Minnesota Center for Transportation Studies; all other cover images purchased from iStockphoto LP.

Technical Report Documentation Page

1. Report No. FHWA-JPO-16-251		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Vehicle-to-Infrastructure (V2I) Safety Applications Performance Requirements, Vol. 4, Reduced Speed Zone Warning with Lane Closure				5. Report Date August 2015	
				6. Performing Organization Code	
7. Author(s) Denny Stephens, Jeremy Schroeder, Rachel Klein				8. Performing Organization Report No. 1000025516-0301-4	
9. Performing Organization Name And Address Battelle Memorial Institute 505 King Avenue Columbus, OH 43201				10. Work Unit No. (TRAVIS)	
				11. Contract or Grant No. DTFH61-12-D-00040	
12. Sponsoring Agency Name and Address U.S. Department of Transportation FHWA Office of Safety Research and Development Turner-Fairbank Highway Research Center 6300 Georgetown Pike McLean, VA 22101				13. Type of Report and Period Covered Final Report	
				14. Sponsoring Agency Code	
15. Supplementary Notes Government Technical Monitor; Gregory Davis, FHWA Office of Safety Research and Development					
16. Abstract This document is the fourth of a seven volume report that describe the Performance Requirements for the connected vehicle vehicle-to-infrastructure (V2I) safety applications developed for the U.S. Department of Transportation (U.S. DOT). This volume describes the Performance Requirements for the infrastructure and vehicle components of the Reduced Speed Zone Warning with Lane Closure V2I Safety Application. This application is designed to advise drivers of an upcoming Reduced Speed Zone and, where applicable, a roadway configuration change. The safety applications described here integrate roadside and in-vehicle advisories, alerts and warnings to make the driver aware of hazards in time to take action to prevent a potential crash. The performance requirements provide requirements for both infrastructure and vehicle application components to ensure the messages are consistent and coordinated, to best capture the attention of the driver and to avoid conflicting or confusing driver messaging.					
17. Key Words Connected vehicles, Vehicle-to-Infrastructure, V2I, V2I Safety Applications, Reduced Speed Zone Warning with Lane Closure, RSZW/LC			18. Distribution Statement		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 79	22. Price

Table of Contents

Table of Contents	i
Chapter 1 Scope	1
1.1 DOCUMENT IDENTIFICATION	1
1.2 DOCUMENT OVERVIEW	1
Chapter 2 Referenced Documents	3
Chapter 3 Performance Requirements	5
3.1 INTRODUCTION AND OVERVIEW	5
3.1.1 Organization of this Chapter	5
3.1.2 Structure and Format of the Performance Requirements	6
3.1.2.1 Performance Requirements Identifier Structure	7
3.1.2.2 Verification Methods	8
3.2 V2I SYSTEM FUNCTIONAL ARCHITECTURE	8
3.2.1 System Components and Interfaces	10
3.2.1.1 Driver	11
3.2.1.2 Infrastructure Systems Components	11
3.2.1.3 Vehicle System Components	12
3.2.1.4 V2I/I2V Wireless Data Interface	13
3.2.1.5 Infrastructure System Interfaces	13
3.2.1.6 Vehicle System Interfaces	13
3.3 REDUCED SPEED ZONE WARNING WITH LANE CLOSURE (RSZW/LC) APPLICATION PERFORMANCE REQUIREMENTS	14
3.3.1 RSZW/LC Application Introduction and Overview	14
3.3.1.1 Application Purpose	14
3.3.1.2 Safety Impacts of the Application	14
3.3.1.3 Summary of Improvements	15
3.3.1.4 How the Application Works	16
3.3.1.5 Application Assumptions and Considerations	28
3.3.1.6 Application Swim Lane & Sequence Diagrams	28
3.3.1.7 Messages Exchanged and Used by the Application	31
3.3.2 RSZW/LC Infrastructure Application Component Requirements	34
3.3.3 RSZW/LC Vehicle Application Component Requirements	48
APPENDIX A. RSZW/LC Application Message Candidate Data Elements	A-1
APPENDIX B. Acronyms and Abbreviations	B-1
APPENDIX C. Terms and Definitions	C-1

List of Tables

Table 3-1. Definition of RSZW/LC Terms	25
Table 3-2. Summary of RSZW/LC Infrastructure and Vehicle Displays	26
Table 3-3. Summary of Messages used by RSZW/LC Application Components	32
Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements	35
Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements	49
Table A-1. Explanation of Candidate Data Table Headers.....	A-2
Table A-2. Description of Candidate Data Elements for the RSZW/LC Infrastructure Data Systems Message	A-3
Table A-3. Description of Candidate Data Elements for the RSZW/LC Roadside Signage Message Data Description	A-4
Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message.....	A-5
Table A-5. Description of Candidate Data Elements for the RSZW/LC I2V Wireless Message Data Description.....	A-10
Table A-6. Description of Candidate Data Elements for the RSZW/LC Vehicle Systems Message Data Descriptions.....	A-11
Table A-7. Description of Candidate Data Elements for the RSZW/LC Driver Warning Message Data Description	A-12

List of Figures

Figure 3-1. Functional Architecture for Connected Vehicle V2I Safety Applications.....	10
Figure 3-2. Illustration of Reduced Speed Zone Roadside and In-Vehicle Signage, with Integrated Road Configuration Change Advisory.....	18
Figure 3-3. Illustration of Lane Closure Roadside Signage and In-Vehicle Advisory, Alert and Warning.....	19
Figure 3-4. Example of Signs used to Indicate a Reduction in the Speed Limit Ahead for Various Types of Speed Zones	20
Figure 3-5. Example of Dynamic Message Sign Alert at a Reduced Speed Zone for a Work Zone that Involves a Change in Roadway Configuration	20
Figure 3-6. Example of Signs used to Indicate a Changed Roadway Configuration Involving a Lane Closure.....	20
Figure 3-7. Illustration of In-vehicle Signage as a Function of Vehicle Speed and Distance from Beginning of Reduced Speed Zone, with or without a Change in Roadway Configuration.....	23
Figure 3-8. Illustration of In-vehicle Signage as a Function of Vehicle Speed and Distance from Start of Reduced Speed Zone that Includes a Change in Roadway Configuration.....	24
Figure 3-9. Swim-lane Process Diagram for the RSZW/LC Application	30

Chapter 1 Scope

1.1 Document Identification

This document is the fourth of a seven volume report that describes the performance requirements for six connected vehicle vehicle-to-infrastructure (V2I) safety applications developed for the U.S. Department of Transportation (U.S. DOT). This volume describes the Performance Requirements for the infrastructure and vehicle components of the Reduced Speed Zone Warning with Lane Closure V2I safety application. This application is designed to advise drivers of an upcoming Reduced Speed Zone and, where applicable, a roadway configuration change. Reduced speed zones may include school zones, work zones, and pedestrian crossing areas. The application will provide an alert to drivers in advance when aggressive braking is required to reduce to the posted speed limit. Where applicable, the application will provide an advisory of an impending change in roadway configuration, such as lane shift or lane closure. For lane closures, where lane level position and maps are available, the vehicle application component will provide vehicle-specific alerts and warnings to the driver to change to a through-lane.

The seven volumes comprising this V2I Safety Applications Performance Requirements report are:

- Vol. 1, V2I Safety Application Overview and Common Requirements
- Vol. 2, Curve Speed Warning (CSW)
- Vol. 3, Red Light Violation Warning (RLVW)
- Vol. 4, Reduced Speed Zone Warning with Lane Closure (RSZW/LC)
- Vol. 5, Spot Weather Information Warning – Reduced Speed (SWIW-RS)
- Vol. 6, Spot Weather Information Warning – Diversion (SWIW-D)
- Vol. 7, Stop Sign Gap Assist (SSGA).

This volume transforms the Concept of Operations (ConOps) and System Requirements previously developed for the RSZW/LC application into a set of performance requirements which specify how the application integrates roadside and in-vehicle advisories, alerts and warnings to make the driver aware of hazards in time to take action to prevent a potential crash. Performance requirements are provided for both infrastructure and vehicle application components of the application to ensure that infrastructure and vehicle messages presented to drivers are consistent and coordinated, to best capture the attention of the driver, and avoid conflicts or confusion.

1.2 Document Overview

The objective of this V2I Safety Application Performance Requirements volume is to provide integrated requirements for the infrastructure and vehicle components of one of a series of V2I safety applications, their wireless messaging and their driver messaging that ensure coordinated and consistent delivery of safety hazard advisories, alerts and warnings to drivers. This volume describes the V2I System of Systems within which the application is expected to function.

The RSZW/LC safety application described here captures relevant data from roadside infrastructure sensors and in-vehicle sensors and processes them to determine if there is a potential crash hazard. If a hazard is detected, the application issues integrated roadside and in-vehicle advisories, alerts and warnings to make the driver aware of the hazards in time to take action to prevent the crash.

The application described here has both an infrastructure-based component and a vehicle-based component, which may be developed by different stakeholders. Infrastructure-based components are expected to be developed by state and local agencies responsible for building and maintaining the roadway infrastructure and their contractors. Vehicle-based components are expected to be developed by vehicle manufacturers, their tier one suppliers, and aftermarket system suppliers. The performance requirements provide requirements for both infrastructure and vehicle application components to ensure the data exchange between the two components is synchronized and consistent and that they deliver messages to the driver that are harmonized to best capture the attention of the driver and that avoid confusing the driver.

This document has been written with the assumption that the reader possesses a general knowledge associated with connected vehicles and the associated infrastructure surrounding connected vehicles.

The intended audience of this document includes infrastructure and vehicle application developers, wireless equipment systems manufacturers, intelligent transportation systems (ITS) developers, state and local departments of transportation, and U.S. DOT Connected Vehicle Program Managers.

The remainder of this volume consists of the following sections and content:

Section 2 (Applicable Documents) describes the external documentation utilized and referenced throughout this document.

Section 3 (Requirements) provides the background and requirements for the RSZW/LC application.

Appendices:

- A. RSZW/LC Application Message Candidate Data Elements
- B. Acronyms and Abbreviations
- C. Terms and Definitions

Chapter 2 Referenced Documents

The following sections include documents that are either cited herein or were reviewed for the development of this document. Documents from U.S. DOT are presented first, followed by documents from other government and non-government organizations.

U.S. Department of Transportation

- Accelerated Vehicle-to-Infrastructure (V2I) Safety Applications Concept of Operations Document. FHWA Office of Safety Research and Development, Turner-Fairbank Highway Research Center. FHWA-JPO-13-058. (2012).
- Accelerated Vehicle-to-Infrastructure (V2I) Safety Applications System Requirements Document. FHWA Office of Safety Research and Development, Turner-Fairbank Highway Research Center. FHWA-JPO-13-059. (2012).
- Driver Vehicle Interface (DVI) Design Assistance for Advanced Technology Applications, Campbell, J. L., Brown, J. L., et al, National Highway Traffic Safety Administration, (in press). (Battelle Final Report to Virginia Tech Transportation Institute and National Highway Traffic Safety Administration).
- Highway Functional Classification: Concepts, Criteria and Procedures, Federal Highway Administration, FHWA-PL-13-026, 2013 Edition.
- Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 edition, Federal Highway Administration. <http://mutcd.fhwa.dot.gov/>.
- Vehicle-to-Infrastructure (V2I) Safety Applications Concept of Operations Document. FHWA Office of Safety Research and Development, Turner-Fairbank Highway Research Center. FHWA-JPO-13-060. (2013).
- Vehicle-to-Infrastructure (V2I) Safety Applications System Requirements Document. FHWA Office of Safety Research and Development, Turner-Fairbank Highway Research Center. FHWA-JPO-13-061. (2013).

American Association of State Highway and Transportation Officials (AASHTO)

- The Green Book. A Policy on Geometric Design of Highways and Streets, 6th edition. 2011.

International Organization for Standardization (ISO)

- ISO 9141-2. Road vehicles – Diagnostic systems – Part 2: CARB requirements for interchange of digital information (1994).
- ISO 11898, Road vehicles – Controller area network (CAN) – Part 6: High-speed medium access unit with selective wake-up functionality.
- ISO 14230-4, Road vehicles – Diagnostic systems – Keyword Protocol 2000 – Part 4 Requirements for emission-related systems.
- ISO 15765, Road vehicles – Diagnostic communication over Controller Area Network (DoCAN) – Part 4: Requirements for emissions-related systems.

U.S. Department of Transportation, FHWA Office of Safety Research and Development, Turner Fairbank Highway Research Center

Institute of Transportation Engineers (ITE) Standards

- ITE ATC Transportation Controller (ATC) v5.2b.
- ITE Traffic Management Data Dictionary (TMDD) Standard v3.03 for the Center-to-Center Communications.

National Marine Electronics Association

- NMEA 0183 Interface Standard.

National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) Standards

- NTCIP 1103 Transportation Management Protocols.
- NTCIP 1204 v03 Object Definitions for Environmental Sensor Stations (ESS) Standard.
- NTCIP 1203 v02 Object Definitions for Dynamic Message Signs (DMS) Standard.
- NTCIP 1209 v02 Object Definitions for Transportation Sensor Systems (TSS).

Radio Technical Commission for Maritime Services

- RTCM 10403.2, Differential GNSS (Global Navigation Satellite Systems) Services – Version 3.

Society of Automotive Engineers (SAE) Standards

- SAE J1211. Handbook for Robustness Validation of Automotive Electrical/Electronic Modules.
- SAE J1850 VPW, J1850 PWM. Class B Data Communications Network Interface (June 2006).
- SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary.
- SAE J2178 Class B Data Communication Network Messages-Detailed Header Formats and Physical Address Assignments.

Transportation Research Board (TRB)

- National Cooperative Highway Research Program (NCHRP) Report 600. Human Factors Guidelines for Road Systems, 2nd edition. (2012).

Chapter 3 Performance Requirements

3.1 Introduction and Overview

This section of the document enumerates the Performance Requirements for the Reduced Speed Zone Warning with Lane Change (RSZW/LC) Application. The performance requirements provide requirements for both infrastructure and vehicle application components to ensure the advisories are consistent and coordinated.

3.1.1 Organization of this Chapter

The chapter begins by describing the V2I System, including its functional architecture, components and interfaces. This is followed application performance requirements first for the infrastructure application component, followed by the vehicle application component. This chapter is organized under the following headings.

- 3.1 Introduction and Overview
 - 3.1.1 Organization of this Chapter
 - 3.1.2 Structure and Format of the Performance Requirements
 - 3.1.2.1 Performance Requirements Identifier Structure
 - 3.1.2.2 Verification Methods
- 3.2 V2I System Functional Architecture
 - 3.2.1 System Components and Interfaces
 - 3.2.1.1 Driver
 - 3.2.1.2 Infrastructure Systems Components
 - 3.2.1.3 Vehicle System Components
 - 3.2.1.4 V2I/I2V Wireless Data Interface
 - 3.2.1.5 Infrastructure System Interfaces
 - 3.2.1.6 Vehicle System Interfaces
- 3.3 Reduced Speed Zone Warning with Lane Closure (RSZW/LC) Application Performance Requirements
 - 3.3.1 RSZW/LC Application Introduction and Overview
 - 3.3.1.1 Application Purpose
 - 3.3.1.2 Safety Impacts of the Application
 - 3.3.1.3 Summary of Improvements
 - 3.3.1.4 How the Application Works
 - 3.3.1.5 Application Assumptions
 - 3.3.1.6 Application Swim Lane & Sequence Diagrams
 - 3.3.1.7 Messages Exchanged and Used by the Application

- 3.3.2 RSZW/LC Infrastructure Application Component Requirements
- 3.3.3 RSZW/LC Vehicle Application Component Requirements

In developing the performance requirements contained here, the authors developed a framework for coordinating the delivery of roadside and in-vehicle messages to drivers. The framework that sets the stage for subsequent requirements is described in the application introduction and overview and in its assumptions. This is followed by Application Swim Lane and Sequence Diagrams that illustrate the flow of data, data processing and decision trees for hazard assessment and for decisions in whether to issue advisories, alerts and/or warnings to drivers.

As illustrated in the V2I System of Systems description below, the V2I application is implemented in a framework of multiple existing and legacy systems that capture data, process it and issue messages to drivers and other systems. The application description includes a description of the messages that are exchanged between systems that make up the V2I System of Systems.

Following explanation of the rationale and underlying frameworks, requirements are presented, first for the infrastructure application components and then for the vehicle application components. Appendix A provides Application Message Data Tables which suggest data elements that may be needed by the application to perform its required functions.

The authors of these requirements expect that questions will arise during the design and implementation of this application. The rationales, frameworks, and requirements presented here are expected to evolve. Understanding that different components will be developed by different agencies, the purpose here is to provide an underlying structure for discussion between these agencies to support coordination and refinement of the requirements that are necessary to successfully develop and implement the application to achieve its safety objectives.

3.1.2 Structure and Format of the Performance Requirements

Each requirement in the following tables includes the following elements:

- **Unique Identifier** of the form [A.B.CC.DD], described in more detail below.
- **Requirement Title** describes the topic of the requirement. **Requirement Titles** are presented in bold face type for readability.
- **Requirement Statement** provides the specific requirement which is subject to verification and validation, and represents the description of design, development, behavior, operation, performance, etc. of the application. **Requirement Statements** are presented in bold type face to distinguish them from supporting text including the *Requirements Elaboration*.
- *Requirements Elaboration* provides supporting text for the **Requirement Statement** that aids in understanding, interpretation and application of the **Requirement Statement** where needed. *Requirements Elaboration* text is presented in italics type face to distinguish it from the **Requirements Statement**. *Requirements Elaboration* is not necessarily subject to verification and validation, but may be useful in establishing methods and acceptance criteria for verification and validation.
- Verification Method describes how the performance requirements will be verified, whether by Inspection (I), Demonstration (D), Test (T) or Analysis (A). Each of these is described in more detail below.

3.1.2.1 Performance Requirements Identifier Structure

Performance requirements for this V2I application is organized and numbered by the application, the component, and requirement category. For consistency and accessibility the requirements are uniquely identified by a four element number of the format [A.B.CC.DD] where A designates the application, B designates the application component, CC designates the application category, and DD is the unique requirement number within the category. The [A] designators for each application are

- [1.B.CC.DD] Common Application Requirements
- [2.B.CC.DD] CSW Application Requirements
- [3.B.CC.DD] RLWV Application Requirements
- [4.B.CC.DD] RSZW/LC Application Requirements
- [5.B.CC.DD] SWIW-RS Application Requirements
- [6.B.CC.DD] SWIW-D Application Requirements
- [7.B.CC.DD] SSGA Application Requirements

The [B] designators for the application components are

- [A.1.CC.DD] Infrastructure Application Component Requirements
- [A.2.CC.DD] Vehicle Application Component Requirements
- [A.3.CC.DD] Infrastructure Application Platform Requirements¹

The [CC] designator for the application categories are

- [A.B.01.DD] Interfaces and Interface Specifications
- [A.B.02.DD] Functional Requirements
- [A.B.03.DD] Data Input Requirements
- [A.B.04.DD] Data Output Requirements

Common Application requirements include the following additional categories:

- [A.B.05.DD] Computation and Communication Performance Requirements
- [A.B.06.DD] Operational Performance Requirements
- [A.B.07.DD] Supportability Requirements
- [A.B.08.DD] Security Requirements
- [A.B.09.DD] Human Factors, Health and Safety Requirements
- [A.B.10.DD] Installation and Setup Requirements
- [A.B.12.DD] Operation, Maintenance and Diagnostic Requirements
- [A.B.12.DD] Documentation Requirements
- [A.B.13.DD] Staffing and Training Requirements
- [A.B.14.DD] Physical and Environmental Performance Requirements

¹ While outside the system of interest, candidate performance requirements are provided in Volume 1 for the Infrastructure Application Platform for reference.

3.1.2.2 Verification Methods

The verification method describes how the performance requirements will be verified in order to ascertain that the system of interest conforms to the requirements in this specification. The four potential methods of verification include the following.

Analysis is a verification method that utilizes established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements are met.

Demonstration is a verification method that generally denotes the actual operation, adjustment, or re-configuration of items to provide evidence that the designed functions were accomplished under specific scenarios.

Inspection is a verification method that consists of investigation, without the use of special laboratory appliances or procedures, of items to determine conformance to those specified requirements. Examination is generally nondestructive and typically includes the use of sight, hearing, smell, touch; and/or simple physical manipulation of the system when it is safe to do so. Inspection can also be applied to the project work products. For instance, verifying that software is developed using a certain programming language would be verified by inspection.

Testing is a verification method that generally denotes the determination of properties by instrumentation and measurement. This method includes functional operation, and involves the application of established scientific principles and procedures.

3.2 V2I System Functional Architecture

Figure 3-1 illustrates the V2I System of Systems Functional Architecture upon which the Performance Requirements are based. The figure illustrates a number of key elements concerning the architecture of the V2I safety application described in this volume. First, the V2I safety application has two core components, an Infrastructure Application Component residing and operating on an Infrastructure Application (Computing) Platform and a Vehicle Application Component residing on a Vehicle Application (Computing) Platform. Both components are necessary to achieve the safety application objectives of integrating and processing infrastructure and vehicle data and delivering coordinated messages to the driver. These two application components share data and information by exchanging messages through wireless data interface(s).

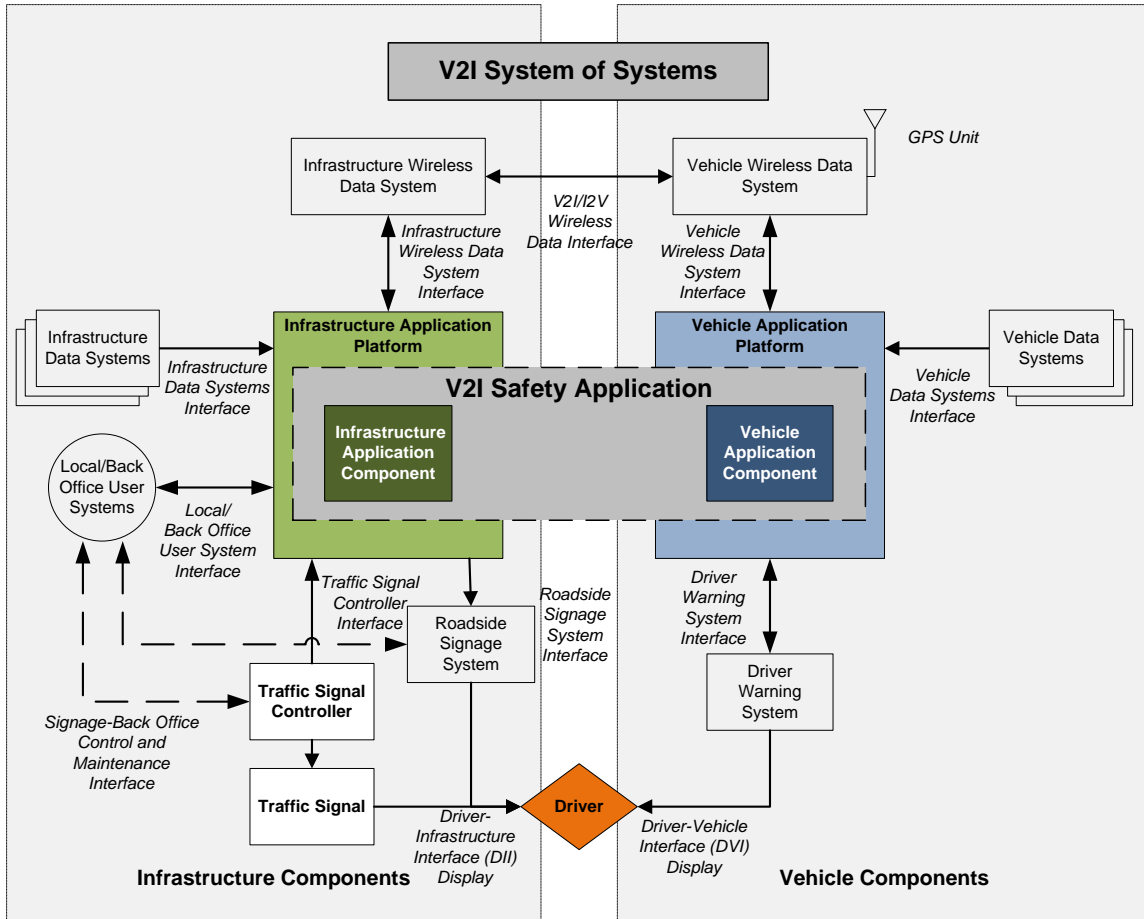
Each of the application components resides and operates on a computing platform that provides the necessary hardware and software data interfaces needed to exchange data with other systems. Each computing platform has an interface for wireless data systems that support with wireless exchange of data between the Infrastructure and Vehicle Application Components. From a requirements standpoint, the Application Components are independent from the form of wireless communication, it is expected that the primary form of communication between the two will be Dedicated Short Range Communication (DSRC).

The Infrastructure Application Platform also provides interfaces for data exchange with Infrastructure Data Systems, Local or Back Office User Systems and user interfaces, Traffic Signal Controllers and Roadside Signage Systems. The Vehicle Application Platform also provides interfaces for capture of data from vehicle systems and a driver warning system with a Driver-Vehicle Interface display.

The infrastructure application component issues messages through dynamic message signs that are visible to and applicable to all approaching vehicles and drivers. The vehicle application component issues messages through a driver warning interface that may be vehicle specific or may be the same as that displayed by dynamic message and static roadside signs. This V2I Safety Application is expected to coordinate and synchronize the display of roadside and in-vehicle messages to the driver.

Vehicle-specific messages for drivers may be equally or more cautious than roadside signs, but must never be less cautious. Vehicle-specific message must never conflict with roadside messages. For example, the vehicle application component in a truck carrying an unusual load with a high center of gravity and high rollover potential may recommend a lower vehicle-specific safe speed in a curve than the infrastructure application component recommends for all vehicles. However, the vehicle application component in a sports car under good road surface conditions must not recommend a higher safe speed in a curve than does the infrastructure signage.

An important concern and rationale for developing these Performance Requirements is that the vehicle and infrastructure components of the applications are likely to be developed and implemented by different entities. Infrastructure components may be developed by public state and local agency infrastructure owners and contractors and vehicle components may be developed by private vehicle manufacturers and suppliers.



Source: Battelle

Figure 3-1. Functional Architecture for Connected Vehicle V2I Safety Applications

3.2.1 System Components and Interfaces

As illustrated in Figure 3-1 there many components which make up the System-of-Interest (SOI) and supporting components. These components include:

- System-Of-Interest Components
 - Infrastructure Application Component
 - Vehicle Application Component
- Supporting Components
 - Infrastructure Application Platform
 - Infrastructure Wireless Data Systems (with GPS)
 - Infrastructure Data Systems
 - Roadside Signage System
 - Traffic Signal Controller
 - Traffic Signal
 - Local/Back Office User Systems

- Vehicle Application Platform
- Vehicle Wireless Data Systems (with GPS)
- Vehicle Data Systems
- Driver Warning System
- Driver

- Interfaces
 - V2I/I2V Wireless Data Interface
 - Infrastructure Wireless Data Systems Interface
 - Vehicle Wireless Data Systems Interface
 - Infrastructure Data Systems Interface
 - Vehicle Data Systems Interface
 - Roadside Signage System Interface
 - Driver Warning System Interface
 - Local/Back Office User Systems Interface
 - Traffic Signal Controller Interface

The function of each of these components and interfaces is described below.

3.2.1.1 Driver

The Driver is the consumer of information delivered by the safety application. Static roadside signage and dynamic Roadside Signage Systems and in-vehicle Driver Warning Systems convey information to drivers such as advisories, alerts, and warnings to make the driver aware of hazards in time to take action to prevent a potential crash.

3.2.1.2 Infrastructure Systems Components

Infrastructure Application Component is the infrastructure component of the V2I safety application. It obtains data from the Vehicle Application Component through the Infrastructure Wireless Data Systems, Infrastructure Data Systems, Traffic Signal Controller and Local/Back Office User Systems, processes the data and issues appropriate message to drivers through Infrastructure Wireless Data Systems and Roadside Signage Systems. The application also issues messages containing relevant data to the Vehicle Application Component through the Infrastructure Wireless Data Systems.

Infrastructure Application Platform is the computational platform which hosts the Infrastructure Application Component and provides the necessary hardware and software interfaces enabling communication with Infrastructure Wireless Data Systems, Infrastructure Data Systems, Roadside Signage System, Traffic Signal Controller, and Local/Back Office User Systems.

Roadside Signage System receives messages from the Infrastructure Application Component and delivers dynamic advisories and alerts to all approaching vehicles from the roadside.

Infrastructure Wireless Data System receives messages from the Infrastructure Application Component through the Infrastructure Application Platform, formats and processes the messages and issues the message via wireless communications to vehicles within wireless communication range. The System also performs the inverse, receiving wireless messages from nearby vehicles, formatting and processing the message and issuing the message to the Infrastructure Application Component through the Infrastructure Application Platform. The system also obtains universal time, coordinated (UTC) time.

Local/Back Office User System provides a technical user interface for the installation, configuration, maintenance, diagnostics, and management of the Infrastructure Application Component. The system may be a computer that is attached locally and temporarily to perform these functions or the system may connect remotely via dedicated lines or the Internet to perform these functions. The system may provide a function for upload or download of configuration and data files to the Infrastructure Application Platform. The system may also provide a connection to obtain GPS differential correction data.

Infrastructure Data Systems provide infrastructure data and information to the Infrastructure Application Component through the Infrastructure Application Platform. Examples of relevant data include weather information, road surface condition data, visibility data, and infrastructure-based vehicle detection and speed data.

Traffic Signal Controller is the external component that provide traffic signal phase and timing data required by some V2I Safety Applications through the Infrastructure Application Platform.

Traffic Signal is the traditional “driver display” component of the Traffic Signal Controller.

3.2.1.3 Vehicle System Components

Vehicle Application Component is the vehicle component of the V2I safety application. It obtains data from the Infrastructure Application Component through Vehicle Wireless Data Systems, Vehicle Data Systems, processes the data and issues appropriate messages to drivers through the Driver Warning System and Driver Vehicle Interface.

Vehicle Application Platform is the computational platform which hosts the Vehicle Application Component and provides the necessary hardware and software interfaces enabling communication with Vehicle Wireless Data Systems, Vehicle Data Systems, and the Driver Warning System.

Driver Warning System is the component which collects and arbitrates messages, advisories, alerts and warnings and delivers them to the driver. These alerts may be visual, aural, haptic, or some other means that captures the driver’s attention and conveys the relevant information. When multiple safety applications are hosted on the Vehicle Applications Platform, the Driver Warning System will prioritize and arbitrate alerts and warnings from the multiple safety applications. Note: The placement of the Driver Warning System shown in Figure 3-1 is intended to show representative functionality and is not meant to restrict implementation.

Vehicle Wireless Data System receives messages from the Vehicle Application Component through the Vehicle Application Platform, formats and processes the messages and issues the message via wireless communications to Infrastructure Wireless Data Systems within wireless communication range. This system also performs the inverse, receiving wireless messages from nearby infrastructure, formatting and processing the message and issuing the message to the Vehicle Application Component through the Vehicle Application Platform. This system also obtains GPS location and time. It may include a processor for GPS differential correction.

Vehicle Data Systems represent systems contained within the vehicle that provide vehicle-related information to the Vehicle Application Component. Information provided may come from a positioning system, vehicle data bus, sensors, actuators on the vehicle, or stability systems. Specific interfaces to the original equipment manufacturers’ (OEM) vehicle systems are dependent on specific information required to support the safety application.

3.2.1.4 V2I/I2V Wireless Data Interface

V2I/I2V Wireless Data Interface is the wireless communications interface that communicates relevant data between the Infrastructure and Vehicle Application Components through their respective Wireless Data Systems and Application Platforms.

3.2.1.5 Infrastructure System Interfaces

Infrastructure Wireless Data System Interface is the interface between the Infrastructure Application Platform and the Infrastructure Wireless Data Systems Component. This interface is used by the Infrastructure Applications Platform and the Infrastructure Applications Components to send and receive data to nearby vehicles via the V2I/I2V Wireless Data Interface.

Infrastructure Data Systems Interface is the interface between the Infrastructure Application Platform and Infrastructure Data Systems. The interface is used by Infrastructure Applications Platform to and Infrastructure Applications Components to capture data from infrastructure sensor systems such as weather information, road surface condition data, visibility data, and infrastructure-based vehicle detection and speed data.

Roadside Signage System Interface is the interface between the Infrastructure Applications Platform and the Roadside Signage System. The interface is used by Infrastructure Applications Platform to and Infrastructure Applications Components to send advisory and alert messages to local dynamic message signs at the roadside for display to all approaching vehicles.

Local/Back Office User System Interface supports IP communication with a computer that is attached locally or remotely via dedicated lines or the Internet to perform upload and download of data files as well as installation, configuration, maintenance, diagnostics, and management of the Infrastructure Application Component.

Traffic Signal Controller Interface is the interface between the Infrastructure Applications Platform and the local Traffic Signal Controller. The interface is used by Infrastructure Applications Platform to and Infrastructure Applications Components to capture traffic signal phase and timing data required by some V2I Safety Applications.

3.2.1.6 Vehicle System Interfaces

Vehicle Wireless Data System Interface is the interface between the Vehicle Application Platform and the Vehicle Wireless Data Systems component. This interface is used by the Vehicle Applications Platform and the Vehicle Applications Components to send and receive data to nearby infrastructure via the V2I/I2V Wireless Data Interface.

Vehicle Data Systems Interface is the interface between the Vehicle Application Platform and Vehicle Data Systems. The interface is used by Vehicle Applications Platform and Vehicle Applications Components to capture data from vehicle systems such as a positioning system, vehicle data bus, sensors, actuators on the vehicle, or stability systems.

Driver Warning System Interface is the interface between the Vehicle Application Platform and Driver Warning System. The interface is used by Vehicle Applications Platform and Vehicle Applications Components to send messages, advisories, alerts and warnings to the Warning System for arbitration and delivery to the driver.

3.3 Reduced Speed Zone Warning with Lane Closure (RSZW/LC) Application Performance Requirements

3.3.1 RSZW/LC Application Introduction and Overview

Reduced Speed Zone Warning with Lane Closure – Application to advise drivers of an upcoming Reduced Speed Zone and, where applicable, a roadway configuration change. The application integrates data from infrastructure- and vehicle-based sensors to coordinate roadside and in-vehicle messages to advise and alert the driver in time to slow to posted speeds and to change lanes. Reduced speed zones may include school zones, work zones, and pedestrian crossing areas. The application will provide an alert to drivers in advance when aggressive braking is required to reduce to the posted speed limit. Where applicable, the application will provide an advisory of an impending change in roadway configuration, such as lane shift or lane closure. For lane closures, where lane level position and maps are available, the vehicle application component will provide vehicle-specific alerts and warnings to the driver to change to a through-lane.

3.3.1.1 Application Purpose

The goal of the RSZW/LC application is to improve safety in Reduced Speed Zones, such as school zones and work zones, by improving conformance with the speed limit in areas where, for example, school children, pedestrians, and construction workers are at risk from speeding vehicles. Where applicable, additional messages are provided for changed roadway configurations, such as a lane closure or lane shift.

The RSZW/LC application uses both infrastructure- and vehicle-based sensor data for providing messages. Driver messages are based upon posted speed limit of the Reduced Speed Zone and, where available, lane-level positioning information and lane-level configuration map of a lane closure.

The RSZW/LC application coordinates roadside messages and in-vehicle advisories and alerts to notify drivers in time for them to slow to the posted speed limit and maintain a speed at or below the posted speed limit within the Reduced Speed Zone. The application also coordinates roadside and in-vehicle advisories of upcoming roadway configurations. For deployments with both reduced speed and changed roadway configurations, advisory and/or alert messages regarding the need to reduce speed and change lanes will be displayed simultaneously. In the case of a lane closure where *road-level* accuracy positioning is available, the application issues *advisories* on the roadside and in-vehicle. Where a lane closure and *lane-level* accuracy position and map are present, the RSZW/LC application also coordinates roadside messages for all vehicles with in-vehicle, vehicle-specific alerts, and warnings to notify drivers in time for them to merge and enter the appropriate lane prior to lane closure.

3.3.1.2 Safety Impacts of the Application

There will be several impacts on drivers in the deployment of the RSZW/LC safety application:

- **Real-Time Messaging:** The greatest impact is that drivers will receive real-time alerts and warnings while driving based on their current driving conditions.
- **Reduction in Frequency and Severity of Incidents Approaching and Within Reduced Speed Zones:** The RSZW/LC application should reduce vehicle speeds

through Reduced Speed Zones, creating a safer environment for construction workers, school children, and pedestrians. Where applicable, the application should also reduce incidents occurring when a vehicle fails to merge or follow a lane shift for a changed roadway configuration.

- **Effective Warning (Format and Timing):** The safety application is designed to provide drivers with a combination of haptic, visual, and/or audio advisory, alert, and warning messages in an effective format that does not distract or overwhelm them. These messages are designed to be presented to drivers in a timeframe that provides adequate reaction time to reduce speed and safely merge, as necessary.
- **Modified Driving Behavior:** It is expected that drivers will modify their driving behaviors in response to the applications' intended purposes, thus creating a safer driving environment. However, as drivers become more accustomed to the safety applications, behavior may change as drivers rely more on the application and potentially assume a less active role in driving defensively. Becoming desensitized to and ignoring provided warnings is an example of a modified behavior that would compromise the safety benefits expected from these applications.

3.3.1.3 Summary of Improvements

- **Reduces number and severity of incidents involving construction workers, school children, and pedestrians and due to failure to merge:** RSZW/LC aids drivers by providing information to discourage speeding into and through a Reduced Speed Zone and potentially endangering construction workers, school children, and pedestrians. The RSZW/LC application will provide messages to drivers regarding the need to slow down based upon the posted speed limit for a Reduced Speed Zone. Where applicable, RSZW/LC will also aid drivers by providing information regarding changes in roadway configuration. The RSZW/LC application will provide messages to the driver regarding the need to merge or follow a lane shift based on current roadway configuration conditions in addition to messages regarding the need to reduce speeds.
- **Increases driver awareness a Reduced Speed Zone:** Unlike current RSZW/LC applications, which largely provide a standard static warning based on radar-detected speeds via the roadside infrastructure, the connected vehicle application provides a real-time alert based on the driver's current driving conditions, both prior to and within the Reduced Speed Zone. Where applicable, the RSZW/LC application also includes the capability of providing messages regarding changes in roadway configuration. The RSZW/LC application is functional for all types of Reduced Speed Zones, such as work zones and school zones.
- **Provides real-time alerts and warnings based on current conditions:** RSZW/LC allows for the real-time provision of alerts based on current vehicle speed while approaching or within a Reduced Speed Zone. Where applicable, the RSZW/LC application additionally allows for the real-time provision of alerts and warnings, given lane-level positioning accuracy, based on current vehicle location while approaching a Reduced Speed Zone in a non-through lane. If lane-level positioning is unavailable and there is a changed roadway configuration, RSZW/LC will provide an advisory message in addition to any message for reduced speed. The application is capable of providing these messages with sufficient time for the driver to receive and react to it.

3.3.1.4 How the Application Works

The objective of RSZW/LC V2I Application is to deliver coordinated infrastructure- and vehicle-based advisories and alerts that notify the driver of potentially unsafe vehicle speeds in sufficient time to slow the vehicle to the posted speed limit prior to and within the Reduced Speed Zone. Additionally, the application is intended to deliver coordinated infrastructure- and vehicle-based advisories that notify the driver of a changed roadway configuration, such as a lane closure or lane shift. RSZW/LC is intended to support a variety of Reduced Speed Zone warning needs where a temporary reduction in speed is necessary to ensure safety of construction workers, school children, or pedestrians near and/or crossing the roadway, as well as vehicles entering and passing through the zone.

This application assumes reduced speed limits are determined by local policy for the zone and that they are fixed and do not vary with vehicle type or weather conditions. Speed limits may change with the weekday, time of day, and season, as in the case of school zones, or may change when construction workers are present, as in the case of work zones.

The application addresses changes in roadway configuration, such as lane shift or lane closure, that are frequently part of work zones. The beginning and end of roadway configuration changes and signage may coincide directly with reduce speed warnings or the roadway configuration changes may occur within a Reduced Speed Zone area. Because roadway configuration changes occur within a zone, signage on both the roadside and within the vehicle may need to display speed and configuration change advisory and alert messages simultaneously. As with other V2I safety applications, the intent of RSZW is to coordinate roadside and in-vehicle signage to draw driver attention to potential safety hazards.

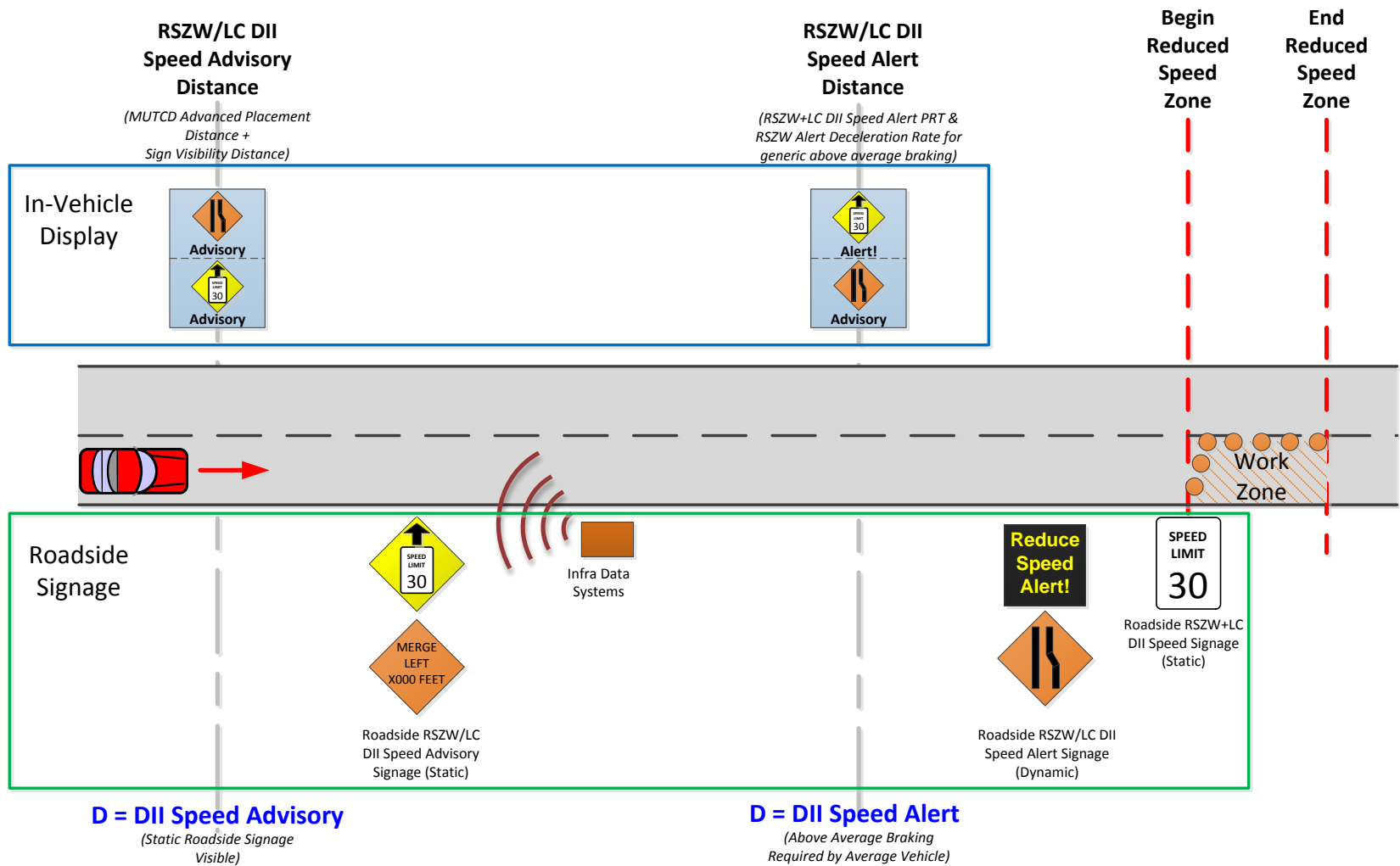
While speed reduction is required in RSZW for safety, it may not represent an imminent threat of a crash. Consequently, the application issues reduced speed advisories and alerts, but does not issue speed reduction warnings. In general, the application delivers advisories for roadway configuration change, but does not issue roadway configuration alerts or warnings. The exception is Lane Closure, which can represent an imminent threat of a crash if the vehicle fails to merge to a through lane and attempts to continue in the closed lane. Accordingly, the application provides for Lane Closure alerts and warnings. However, lane-level accuracy roadway and lane closure maps and lane-level accuracy vehicle positioning are all required to support this feature. Road-level accuracy positioning and maps are sufficient for the remainder of the RSZW/LC application features.

Figure 3-2 and Figure 3-3 below illustrate RSZW/LC roadside and in-vehicle signage concepts. Figure 3-2 illustrates Reduced Speed Zone and generic road configuration change signage, roadside and in-vehicle. The figure shows the vehicle approaching the entrance to a Reduced Speed Zone. The boxes below the roadway illustrate *roadside signage* displayed to the driver. The boxes above the roadway illustrate the *in-vehicle signage* displays.

In Figure 3-2 the driver first encounters static (or fixed) reduced speed signage advising the driver of an impending Reduced Speed Zone and the posted speed limit for all vehicles. Driver Infrastructure Interface (DII) signage may include a reduced speed ahead graphic or text and the posted speed limit, such as that shown in Figure 3-4. Subsequently, the driver encounters a roadside speed detection device and a DII dynamic message sign (DMS). DMS messages are typically text based, as illustrated in Figure 3-5, but may contain graphics. If the speed of the subject or any nearby vehicle exceeds a "DII Alert Speed" (posted speed limit) the DMS displays a DII Speed Alert, such as flashing or some other accepted means of capturing the driver's attention.

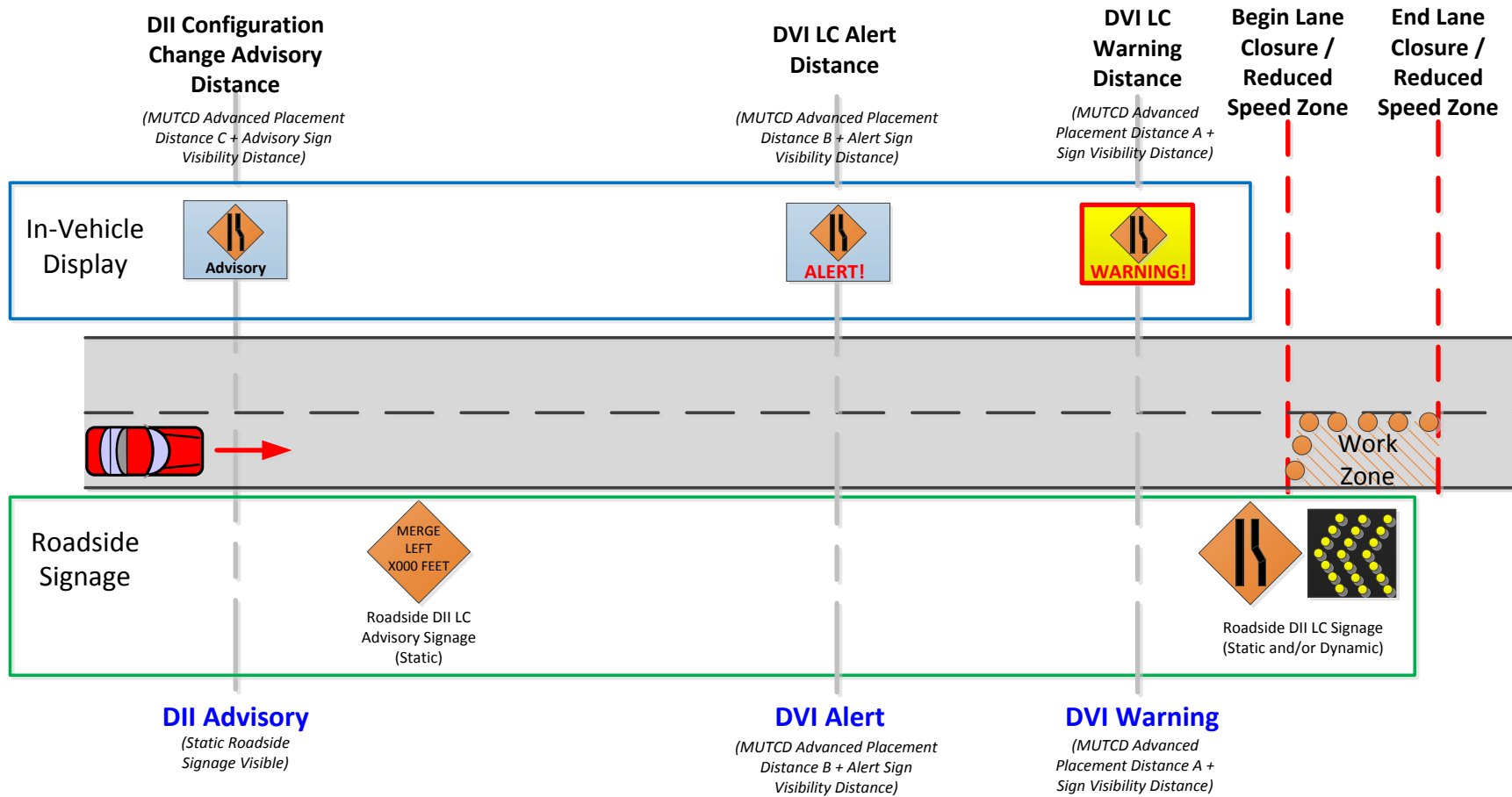
Where applicable, DII signage may also display text or graphics to indicate a changed roadway configuration such as shown in Figure 3-6. The location of these signs in advance of the Reduced Speed Zone is defined by the MUTCD advanced placement distance in Table 2C-4 and Table 6C-1. Given a changed roadway configuration, the DMS displays a DII Configuration Change Advisory. (It is assumed that the infrastructure does not include sensors to detect vehicles in closing lanes that would be necessary to support Lane Closure alerts).

For RSZW/LC deployments with changed roadway configurations, appropriate advisory and alert signage may be displayed simultaneously if configuration changes coincide with reduced speeds, or may be staggered if they don't.



Source: Battelle

Figure 3-2. Illustration of Reduced Speed Zone Roadside and In-Vehicle Signage, with Integrated Road Configuration Change Advisory



Source: Battelle

Figure 3-3. Illustration of Lane Closure Roadside Signage and In-Vehicle Advisory, Alert and Warning



Source: MUTCD 2009 Ed.

Figure 3-4. Example of Signs used to Indicate a Reduction in the Speed Limit Ahead for Various Types of Speed Zones



Source: WorkZoneSafety.org

Figure 3-5. Example of Dynamic Message Sign Alert at a Reduced Speed Zone for a Work Zone that Involves a Change in Roadway Configuration



Source: MUTCD 2009 Ed.

Figure 3-6. Example of Signs used to Indicate a Changed Roadway Configuration Involving a Lane Closure

The box above the vehicle and road in Figure 3-2 and Figure 3-3, illustrates the coordinated in-vehicle RSZW/LC signage. This illustration assumes the vehicle includes a graphical Driver Vehicle Interface (DVI) display. As the vehicle approaches the Reduced Speed Zone as illustrated in Figure 3-2, the RSZW/LC Vehicle Application Component receives a wireless message from the infrastructure containing infrastructure data and collects applicable speed and other necessary data from the vehicle. At approximately the same time that a driver would observe the static roadside advisory signs for reduced speed, the DVI displays an advisory message containing that information. (The distance at which the RSZW/LC Advisories are displayed in the vehicle in advance of the Reduced Speed Zone is the MUTCD “Sign Visibility Distance” plus the MUTCD Advanced placement Distance in Table 2C-4 and Table 6C-1, respectively). If no speed alerts or warnings are warranted subsequently, the DVI continues to display the RSZW/LC Speed Advisory continuously until the vehicle exits the Reduced Speed Zone.

If the vehicle approaches above the RSZW/LC DII Alert Speed, (i.e., posted speed limit) beyond the point where aggressive braking is required to achieve the DII Alert Speed prior to entering the Reduced Speed Zone, a DII Speed Alert is issued by the DVI. If the vehicle decelerates to the RSZW/LC DII Alert Speed before the Speed Alert Distance thresholds are crossed, no DVI alerts are issued. As noted earlier, an RSZW/LC Speed Advisory is displayed by default through the end of the zone.

When roadway configuration changes, such as lane shifts and lane closures, occur within Reduced Speed Zones, the DVI displays configuration change advisories simultaneously with reduced speed advisories and alerts. Configuration change advisories are displayed at distances defined by the MUTCD. The DVI continues to display the DII Configuration Change Advisory until the end of the configuration change.

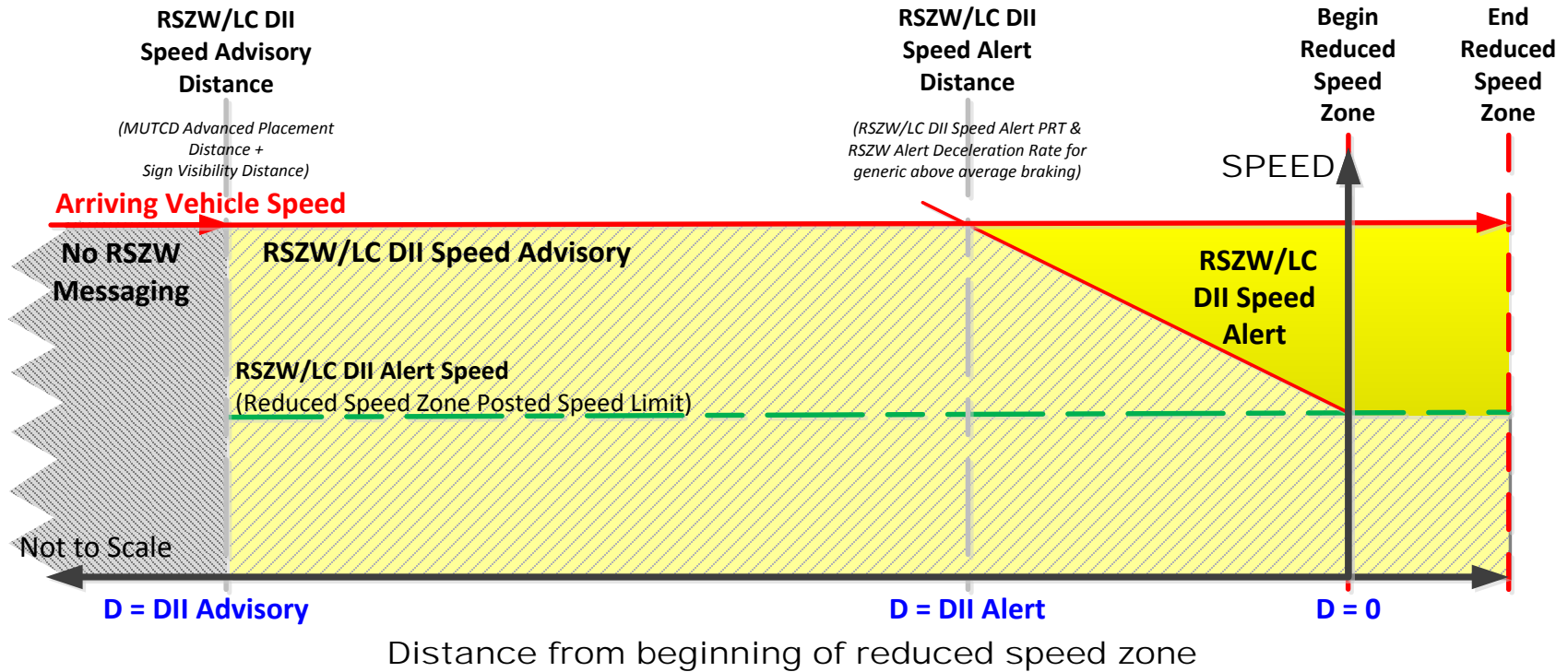
Figure 3-3 illustrates the roadside and in-vehicle signage for the case where the roadway configuration change is a lane closure *and* lane-level accuracy position and map are available. In this case when the subject vehicle fails to change lanes the RSZW/LC Vehicle Application Component issues a Lane Closure Alert and a Lane Closure Warning to the driver. The RSZW/LC DVI Lane Closure Alert Distance is a distance at which the vehicle *should have already merged* into a through lane prior to the entrance to the Reduced Speed Zone. The RSZW/LC DVI Lane Closure Warning Distance is the safety critical distance at which the vehicle *must merge immediately* to avoid a collision at the merge point. The Alert and Warning Distances are not vehicle specific, but are based on the MUTCD Advanced placement Distance in Table 6C-1. The warning continues until the vehicle exits the closing lane. If the vehicle merges into a through lane before the Alert or Warning Distance thresholds are crossed, no RSZW/LC DVI Lane Closure alerts or warnings are issued.

In-vehicle alert messages are given precedence (i.e., appearing before or first in the message) over advisory messages. When a warning is warranted, the RSZW/LC application will display the warning message by itself.

Figure 3-7 illustrates speed advisories and alerts displayed within the vehicle as a function of vehicle speed and distance from the entrance to the Reduced Speed Zone. The DII Speed Advisory Distance is based upon the MUTCD advanced placement distance and the sign visibility distance. The RSZW/LC DII Speed Alert Distance is the distance at which *above average braking* is required by a *generic vehicle* to achieve the DII Alert Speed at the entrance to the Reduced Speed Zone. The DII Alert Speed, DII Speed Alert perception reaction time (PRT) and DII Speed Alert Deceleration Rate (for generic worst case vehicles) are supplied to the vehicle application component by the infrastructure for RSZW/LC messages.

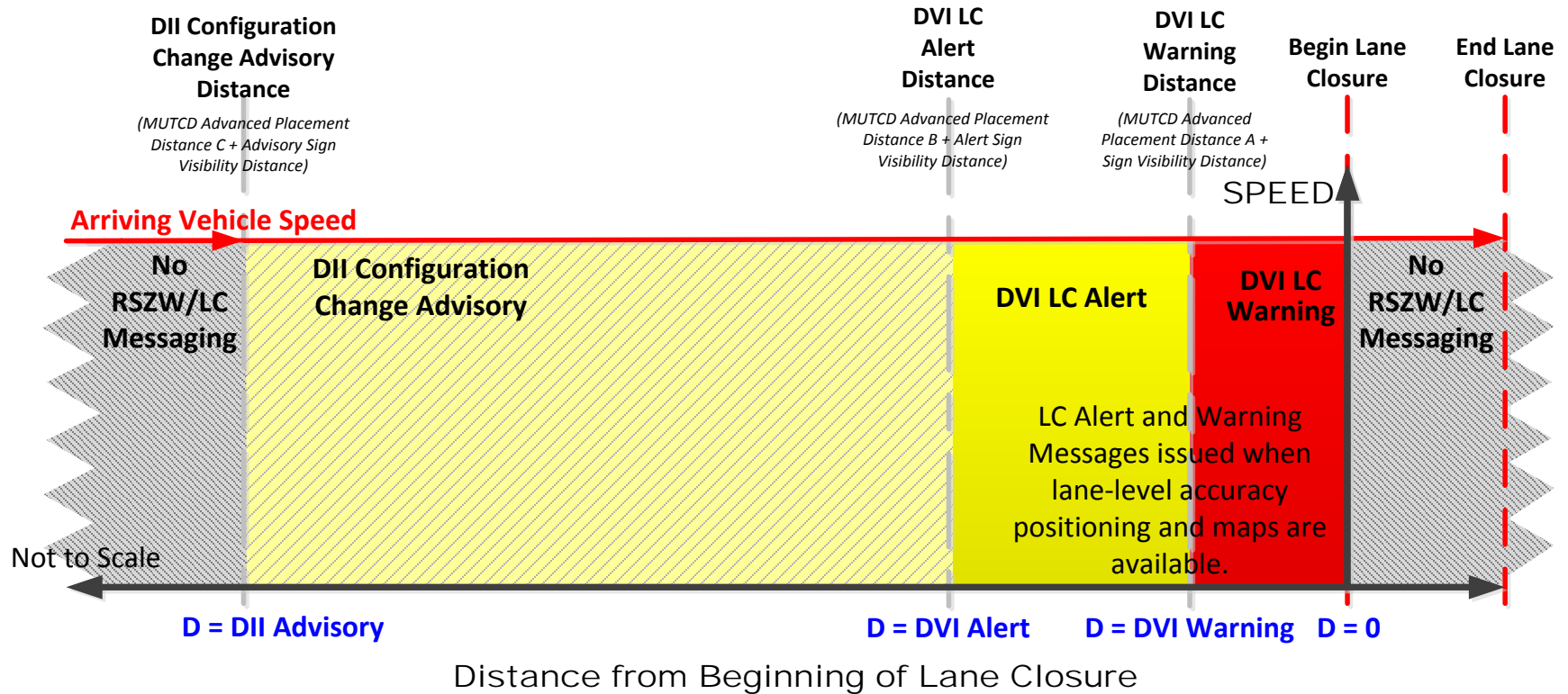
Figure 3-8 illustrates Lane Closure advisories, alerts, and warnings displayed within the vehicle as a function of vehicle distance from the end of the lane. It illustrates the DVI Lane Closure Alert Distance and the DVI Lane Closure Warning Distance, which are functions of MUTCD Advanced Placement Distances and sign visibility distances. The distances at which Reduced Speed alerts and Lane Closure alerts are issued are not expected to coincide.

Table 3-1 provides definitions of the terms used here for the RSZW/LC advisories, alerts and warnings. Table 3-2 provides a tabular summary of the RSZW/LC DII and DVI display advisory, alert and warning criteria, display signage and their distances from the entrance to the Reduced Speed Zone and, where applicable, the end of the lane. It is expected that, when a road configuration or lane closure message is present, it coincides with a reduced speed message. With the exception of warnings, the two messages are expected to be shown simultaneously. In general, alerts have priority over advisories. Because Lane Closure is considered crash imminent while Reduced Speed is not, Lane Closure messaging has priority over Reduced Speed. As the only warning for this application, Lane Closure Warning is the exception and is shown by itself with no other messaging.



Source: Battelle

Figure 3-7. Illustration of In-vehicle Signage as a Function of Vehicle Speed and Distance from Beginning of Reduced Speed Zone, with or without a Change in Roadway Configuration



Source: Battelle

Figure 3-8. Illustration of In-vehicle Signage as a Function of Vehicle Speed and Distance from Start of Reduced Speed Zone that Includes a Change in Roadway Configuration

Table 3-1. Definition of RSZW/LC Terms

RSZW/LC DII Speed Advisory	Informative signage indicating a Reduced Speed Zone ahead.
RSZW/LC DII Alert Speed	The posted speed limit within the Reduced Speed Zone.
RSZW/LC DII Speed Alert	Dynamic signage indicating the speed of an approaching vehicle is either traveling at a speed greater than the posted speed limit of the Reduced Speed Zone (i.e., RSZW/LC DII Alert Speed) or that a generic worst case vehicle must apply above average braking to transition to the reduced posted speed limit at the beginning of the reduced speed limit zone.
RSZW/LC DII Speed Alert Distance	Generic, infrastructure-based recommendation for distance at which to display RSZW/LC DII Speed Alert in the vehicle DVI. Distance at which above average braking is required by a generic worst case vehicle to achieve the DII Alert Speed at the entrance to the reduced speed zone. Dependent upon RSZW/LC DII Speed Alert PRT, RSZW/LC DII Speed Alert Deceleration Rate, and current environmental conditions.
RSZW/LC DII Speed Alert PRT	Generic, infrastructure-based recommendation for Perception Reaction Time used in computing DII Alert Distance.
RSZW/LC DII Speed Alert Deceleration Rate	Generic, infrastructure-based recommendation regarding vehicle deceleration rate to the reduced posted speed limit used in computing DII Speed Alert Distance.
RSZW/LC DII Configuration Change Advisory	Informative signage indicating a roadway configuration change ahead in the Reduced Speed Zone. Displayed in conjunction with appropriate RSZW/LC DII Speed Advisory or RSZW/LC DII Speed Alert, but given precedence over RSZW/LC DII Speed Advisory.
RSZW/LC DVI Lane Closure Alert	In vehicle display indicating to the subject vehicle an escalating need to change lanes prior to the Reduced Speed Zone with a changed roadway configuration. Displayed in conjunction with, but given precedence over, appropriate RSZW/LC DII Speed Advisory or RSZW/LC DII Speed Alert.
RSZW/LC DVI Lane Closure Alert Distance	Vehicle specific recommendation for distance at which to display RSZW/LC DVI LC Alert in the vehicle DVI. Distance based on MUTCD Table 6C-1 and local work zone temporary traffic control plan.
RSZW/LC DVI Lane Closure Warning	In vehicle display indicating to the subject vehicle an urgent need to change lanes prior to the imminent end of lane. Takes precedence over any RSZW/LC DII Speed Advisory or RSZW/LC DII Speed Alert message and is displayed alone.
RSZW/LC DVI Lane Closure Warning Distance	Vehicle specific recommendation for distance at which to display RSZW/LC DVI LC Warning. Distance at which immediate action is required by the subject vehicle to avoid imminent collision at the end of lane. Distance based on MUTCD Table 6C-1 and local work zone temporary traffic control plan.

Source: Battelle

Table 3-2. Summary of RSZW/LC Infrastructure and Vehicle Displays

	Driver Infrastructure Interface			Driver Vehicle Interface		
	Display Criterion	Display Signage	Distance from Entrance	Display Criterion	Display Signage*	Distance from Entrance
Reduced Speed Advisory (Road-level positioning accuracy)	Approaching Reduced Speed Zone	DII Speed Reduction Advisory: all vehicle advisory to reduce speed to RSZW/LC DII Alert Speed	MUTCD Advanced Placement Distance	Received RSZW/LC I2V Wireless Message	DII Speed Reduction Advisory: display all vehicle advisory to reduce speed to the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.	MUTCD Advanced Placement Distance + Sign Visibility Distance
Reduced Speed Alert (Infrastructure-all vehicles) (Road-level positioning accuracy)	Infrastructure detected speed of an approaching vehicle is above the RSZW/LC DII Alert Speed and a worst case vehicle must apply above average braking to achieve RSZW/LC DII Alert speed prior to entering the Reduced Speed Zone.	DII Speed Reduction Alert: all vehicle alert to reduce speed to the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.	MUTCD Advanced Placement Distance	Received RSZW/LC I2V Wireless Message indicating infrastructure detected speed of an approaching vehicle is above the RSZW/LC DII Alert Speed and a worst case vehicle must apply above average braking to achieve RSZW/LC DII Alert speed prior to entering the Reduced Speed Zone.	DII Speed Reduction Alert: all vehicle alert to reduce speed to the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.	Distance at which above average braking is required by a worst case vehicle to achieve the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.
Reduced Speed Alert-Vehicle Specific	NA	NA	NA	Received RSZW/LC I2V Wireless Message. Subject vehicle within distance at which above average braking is required to achieve the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.	DVI Speed Reduction Alert: vehicle-specific alert to reduce speed to the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.	Distance at which above average braking is required by subject vehicle to achieve the RSZW/LC DII Alert Speed prior to entering the Reduced Speed Zone.

Table 3-2. Summary of RSZW/LC Infrastructure and Vehicle Displays (Continued)

	Driver Infrastructure Interface			Driver Vehicle Interface		
	Display Criterion	Display Signage	Distance from Entrance	Display Criterion	Display Signage*	Distance from Entrance
Configuration Change Advisory (Road-level positioning accuracy)	Approaching Changed Roadway Configuration within a Reduced Speed Zone	DII Configuration Change Advisory: all vehicle advisory of upcoming change in roadway configuration (i.e. lane closure or lane shift)	MUTCD Advanced Placement Distance C	Received RSZW/LC I2V Wireless Message	DII Configuration Change Advisory: display all vehicle advisory of upcoming change in roadway configuration (i.e. lane closure or lane shift)	MUTCD Advanced Placement Distance + Sign Visibility Distance
Lane Closure Alert – Vehicle-specific (priority)	NA	NA	NA	Subject vehicle is in a non-through lane and the vehicle must merge prior to lane termination.	DVI Lane Closure Alert: vehicle-specific alert to merge into a through lane prior to lane termination.	Distance at which subject vehicle should already have merged into a through lane prior to lane termination.
Lane Closure Warning (priority)	N/A	N/A	N/A	Received RSZW/LC I2V Wireless Message. Received Lane Level Accuracy position and Lane Closure Map. Subject vehicle is in a non-through lane and must merge immediately to avoid a collision at the lane termination.	DVI Lane Closure Warning: vehicle-specific warning to merge into a through lane prior to lane termination.	Distance at which subject vehicle must merge immediately to avoid a collision at the lane termination.

Note: where applicable, a reduced speed message and a lane closure message may be displayed together on the DII and DVI. In general, alerts have priority over advisories. Because Lane Closure is considered crash imminent while Reduced Speed is not, Lane Closure messaging has priority over Reduced Speed messaging. As the only warning for this application, Lane Closure Warning is shown by itself with no other messaging.

Source: Battelle

3.3.1.5 Application Assumptions and Considerations

Assumptions

- The vehicle is driving along a route equipped with a RSZW/LC application.
- The vehicle is traveling on a route that will require it to drive through a Reduced Speed Zone.
- The Reduced Speed Zone is marked with a posted speed limit.
- The RSZW/LC application may be used in conjunction with other connected vehicle applications.
- The timing for issuing RSZW/LC advisory and alert messages regarding the need to change lanes and reduce speed may not occur at the same time.
- RSZW/LC Alert and Warning messages will only be issued in the vehicle if lane-level positioning and lane level map information is available for a lane closure deployment.
- In the case of an equipped vehicle, if any data element is unavailable for calculating an appropriate speed, a previously determined default value will be used by the application to compute a safe speed.
- The application is intended for regulatory speed limits.
- The “Reduced Speed Zone” category encompasses any segment of roadway that is temporarily subject to reduced speeds, which includes but is not limited to construction/work zones, and school zones.
- Some Reduced Speed Zones, such as a school zone, may only be applicable for specific times of day, days of week, or seasonal changes in speed.
- In the case of a work zone, the work zone may be susceptible to both speed reductions and roadway configuration changes (e.g., lane closures, lane shifts).
- The roadway leading up to the Reduced Speed Zone includes static and/or dynamic signage warning the vehicle of the reduced speed (and when necessary roadway configuration changes).

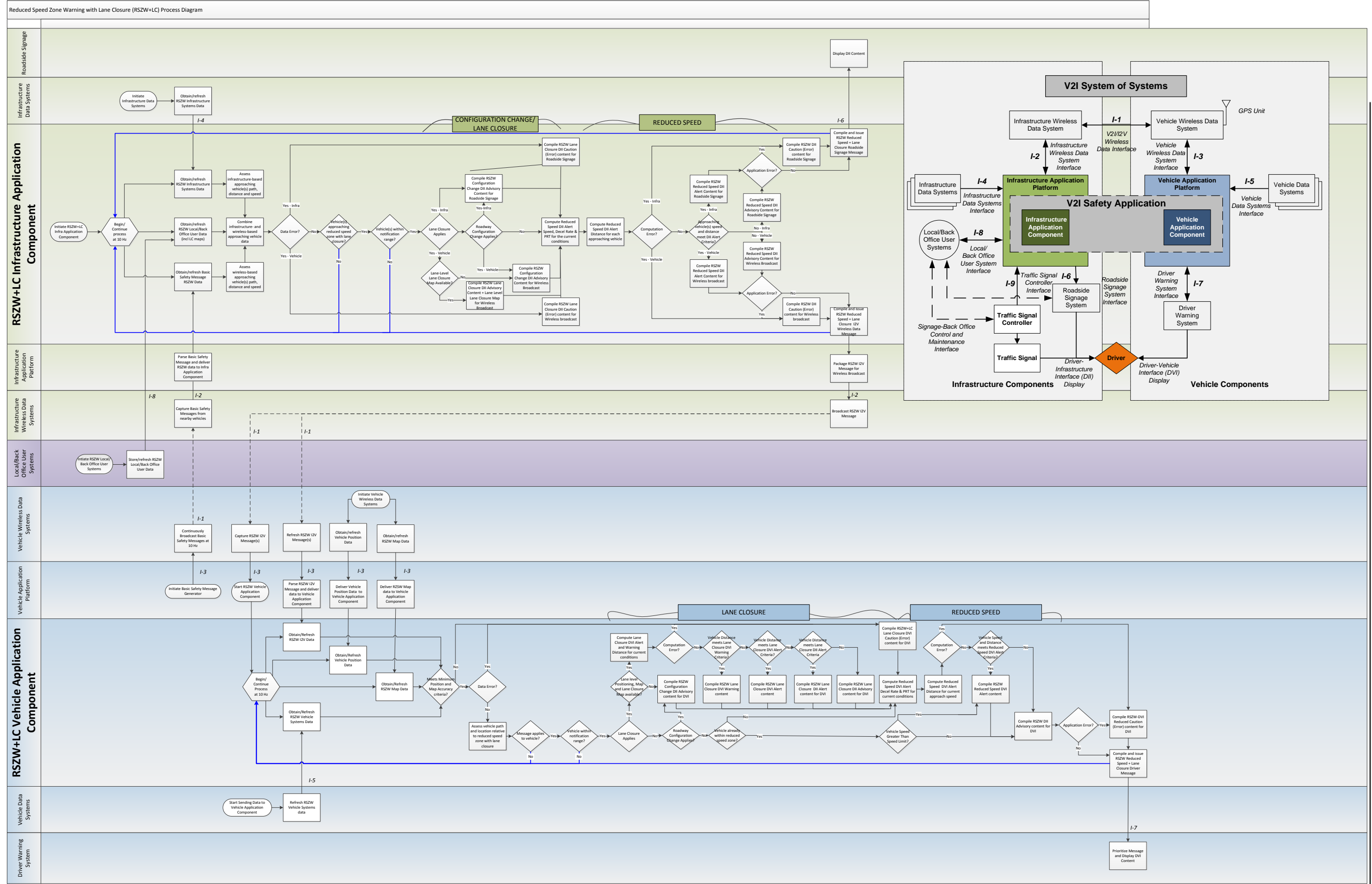
Considerations

The RSZW/LC system is intended to advise and alert the equipped vehicle only about the Reduced Speed Zone, with additional advisory, alert, and warning messages when changes in roadway configuration are present. The system does not consider other drivers on the roadway or their driving behavior.

3.3.1.6 Application Swim Lane & Sequence Diagrams

As the next step in the description of the RSZW/LC Application, Figure 3-9 provides a swim-lane process diagram for the RSZW/LC application, including the processes for deployments with changes in roadway configuration, illustrating the sequence of data flows and processing by the RSZW/LC Infrastructure Application Component and the RSZW/LC Vehicle Application Component. The figure includes the V2I Systems Architecture diagram presented earlier for reference.

At a high level, the RSZW/LC Infrastructure Application Component obtains infrastructure, local/back office and vehicle data inputs, determines whether or not a change in roadway configuration is present, and if an advisory or alert is warranted, and, if so, issues a RSZW/LC Roadside Signage Message to the Roadside Signage System for display and a RSZW/LC I2V Wireless Data Message to the Infrastructure Wireless Data System for broadcast to nearby vehicles. Upon receipt of a RSZW/LC I2V Wireless Data Message, the Vehicle Application Platform initiates the RSZW/LC Vehicle Application Component. The RSZW/LC Vehicle Application Component obtains I2V, position and map data inputs, determines if a driver alert or warning is warranted and, if so, issues a RSZW/LC Driver Warning Message to the Driver Warning System. These processes are performed at a rate of 10 Hz to update RSZW/LC Roadside Signage Message and the RSZW/LC Driver Warning Message to drivers whose vehicles are rapidly approaching the Reduced Speed Zone and may be rapidly changing speed. These diagrams illustrate the concepts that are the basis for RSZW/LC application requirements enumerated in section 3.5.2 and 3.5.3.



Source: Battelle

3.3.1.7 Messages Exchanged and Used by the Application

For the purposes of these requirements, the data exchanged between system components, across system interfaces are encapsulated in ten messages summarized in Table 3-3 below. The table summarizes the message name, the source and recipient of the message, general description of the message content, location for description of data elements, and purpose of the message. In some cases such as the Basic Safety Message, the message is defined in an existing standard, such as SAE J2735. For further reference and background information, Appendix A suggests candidate data elements which may be included in these messages to support the RSZW/LC safety application algorithms. Table A-1 provides an explanation of the headers in candidate data tables. As noted in Table 3-3, Table A-2 through Table A-7 describe the candidate data elements for each of the messages. This information is provided for guidance when implementing the performance requirements specified in this document.

Table 3-3. Summary of Messages used by RSZW/LC Application Components

Message	Input Source	Output Recipient	Content Utilized	Data Description	Purpose
Infrastructure Component Messages					
RSZW/LC Infrastructure Systems Message	External Vehicle Detection System, Infra Data System – Vehicle Speeds	Infra Application Component	Detection of approaching vehicles and their speed	Table A-2 RSZW/LC Infrastructure Systems Message Data Description	Used as input by RSZW/LC Infrastructure Application Component to determine if vehicles are approaching the Reduced Speed Zone and their speed and distance.
RSZW/LC Roadside Signage Message	Infra Application Component	Roadside Signage System	RSZW/LC Roadside Signage message content	Table A-3 RSZW/LC Roadside Signage Message Data Description	RSZW/LC message content to be displayed on dynamic roadside signage.
RSZW/LC Infrastructure Map Message	Local-Back Office Users Systems Interface	Infrastructure Map Message Handler	Detailed map of Reduced Speed Zone and roadway geometry, road-level or lane-level accuracy	Table A-4 RSZW/LC Map Message Data Description	Used as input by RSZW/LC Vehicle Application Component to determine if subject vehicle is approaching the Reduced Speed Zone and to assess the roadway configuration. Location of fixed and variable signage. May be uploaded through an externally generated data file.
V2I/I2V Messages					
Basic Safety Message	Vehicle Basic Safety Message Generator	Infrastructure Application Component	Vehicle location, speed and heading	SAE J2735 Basic Safety Message	Data used by Infrastructure Application Component to determine if vehicles are approaching Reduced Speed Zone and, if so, their speed.
RSZW/LC I2V Wireless Message	Infra Application Component	Vehicle Application Component	RSZW/LC Operational Data	Table A-5 RSZW/LC I2V Wireless Message Data Description	Data used by vehicle application component to determine the applicable time and location of the RSZW/LC advisories, alerts, and warnings.
RSZW/LC Wireless Map	Infrastructure Map Message Handler	Vehicle Application	Detailed map of Reduced Speed	Table A-4 RSZW/LC Map Message Data	Used as input by RSZW/LC Vehicle Application Component to determine if subject vehicle is approaching the reduced

Table 3-3. Summary of Messages used by RSZW/LC Application Components (Continued)

Message	Input Source	Output Recipient	Content Utilized	Data Description	Purpose
Message		Component	Zone and roadway geometry, road-level or lane-level accuracy.	Description	speed zone and if advisories, alerts and warnings are warranted.
Wireless Position Correction Message	Infrastructure Position Correction Message Handler	Vehicle GPS Message Handler	Differential GPS Correction Data	SAE J2735 RTCM Corrections Message	Used as input by vehicle application component to determine if advisories, alerts and warnings are warranted.
Vehicle Component Messages					
GPS Position Message	Vehicle GPS Position Message Handler	Vehicle Application Component	Location, speed, heading of subject vehicle	SAE J2735 Full Position Vector	Use by the RSZW/LC Vehicle Application Component to determine vehicle position, speed and heading to determine if and when to issue advisories, alerts, or warnings.
RSZW/LC Vehicle Systems Message	Vehicle Data Systems	Vehicle Application Component	Vehicle Characteristics, Vehicle Functional Status	Table A-6 RSZW/LC Vehicle Systems Message Data Description	Used as input by RSZW/LC Vehicle Application Component to determine the vehicle speed.
RSZW/LC Driver Warning Message	Vehicle Application Component	Driver Warning System	RSZW/LC in-vehicle message content	Table A-7 RSZW/LC Driver Warning Message Data Description	RSZW/LC message content to be displayed on in-vehicle displays.

Source: Battelle

3.3.2 RSZW/LC Infrastructure Application Component Requirements

Table 3-4 catalogs the performance requirements for the RSZW/LC Infrastructure Application Component. These were developed based upon the integration strategy described in Section 3.3.1.4 above. It is expected that, as connected vehicle technology evolves and vehicle and infrastructure application component owners develop this and other V2I Safety Applications, the rationales, frameworks, and performance requirements presented here will evolve. Accordingly, before embarking upon design and development, application owners should update and refine the requirements to reflect current standards and policies. It is the responsibility of the designer to ensure that the resulting applications do not conflict with applicable published state and national regulations, policies, and guidelines

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
4.01	RSZW/LC Infrastructure Application Component Requirements			
4.01.01	RSZW/LC Infrastructure Application Component Interfaces and Interface Specifications			
[4.01.01.01]	RSZW/LC Infrastructure Systems Message Interface	The RSZW/LC Infrastructure Application Component shall obtain RSZW/LC Infrastructure Systems Messages through the Infrastructure Data Systems Interface.		D
[4.01.01.02]	Basic Safety Message Interface	The RSZW/LC Infrastructure Application Component shall obtain Basic Safety Messages through the Infrastructure Wireless Data Systems Interface.		D
[4.01.01.03]	RSZW/LC Local/Back Office User Data Interface	The RSZW/LC Infrastructure Application Component shall obtain RSZW/LC Local/Back Office User Data through the Local/Back Office User Systems Interface.		D
[4.01.01.04]	RSZW/LC I2V Wireless Message Interface	The RSZW/LC Infrastructure Application Component shall issue RSZW/LC I2V Wireless Messages through the Infrastructure Wireless Data Systems Interface.		D
[4.01.01.05]	RSZW/LC Roadside Signage Message Interface	The RSZW/LC Infrastructure Application Component shall issue RSZW/LC Roadside Signage Messages through the Roadside Signage System Interface.		D
4.01.02	RSZW/LC Infrastructure Application Component Functional Requirements			
[4.01.02.01]	Common Infrastructure Application Component Requirements	The RSZW/LC Infrastructure Application Component shall adhere to Common Infrastructure Application Component Requirements.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.02]	RSZW/LC Infrastructure Systems Message Initiation	The RSZW/LC Infrastructure Application Component shall obtain RSZW/LC Infrastructure Systems Messages upon initiation of the component.		D
[4.01.02.03]	RSZW/LC Infrastructure Systems Data – Vehicle Speed	The RSZW/LC Infrastructure Application component shall obtain speed and distance of approaching vehicles from Infrastructure Data Systems before the vehicles are within the RSZW/LC DII Advisory Distance of the reduced speed or lane closure zone entrance.	<p><i>The RSZW/LC DII Advisory Distance is the distance from the beginning of the reduced speed or lane closure zone defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.</i></p> <p><i>The RSZW/LC Infrastructure Application component does not correlate connected vehicle and infrastructure data. It processes each independently and issues advisories or alerts if any vehicle meets the relevant criteria.</i></p>	D
[4.01.02.04]	RSZW/LC Infrastructure Systems Message Refresh Rate	The RSZW/LC Infrastructure Application Component shall refresh the RSZW/LC Infrastructure Systems Message at a configurable frequency.	<i>Table (RSZW/LC Infrastructure) RSZW/LC Infrastructure Systems Data Description is referenced for guidance.</i>	D
[4.01.02.05]	Basic Safety Message Initiation	The RSZW/LC Infrastructure Application Component shall obtain Basic Safety Messages upon initiation of the component.	<i>The RSZW/LC Infrastructure Application component does not correlate connected vehicle and infrastructure data. It processes each independently and issues advisories or alerts if any vehicle meets the relevant criteria.</i>	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.06]	Basic Safety Message Vehicle Speed	The RSZW/LC Infrastructure Application component shall obtain speed and distance of approaching vehicles from Basic Safety Messages before the vehicles are within the RSZW/LC DII Advisory Distance of the reduced speed or lane closure zone entrance.	<i>The RSZW/LC DII Advisory Distance is the distance from the beginning of the reduced speed or lane closure zone defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.</i> <i>The RSZW/LC Infrastructure Application component does not correlate connected vehicle and infrastructure data. It processes each independently and issues advisories or alerts if any vehicle meets the relevant criteria.</i>	D
[4.01.02.07]	Basic Safety Message Refresh Rate	The RSZW/LC Infrastructure Application Component shall refresh Basic Safety Messages at a configurable frequency.	<i>Table (RSZW/LC Local-Back Office) RSZW/LC Local-Back Office User Systems Data Description is referenced for guidance.</i>	D
[4.01.02.08]	RSZW/LC Local/Back Office User Data Initiation	The RSZW/LC Infrastructure Application Component shall obtain RSZW/LC Local/Back Office User Data upon initiation of the component.		D
[4.01.02.09]	GPS Position Accuracy	GPS Position data used by the RSZW/LC Vehicle Application Component shall be of at least Road Level Position Accuracy.	<i>Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.</i>	D
[4.01.02.10]	RSZW/LC Local/Back Office User Data Refresh Rate	The RSZW/LC Infrastructure Application Component shall refresh RSZW/LC Local/Back Office User Data at a configurable frequency.	<i>Table (RSZW/LC Local-Back Office) RSZW/LC Local-Back Office User Systems Data Description is referenced for guidance.</i>	D
[4.01.02.11]	GPS Position Accuracy for Lane Closure	GPS Position data used by the RSZW/LC Vehicle Application Component for Lane Closure calculations shall be of at least Lane Level Position Accuracy.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.12]	Map Data Accuracy	Map data used by the RSZW/LC Infrastructure Application Component shall be of at least Road Level Position Accuracy.	<i>Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.</i>	D
[4.01.02.13]	Map Data Accuracy	Map data used by RSZW/LC Vehicle Application Component shall be of at least Road Level Position Accuracy.	<i>Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.</i>	D
[4.01.02.14]	Map Data Accuracy for Lane Closure	Map data used by the RSZW/LC Infrastructure Application Component for Lane Closure Calculations shall be of at least Lane Level Position Accuracy.	<i>Lane Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.</i>	D
[4.01.02.15]	Map Data Accuracy for Lane Closure	Map data used by the RSZW/LC Vehicle Application Component for Lane Closure calculations shall be of at least Lane Level Position Accuracy.		D
[4.01.02.16]	Approaching Vehicle Characterization	The RSZW/LC Infrastructure Application Component shall assess RSZW/LC Infrastructure Data and RSZW/LC Vehicle Data and determine if vehicle(s) are approaching the speed zone, if so, the distance and approaching speed of each.		D
[4.01.02.17]	Determine whether Lane Closure is applicable	The RSZW/LC Infrastructure Application Component shall assess local/back office data to determine if Roadway Configuration Change is applicable and if Lane Closure is applicable.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.18]	RSZW/LC Configuration Change DII Advisory Distance Definition	The RSZW/LC Configuration Change DII Advisory Distance shall be the distance from the beginning of the Configuration Change defined in the MUTCD Table 6C-1, "Recommended Advanced Warning Sign Minimum Spacing" as the MUTCD Advanced Placement Distance C plus the Advisory Sign Visibility Distance.		D
[4.01.02.19]	Compute RSZW/LC Configuration Change DII Advisory Distance	If Roadway Configuration Change or Lane Closure is applicable, the RSZW/LC Infrastructure Application Component shall determine the RSZW/LC Configuration Change DII Advisory Distance based upon MUTCD guidelines.		D
[4.01.02.20]	RSZW/LC DII Content General	RSZW/LC DII content shall use a prohibitive frame, indicating that conditions may be unsafe.	<i>RSZW/LC DII content shall not indicate that conditions are safe.</i>	D
[4.01.02.21]	RSZW/LC Configuration Change DII Advisory Criterion for Roadside Signage	If Roadway Configuration Change or Lane Closure is applicable and if the distance of any approaching vehicle is less than the RSZW/LC Configuration Change DII Advisory Distance then the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC Roadside Signage Message containing a current RSZW/LC Configuration Change DII Advisory to the Roadside Signage System Interface.	<i>A DII Advisory message is issued to Roadside Signage Systems and Wireless Data Systems when a vehicle is within sight of an advisory sign (static). Assumption: Application includes one static advisory sign and one DMS sign (which, when on, flashes either an advisory or an alert)</i>	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.22]	RSZW/LC Configuration Change DII Advisory Criterion for I2V Message if Lane-Level Accuracy is unavailable	If Roadway Configuration Change is applicable or if Lane Closure is applicable, and if the distance of any approaching vehicle is less than the RSZW/LC Configuration Change DII Advisory Distance then the RSZW/LC Infrastructure Application Component shall issue an RSZW/LC I2V Message containing an RSZW/LC Configuration Change DII Advisory to the Infrastructure Wireless Data Systems Interface.		D
[4.01.02.23]	RSZW/LC Infrastructure Application Component Caution (Error) Message for Lane Closure for Roadside Signage Criterion	In the event of an input data, computational or other recoverable RSZW/LC Infrastructure Application Component error, preventing issuing of RSZW/LC DII advisories the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC Roadside Signage Message containing an RSZW/LC DII Caution (Error) to the Roadside Signage System Interface.	<i>Caution message is displayed when denoting an error.</i>	D
[4.01.02.24]	RSZW/LC Infrastructure Application Component Caution (Error) Criterion for Lane Closure for I2V Message	In the event of an input data, computational or other recoverable RSZW/LC Infrastructure Application Component error, preventing issuing of RSZW/LC DII advisories the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC I2V Message containing a RSZW/LC DII Caution (Error) and an indication of RSZW/LC Infrastructure Application Component Error to the Infrastructure Wireless Data Systems Interface.	<i>Caution message is displayed when denoting an error.</i>	D
[4.01.02.25]	Determine RSZW/LC Reduced Speed DII Alert Speed	The RSZW/LC Reduced Speed DII Alert Speed shall be equal to the posted speed limit of the reduced speed zone for which the RSZW/LC application applies.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.26]	Determine RSZW/LC Reduced Speed DII Alert Deceleration Rate	The RSZW/LC Infrastructure Application Component shall determine the RSZW/LC Reduced Speed DII Alert Deceleration Rate.	<i>The following information is referenced for guidance: 0.34g is the uniform deceleration rate required to safely stop a fully loaded (new) tractor trailer as defined in NHTSA FMVSS 121. 0.56g is the uniform deceleration rate required to safely stop a fully passenger vehicle as defined in NHTSA FMVSS 135. Industry guidelines and/or local policy should provide guidance on deceleration rates for specific circumstances.</i>	D
[4.01.02.27]	Determine RSZW/LC Reduced Speed DII Alert Perception Reaction Time	The RSZW/LC Infrastructure Application Component shall determine the RSZW/LC Reduced Speed DII Alert Perception Reaction Time.	<i>National Cooperative Highway Research Program (NCHRP) Report 600A "Human Factors Guidelines for Road Systems" is referenced for Guidance.</i>	D
[4.01.02.28]	RSZW/LC Reduced Speed DII Advisory Distance Definition	The RSZW/LC Reduced Speed DII Advisory Distance shall be the distance from the beginning of the speed zone defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.	<i>The DII Advisory Distance for reduced speed is typically static, defined by the MUTCD Table 2C-4.</i>	D
[4.01.02.29]	RSZW/LC Reduced Speed DII Alert Distance Definition	The RSZW/LC Reduced Speed DII Alert Distance shall be the distance traveled during the RSZW/LC Reduced Speed DII Alert Perception Reaction Time plus the distance required to slow the detected vehicle from its measured speed to the RSZW/LC Reduced Speed DII Alert Speed, at a uniform deceleration equal to the RSZW/LC Reduced Speed DII Alert Deceleration Rate.	<i>The following information is referenced for guidance: 0.34g is the uniform deceleration rate required to safely stop a fully loaded (new) tractor trailer as defined in NHTSA FMVSS 121. 0.56g is the uniform deceleration rate required to safely stop a fully passenger vehicle as defined in NHTSA FMVSS 135. Industry guidelines and/or local policy should provide guidance on deceleration rates for specific circumstances.</i>	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.30]	Compute RSZW/LC Reduced Speed DII Advisory Distance	The RSZW/LC Infrastructure Application Component shall determine the RSZW/LC Reduced Speed DII Advisory Distance based upon MUTCD guidelines.		D
[4.01.02.31]	Compute RSZW/LC Reduced Speed DII Alert Distance	The RSZW/LC Infrastructure Application Component shall compute the RSZW/LC Reduced Speed DII Alert Distance for each approaching vehicle using the RSZW/LC Reduced Speed DII Alert Speed, the RSZW/LC Reduced Speed Alert Deceleration Rate and the RSZW/LC Reduced Speed DII Alert Perception Reaction Time.		D
[4.01.02.32]	RSZW/LC Reduced Speed DII Alert Criterion for Roadside Signage	If the distance of any approaching vehicle is less than its RSZW/LC Reduced Speed DII Alert Distance then the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC Roadside Signage Message containing a current RSZW/LC Reduced Speed DII Alert to the Roadside Signage Interface.	<i>The DII Alert Distance for reduced speed is negative when vehicle speeds are below the DII Alert Speed for reduced speed, such that no alert is issued.</i>	D
[4.01.02.33]	RSZW/LC Reduced Speed DII Advisory Criterion for Roadside Signage	If the distance of any approaching vehicle is less than the RSZW/LC Reduced Speed DII Advisory Distance and greater than or equal to its RSZW/LC Reduced Speed DII Alert Distance then the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC Roadside Signage Message containing a current RSZW/LC Reduced Speed DII Advisory to the Roadside Signage Interface.	<i>A DII Advisory message is issued to Roadside Signage Systems and Wireless Data Systems when a vehicle is within sight of an advisory sign (static). Assumption: Application includes one static advisory sign and one DMS sign (which, when on, flashes either an advisory or an alert)</i>	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.34]	Issue RSZW/LC Roadside Signage Message	If an RSZW/LC Configuration Change Advisory, RSZW/LC Reduced Speed Advisory, RSZW/LC Reduced Speed Alert, or RSZW/LC Caution (Error) is warranted, the RSZW/LC Infrastructure Application Component shall issue an RSZW/LC Roadside Signage Message, containing the appropriate content of both, to the Roadside Signage System Interface.	<i>A DII Advisory message for reduced speed is issued to Roadside Signage and Wireless Data based on the MUTCD advanced placement distance plus advisory sign visibility distance.</i>	D
[4.01.02.35]	RSZW/LC Reduced Speed DII Alert Criterion for I2V Message	If the distance of any approaching vehicle is less than its RSZW/LC Reduced Speed DII Alert Distance then the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC I2V Message, containing an RSZW/LC Reduced Speed DII Alert to the Infrastructure Wireless Data Systems Interface.	<i>The DII Alert Distance for reduced speed is negative when vehicle speeds are below the DII Alert Speed for reduced speed, such that no alert is issued.</i>	D
[4.01.02.36]	RSZW/LC Reduced Speed DII Advisory Criterion for I2V Message	If the distance of any approaching vehicle is less than the RSZW/LC Reduced Speed DII Advisory Distance and greater than or equal to its RSZW/LC Reduced Speed DII Alert Distance then the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC I2V Message, containing an RSZW/LC Reduced Speed DII Advisory to the Infrastructure Wireless Data Systems Interface.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.02.37]	RSZW/LC Infrastructure Application Component Caution (Error) Message for Reduced Speed for Roadside Signage Criterion	In the event of an input data, computational or other recoverable RSZW/LC Infrastructure Application Component error, preventing issuing of RSZW/LC Reduced Speed DII advisories or RSZW/LC Reduced Speed DII alerts, the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC Roadside Signage Message containing a current RSZW/LC Reduced Speed DII Caution (Error) to the Roadside Signage System Interface.	<i>Caution message is displayed when denoting an error.</i>	D
[4.01.02.38]	RSZW/LC Infrastructure Application Component Caution (Error) Criterion for Reduced Speed for I2V Message	In the event of an input data, computational or other recoverable RSZW/LC Infrastructure Application Component error, preventing issuing of RSZW/LC Reduced Speed DII advisories or RSZW/LC Reduced Speed DII alerts, the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC I2V Message, containing an RSZW/LC Reduced Speed DII Caution (Error) to the Infrastructure Wireless Data Systems Interface.	<i>Caution message is displayed when denoting an error.</i>	D
[4.01.02.39]	Issue RSZW/LC I2V Message	If an RSZW/LC Configuration Change Advisory, RSZW/LC Reduced Speed Advisory, RSZW/LC Reduced Speed Alert, or RSZW/LC Caution (Error) is warranted, the RSZW/LC Infrastructure Application Component shall issue a RSZW/LC I2V Message, containing the appropriate content of both, to the Infrastructure Wireless Data Systems Interface.		D
[4.01.02.40]	RSZW/LC Message Type Precedence for Roadside Signage	RSZW/LC Lane Change Alerts and Warnings shall take precedence over RSZW/LC Reduced Speed Alerts when sent to the Roadside Signage System Interface.		D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
4.01.03	RSZW/LC Infrastructure Application Component Data Input Requirements			
[4.01.03.01]	RSZW/LC Infrastructure Systems Message Content	The RSZW/LC Infrastructure Systems Message shall contain data required to perform the calculations specified under RSZW/LC Infrastructure Application Functional Requirements.	Table (RSZW/LC Infrastructure) RSZW/LC Infrastructure Systems Message Data Description is referenced for guidance.	D
[4.01.03.02]	RSZW/LC Infrastructure Systems Message Specification for Vehicle Speed Sensors	The RSZW/LC Infrastructure Systems Message for capturing data from local Infrastructure-based Vehicle Speed Sensor Systems shall conform to NTCIP 1209 v02 Object Definitions for Transportation Sensor Systems (TSS).		D
[4.01.03.03]	Basic Safety Message Specification	The Basic Safety Message messages shall conform to SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary.		D
[4.01.03.04]	RSZW/LC Local/Back Office User Data Content	The RSZW/LC Local/Back Office User Data shall contain data required to perform the calculations specified under RSZW/LC Infrastructure Application Functional Requirements.	Table (RSZW/LC Infrastructure) RSZW/LC Infrastructure Systems Message Data Description is referenced for guidance.	D
[4.01.03.05]	RSZW/LC Local/Back Office User Data Specifications	The RSZW/LC Local/Back Office User Data and all Local/Back Office User System messages shall conform to Traffic Management Data Dictionary (TMDD) Standard v3.03 for the Center-to-Center Communications.		D
[4.01.03.06]	RSZW/LC Local/Back Office User Data Content Text	The RSZW/LC Local/Back Office User Data shall contain text used in RSZW/LC DII Advisory and RSZW/LC DII Alert roadway signage.		D
[4.01.03.07]	RSZW/LC Local/Back	RSZW/LC DII advisory and RSZW/LC DII alert text	Prohibitive frame means that DII advisory and	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
	Office User Data Content Prohibitive Frame	shall use a prohibitive frame indicating when unsafe conditions may exist.	<i>DII alert messages shall not indicate that conditions may be safe.</i>	
[4.01.03.08]	RSZW/LC Local/Back Office User Data Content Graphics	The RSZW/LC Local/Back Office User Data shall contain shapes and graphics used in RSZW/LC DII Advisory and RSZW/LC DII Alert roadway signage.		D
4.01.04	RSZW/LC Infrastructure Application Component Data Output Requirements			
[4.01.04.01]	RSZW/LC I2V Wireless Message Content	The RSZW/LC I2V Wireless Message shall contain data required to perform the calculations specified under RSZW/LC Vehicle Application Functional Requirements.	<i>Table (RSZW/LC Wireless) RSZW/LC I2V Wireless Message Data Description is referenced for guidance.</i>	D
[4.01.04.02]	RSZW/LC I2V Wireless Message Specification	The RSZW/LC I2V Wireless Message shall conform to SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary.		D
[4.01.04.03]	RSZW/LC I2V Wireless Message Content Text	The RSZW/LC I2V Wireless Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution (Error) text used in roadway signage.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D
[4.01.04.04]	RSZW/LC I2V Wireless Message Prohibitive Frame	The RSZW/LC I2V Wireless Message content (RSZW/LC DII advisory, RSZW/LC DII alert, and RSZW/LC DII Caution (Error) messages) shall use a prohibitive frame indicating when unsafe conditions may exist.	<i>Prohibitive frame means that DII advisory and alert messages shall not indicate that conditions may be safe.</i>	D

Table 3-4. RSZW/LC Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.01.04.05]	RSZW/LC I2V Wireless Message Graphics	The RSZW/LC I2V Wireless Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution (Error) shapes and graphics used in roadway signage.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D
[4.01.04.06]	RSZW/LC Roadside Signage Message Content	The RSZW/LC Roadside Signage Message shall contain the content to be displayed on dynamic roadside signage.	<i>The RSZW/LC Roadside Signage Message shall contain one of three types of DII contents, a RSZW/LC DII Advisory, a RSZW/LC DII Alert, or a RSZW/LC DII Caution. Table (RSZW/LC Roadside) RSZW/LC Roadside Signage Message Data Description is referenced for guidance.</i>	D
[4.01.04.07]	RSZW/LC Roadside Signage Message Specifications	The RSZW/LC Roadside Signage Message shall conform to NTCIP 1203 v02 Object Definitions for Dynamic Message Signs (DMS) Standard.		D
[4.01.04.08]	RSZW/LC Roadside Signage Message Text	The RSZW/LC Roadside Signage Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution text.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D
[4.01.04.09]	RSZW/LC Roadside Signage Message Prohibitive Frame	The RSZW/LC Roadside Signage Message (RSZW/LC DII advisory and RSZW/LC DII alert messages) shall use a prohibitive frame indicating when unsafe conditions may exist.	<i>Prohibitive frame means that DII advisory and alert messages shall not indicate that conditions may be safe.</i>	D
[4.01.04.10]	RSZW/LC Roadside Signage Message Graphics	The RSZW/LC Roadside Signage Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution shapes and graphics.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D

Source: Battelle

3.3.3 RSZW/LC Vehicle Application Component Requirements

Table 3-5 catalogs the performance requirements for the RSZW/LC Vehicle Application Component. These were developed based upon the integration strategy described in Section 3.3.1.4 above. It is expected that, as connected vehicle technology evolves and vehicle and infrastructure application component owners develop this and other V2I Safety Applications, the rationales, frameworks, and performance requirements presented here will evolve. Accordingly, before embarking upon design and development, application owners should update and refine the requirements to reflect current standards and policies. It is the responsibility of the designer to ensure that the resulting applications do not conflict with applicable published state and national regulations, policies, and guidelines.

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
4.02	RSZW/LC Vehicle Application Component Requirements			
4.02.01	RSZW/LC Vehicle Application Component Interfaces and Interface Specifications			
[4.02.01.01]	RSZW/LC I2V Wireless Message Interface	The RSZW/LC Vehicle Application Component shall obtain RSZW/LC I2V Wireless Messages through the Vehicle Wireless Data Systems Interface.		D
[4.02.01.02]	RSZW/LC Vehicle Data Interface	The RSZW/LC Vehicle Application Component shall obtain RSZW/LC Vehicle Data through the Vehicle Data Systems Interface.		D
[4.02.01.03]	RSZW/LC Driver Message Interface	The RSZW/LC Vehicle Application Component shall issue RSZW/LC Driver Messages through the Driver Warning System Interface.		D
4.02.02	RSZW/LC Vehicle Application Component Functional Requirements			
[4.02.02.01]	Common Vehicle Application Component Requirements	The RSZW/LC Vehicle Application Component shall adhere to Common Vehicle Application Component Requirements.		D
[4.02.02.02]	RSZW/LC Vehicle Application Component Initiation	The RSZW/LC Vehicle Application Component shall be initiated upon receipt of an RSZW/LC I2V Wireless Message by the Vehicle Wireless Data Systems.		D
[4.02.02.03]	RSZW/LC I2V Wireless Message Initiation	The RSZW/LC Vehicle Application Component shall obtain RSZW/LC I2V Wireless Messages upon initiation of the component.		D
[4.02.02.04]	RSZW/LC I2V Wireless Message Refresh Rate	The RSZW/LC Vehicle Application Component shall refresh the RSZW/LC I2V Wireless Message Input at a configurable frequency.		D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.05]	RSZW/LC Vehicle Data Initiation	The RSZW/LC Vehicle Application Component shall obtain RSZW/LC Vehicle Data upon initiation of the component.		D
[4.02.02.06]	Vehicle Data Systems Refresh Rate	The RSZW/LC Vehicle Application Component shall refresh RSZW/LC Vehicle Data at a configurable frequency.		D
[4.02.02.07]	RSZW/LC Infrastructure Data	Upon receipt of a RSZW/LC I2V Wireless Message, the RSZW/LC Vehicle Application Component shall open the message and parse it for relevant RSZW/LC data.		D
[4.02.02.08]	RSZW/LC Positioning Accuracy Determination	The RSZW/LC Vehicle Application Component shall determine if the received Position Data and the Map Data meet the position accuracy requirements for the received RSZW/LC I2V Wireless Message.		D
[4.02.02.09]	RSZW/LC Positioning Accuracy Assessment	If the received Position Data and Map Data do not meet the position accuracy requirements for the RSZW/LC I2V Wireless Message, the RSZW/LC Vehicle Application Component shall refresh the Position Data and Map Data and continue processing.	<i>The application should continue iteratively obtaining position and map data until RSZW/LC application position accuracy requirements are satisfied for the RSZW/LC I2V Wireless Message.</i>	D
[4.02.02.10]	RSZW/LC Positioning Accuracy Message – Advisory	If the received Position Data and Map Data do not meet the position accuracy requirements for the received RSZW/LC I2V Wireless Message, the RSZW/LC Vehicle Application Component shall issue a RSZW/LC Driver Message containing a RSZW/LC DII Advisory to the Driver Warning System.	<i>The RSZW/LC Application issues only advisory messages if position and map accuracy are not sufficient to support alert and warning calculations.</i>	D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.11]	RSZW/LC I2V Message Applicability Determination	The RSZW/LC Vehicle Application Component shall determine if the received RSZW/LC I2V Wireless Message is applicable, based upon the subject vehicle's apparent path, the specified class of vehicles to which the message applies and other message criteria.		D
[4.02.02.12]	RSZW/LC I2V Message Applicability Assessment	If the received RSZW/LC I2V Wireless Message is not applicable, the RSZW/LC Vehicle Application Component shall refresh the RSZW/LC I2V Wireless Message and continue processing.	<i>The application should continue iteratively obtaining RSZW/LC I2V Wireless Messages until a message applicable to current vehicle conditions is received.</i>	D
[4.02.02.13]	RSZW/LC DVI Lane Change Alert Distance Definition	The RSZW/LC DVI Lane Change Alert Distance shall be the distance from the beginning of the lane closure merge defined in the MUTCD Table 6C-1, "Recommended Advanced Warning Sign Minimum Spacing" as the MUTCD Advanced Placement Distance X plus the Sign Visibility Distance.		D
[4.02.02.14]	Compute RSZW/LC DVI Lane Change Alert Distance	If lane closure is applicable the RSZW/LC Vehicle Application Component shall determine the RSZW/LC DVI Lane Change Alert Distance based on infrastructure data (e.g., MUTCD guidelines and sign visibility distance) provided by the Infrastructure Wireless Data Systems Interface.		D
[4.02.02.15]	RSZW/LC DVI Lane Change Warning Distance Definition	The RSZW/LC DVI Lane Change Warning Distance shall be the distance from the beginning of the lane closure merge defined in the MUTCD Table 6C-1, "Recommended Advanced Warning Sign Minimum Spacing" as the MUTCD Advanced Placement Distance A plus the Sign Visibility Distance.		D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.16]	Compute RSZW/LC DVI Lane Change Warning Distance	If lane closure is applicable the RSZW/LC Vehicle Application Component shall determine the RSZW/LC DVI Lane Change Warning Distance based on infrastructure data (e.g., MUTCD guidelines and sign visibility distance) provided by the Infrastructure Wireless Data Systems Interface.		D
[4.02.02.17]	RSZW/LC DVI Warning Criterion	If the distance of the subject vehicle is less than the RSZW/LC DVI Lane Change Warning Distance, then the RSZW/LC Vehicle Application Component shall compile a RSZW/LC DVI Lane Change Warning for the Driver.		D
[4.02.02.18]	RSZW/LC DVI Alert Criterion	If the distance of the subject vehicle is less than the RSZW/LC DVI Lane Change Alert Distance and greater than or equal to the RSZW/LC DVI Lane Change Warning Distance, then the RSZW/LC Vehicle Application Component shall compile a RSZW/LC DVI Lane Change Alert for the Driver.		D
[4.02.02.19]	RSZW/LC Configuration Change DII Advisory Criterion	If Roadway Configuration Change is applicable or if Lane Closure is applicable, and if the distance of any approaching vehicle is less than the RSZW/LC Configuration Change DII Advisory Distance then the RSZW/LC Vehicle Application Component shall compile an RSZW/LC Configuration Change DII Advisory for the Driver.		D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.20]	RSZW/LC Configuration Change DII Advisory, RSZW/LC DVI Alert, and RSZW/LC DVI Warning Termination	The RSZW/LC Vehicle Application Component shall cease issuing RSZW/LC DII advisories, RSZW/LC DVI alerts, and RSZW/LC DVI warnings when the vehicle exits the RSZW/LC zone.		D
[4.02.02.21]	RSZW/LC DVI and RSZW/LC DII Message Consistency	The RSZW/LC Vehicle Application Component shall not issue a less cautious message (e.g., RSZW/LC DVI Lane Change Alert or RSZW/LC DVI Lane Change Warning) than the RSZW/LC Infrastructure Application components.		D
[4.02.02.22]	RSZW/LC DVI Message Precedence	The RSZW/LC Vehicle Application Component shall govern the lane closure message to be delivered to the Driver Warning System, based upon available RSZW/LC infrastructure and RSZW/LC vehicle data.		D
[4.02.02.23]	RSZW/LC Caution (Error) Message Definition	The RSZW/LC DVI Caution (Error) Message shall contain a blank or generic caution and an indication that the system is not operational.		D
[4.02.02.24]	RSZW/LC Vehicle Application Component Error	In the event of an input data error, a computational error, or other nonrecoverable RSZW/LC Vehicle Application Component Error preventing issuing of RSZW/LC DII advisories, RSZW/LC DVI alerts, RSZW/LC DVI warnings, or position and map accuracy requirements not being met, the RSZW/LC Vehicle Application Component shall compile a RSZW/LC DVI Caution (Error) for the Driver.		D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.25]	RSZW/LC Reduced Speed DII Alert Criterion	If the distance of the subject vehicle is less than RSZW/LC Reduced Speed DII Alert Distance, the RSZW/LC Vehicle Application Component shall compile an RSZW/LC Reduced Speed DII Alert for Driver.		D
[4.02.02.26]	RSZW/LC Reduced Speed DII Advisory Criterion	If the distance of the subject vehicle is less than the RSZW/LC Reduced Speed DII Advisory Distance and greater than or equal to the RSZW/LC Reduced Speed DII Alert Distance, the RSZW/LC Vehicle Application Component shall compile an RSZW/LC Reduced Speed DII Advisory for the Driver.		D
[4.02.02.27]	RSZW/LC Reduced Speed DII Advisory RSZW/LC Reduced Speed DII Alert Termination	The RSZW/LC Vehicle Application Component shall cease issuing RSZW/LC Reduced Speed DII advisories and RSZW/LC Reduced Speed DII alerts when the vehicle exits the zone.		D
[4.02.02.28]	RSZW/LC Reduced Speed DVI and RSZW/LC Reduced Speed DII Message Consistency	The RSZW/LC Vehicle Application Component shall not issue a less cautious RSZW/LC Reduced Speed Message (e.g., RSZW/LC Reduced Speed DII Advisory or RSZW/LC Reduced Speed DII Alert) than the RSZW/LC Infrastructure Application components.		D
[4.02.02.29]	RSZW/LC Reduced Speed DVI Message Precedence	The RSZW/LC Vehicle Application Component shall govern the reduced speed message to be delivered to the Driver Warning System, based upon available RSZW/LC infrastructure and RSZW/LC vehicle data.		D
[4.02.02.30]	RSZW/LC Reduced Speed Caution (Error) Message Definition	The RSZW/LC Reduced Speed DVI Caution (Error) Message shall contain a blank or generic caution and an indication that the system is not operational.		D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.02.31]	RSZW/LC Reduced Speed Vehicle Application Component Error	In the event of an input data error, a computational error, or other nonrecoverable RSZW/LC Vehicle Application Component Error preventing issuing of RSZW/LC Reduced Speed DII advisories or RSZW/LC Reduced Speed DII alerts, or position and map accuracy requirements not being met, the RSZW/LC Vehicle Application Component shall compile a RSZW/LC Reduced Speed DVI Caution (Error) for the Driver.		D
[4.02.02.32]	Issue RSZW/LC I2V Message	If an RSZW/LC Configuration Change Advisory, RSZW/LC Lane Change Alert, RSZW/LC Lane Change Warning, RSZW/LC Reduced Speed Advisory, RSZW/LC Reduced Speed Alert, or RSZW/LC Caution (Error) is warranted, the RSZW/LC Vehicle Application Component shall issue a RSZW/LC Driver Warning Message, containing the appropriate content of both, to the Driver Warning System Interface.		D
[4.02.02.33]	RSZW/LC Message Type Precedence for Driver Warning System Messages	RSZW/LC Lane Change Alerts and Warnings shall take precedence over RSZW/LC Reduced Speed Alerts when sent to the Driver Warning System Interface.	<i>The RSZW/LC Reduced Speed element does not include a warning, only the RSZW/LC element includes a warning.</i>	D
4.02.03	RSZW/LC Vehicle Application Component Data Input Requirements			
[4.02.03.01]	RSZW/LC I2V Wireless Message Content	The RSZW/LC I2V Wireless Message shall contain the data required to perform the calculations specified under RSZW/LC Vehicle Application Functional Requirements.	<i>Table (RSZW/LC Wireless) RSZW/LC I2V Wireless Message Data Description is referenced for guidance.</i>	D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[4.02.03.02]	RSZW/LC I2V Wireless Message Specification	The RSZW/LC I2V Wireless Message shall conform to SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary.		I
[4.02.03.03]	RSZW/LC I2V Wireless Message Content Text	The RSZW/LC I2V Wireless Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution (Error) text used in roadway signage.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D
[4.02.03.04]	RSZW/LC I2V Wireless Message Graphics	The RSZW/LC I2V Wireless Message shall contain RSZW/LC DII Advisory, RSZW/LC DII Alert, and RSZW/LC DII Caution (Error) shapes and graphics used in roadway signage.	<i>The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.</i>	D
[4.02.03.05]	RSZW/LC Vehicle Systems Message Content	The RSZW/LC Vehicle Systems Message shall contain data required to perform the calculations specified under RSZW/LC Vehicle Application Functional Requirements.	<i>Table (RSZW/LC Vehicle) RSZW/LC Vehicle Systems Message Data Description is referenced for guidance.</i>	D
[4.02.03.06]	Vehicle Data Systems Message Specifications	The RSZW/LC Vehicle Systems Message shall conform to the standards and guidelines specified by the vehicle Original Equipment Manufacturer.	<i>Specific interfaces to the OEM vehicle systems will be dependent on specific information required to support the safety application. Examples of vehicle data communication system specifications include: ISO 14230-4, ISO 9141-2, SAE J1850 VPW, SAE J1850 PWM, ISO 15765, ISO 11898, and SAE J2178</i>	D

Table 3-5. RSZW/LC Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
4.02.04	RSZW/LC Vehicle Application Component Data Output Requirements			
[4.02.04.01]	RSZW/LC Driver Message Content	The RSZW/LC Driver Message shall contain the RSZW/LC DII Advisory, RSZW/LC DII Alert, RSZW/LC DII Caution, RSZW/LC DVI Alert, RSZW/LC DVI Warning, or RSZW/LC DVI Caution content to be displayed on the Driver Warning Interface.	Table (RSZW/LC Driver) RSZW/LC Driver Message Data Description is referenced for guidance.	D
[4.02.04.02]	RSZW/LC Driver Message Specifications	The following is referenced for guidance pertaining to RSZW/LC Driver Message Specifications: Campbell, J. L., Brown, J. L., Graving, J. S., Richard, C. M., Lichty, M. G., Sanquist, T., Bacon, L. P., ... Morgan, J. F. (in press). Driver Vehicle Interface (DVI) Design Assistance for Advanced Technology Applications. (Final report to Virginia Tech Transportation Institute and National Highway Traffic Safety Administration). Seattle, WA: Battelle.		D

Source: Battelle

APPENDIX A. RSZW/LC Application Message Candidate Data Elements

Appendix A suggests candidate data elements which may be included in these messages to support the RSZW/LC safety application algorithms. Table A-1 provides an explanation of the headers in candidate data tables. As noted in Table 3-3, Table A-2 through Table A-7 describe the candidate data elements for each of the messages. This information is provided for guidance when implementing the performance requirements specified in this document.

Table A-1. Explanation of Candidate Data Table Headers

Data Element Descriptor	Explanation	Example
Data Item Description	Name of obtainable measure or item,	Posted speed limit, number of lanes
Application	V2I Safety Application that the data element pertains to	RLVW, RSZW/LC
Type of Data	Identifies a general classification of the data element	Location data, speed data
Static/ Dynamic	Distinguishes the frequency by which the data element is subject to changes	Static, Dynamic
Need	Identifies whether the data element is critical to the application function, versus those that can enhance it	Required, optional
Input Source	Identifies the component that supplies the data element	Vehicle Application Component, infrastructure data system
Output Recipient	Identifies the component that receives the data element	Vehicle Application Component, infrastructure application component
Unit of Measure (English)	Metric used to quantify the data element, English system of measurement	Feet, °F
Valid Range (English)	Span of values from minimum to maximum that are acceptable inputs, English system of measurement	5-20, (-30)-120
Accuracy/ Tolerance (English)	Degree of variance between actual and measured value that will be acceptable, English system of measurement	+/-5, +/-0.01
Unit of Measure (Metric)"	Metric used to quantify the data element, international system of measurement	Meter, °C
Valid Range (Metric)	Span of values from minimum to maximum that are acceptable inputs, international system of measurement	5-20, (-30)-120
Accuracy/Tolerance(Metric)"	Degree of variance between actual and measured value that will be acceptable, international system of measurement	+/-5, +/-0.01
Refresh Rate	Frequency that the data element is updated with a new external value	10 Hz, Annually
References	Source documents that contain supporting information	MUTCD
Notes	Supplemental explanation	Determined by MUTCD or Local Policy

Source: Battelle.

Table A-2. Description of Candidate Data Elements for the RSZW/LC Infrastructure Data Systems Message

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Target (#)	RSZW/LC	Approaching Vehicle	Dynamic	Required	External Vehicle Detection System	Infra Application Component	Integer	1-15	NA	Integer	1-15	NA	10 Hz		The Application shall be capable of processing up to 15 simultaneous targets identified by Infrastructure Data Systems
Target (#) Range	RSZW/LC	Approaching Vehicle	Dynamic	Required	External Vehicle Detection System	Infra Application Component	ft	1-5000	+/- 2	m	0.3-1524	+/-0.6	10 Hz		The Application shall be capable of processing up to 15 simultaneous targets identified by Infrastructure Data Systems
Target (#) Range Rate	RSZW/LC	Approaching Vehicle	Dynamic	Required	External Vehicle Detection System	Infra Application Component	ft/s	1-200	+/- 1	m/s	0.3-61	0.3	10 Hz		The Application shall be capable of processing up to 15 simultaneous targets identified by Infrastructure Data Systems

Source: Battelle

Table A-3. Description of Candidate Data Elements for the RSZW/LC Roadside Signage Message Data Description

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
DII MUTCD Sign Number	RSZW/LC	RSZW/LC Roadside Signage Data	Dynamic	MUTCD Sign Number or Graphic and Text	Infra Application Component	Roadside Signage System	Integer	TBD	NA	Integer	TBD	NA	1 Hz		Determined by MUTCD, Local Policy, and Roadside Signage System manufacturer specifications
DII Graphic	RSZW/LC	RSZW/LC Roadside Signage Data	Dynamic	MUTCD Sign Number or Graphic and Text	Infra Application Component	Roadside Signage System	TBD	TBD	NA	TBD	TBD	NA	1 Hz		Determined by MUTCD, Local Policy, and Roadside Signage System manufacturer specifications
DII Text	RSZW/LC	RSZW/LC Roadside Signage Data	Dynamic	MUTCD Sign Number or Graphic and Text	Infra Application Component	Roadside Signage System	Alpha numeric, upper and lower case	A-Z, a-z, 0-9	NA	Alpha numeric, upper and lower case	A-Z, a-z, 0-9	NA	1 Hz		Max 3 Lines, 20 Characters each is typical for Roadside Dynamic Message Signs
DII Advisory Valid Time	RSZW/LC	RSZW/LC Roadside Signage Data	Dynamic	Required	Infra Application Component	Roadside Signage System	min	0.01-1440	+/- 0.01	min	0.01-1440	+/- 0.01	1 Hz		Determined by MUTCD, Local Policy, and Roadside Signage System manufacturer specifications

Source: Battelle

Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message

Data Item Description	Application	Type of Data	Static/ Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/ Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/ Tolerance (Metric)	Refresh Rate	References	Notes
Reduced Speed Zone Geometry															
Reduced Speed Zone Begin – Latitude	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-90)-90	+/- 0.000001	degrees	(-90)-90	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – Longitude	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-180)-180	+/- 0.000001	degrees	(-180)-180	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – Elevation	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	(-150)-12,000	+/- 2	m	(-46)-3658	+/-0.6	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Reduced Speed Zone End – Latitude	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-90)-90	+/- 0.000001	degrees	(-90)-90	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Reduced Speed Zone End – Longitude	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-180)-180	+/- 0.000001	degrees	(-180)-180	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Reduced Speed Zone End – Elevation	RSZW/LC	Reduced Speed Zone Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	(-150)-12,000	+/- 2	m	(-46)-3658	+/-0.6	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
RSZW/LC Operational Data															
Posted Speed Limit	RSZW/LC	RSZW/LC Operational Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	mph	25-90	+/- 2	km/h	40-145	+/-3.2	Speed Limit Revision		Static Data may be loaded through an externally generated data file.
Advisory Speed Limit	RSZW/LC	RSZW/LC Operational Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	mph	5-65	+/- 2	km/h	8-105	+/-3.2	Speed Limit Revision		Static Data may be loaded through an externally generated data file.
RSZW/LC Roadside Signage Data															
Reduced Speed Zone Begin – MUTCD Sign Number options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	Integer	NA	NA	Integer	NA	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.

Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message (Continued)

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Reduced Speed Zone Begin – Graphic options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – Advisory Text options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	Latin Alphabet	A-Z	NA	Latin Alphabet	A-Z	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – DII Advisory Sign Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – DII Advisory Visibility Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – MUTCD Sign Number options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	Integer	NA	NA	Integer	NA	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – Graphic options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.

Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message (Continued)

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Reduced Speed Zone Begin – Alert Text options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	Latin Alphabet	A-Z	NA	Latin Alphabet	A-Z	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – DII Alert Sign Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Optional	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Reduced Speed Zone Begin – DII Alert Visibility Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Optional	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration/Lane Change Geometry															
Configuration Change/Lane Closure Begin – Latitude	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-90)-90	+/- 0.000001	degrees	(-90)-90	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Longitude	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-180)-180	+/- 0.000001	degrees	(-180)-180	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Elevation	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	(-150)-12,000	+/- 2	m	(-46)-3658	+/-0.6	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure End – Latitude	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-90)-90	+/- 0.000001	degrees	(-90)-90	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure End – Longitude	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	degrees	(-180)-180	+/- 0.000001	degrees	(-180)-180	+/- 0.000001	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.

Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message (Continued)

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Configuration Change/Lane Closure End – Elevation	RSZW/LC	Configuration /Lane Change Geometry	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	(-150)-12,000	+/- 2	m	(-46)-3658	+/-0.6	Reconstruction, Repaving, or Restriping		Static Data may be loaded through an externally generated data file.
RSZW/LC Roadside Signage Data															
Configuration Change/Lane Closure Begin – MUTCD Sign Number options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	Integer	NA	NA	Integer	NA	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Graphic options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Advisory Text options for consideration to be used as DII Advisory Message	RSZW/LC	RSZW Roadside Signage Data	Static	At Least One Required from Group	Local User/Data Infrastructure	Infra Application Component	Latin Alphabet	A-Z	NA	Latin Alphabet	A-Z	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – DII Advisory Sign Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – DII Advisory Visibility Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Required	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.

Table A-4. Description of Candidate Data Elements for the RSZW/LC Infrastructure Map Message and RSZW/LC Wireless Map Message (Continued)

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Configuration Change/Lane Closure Begin – MUTCD Sign Number options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	Integer	NA	NA	Integer	NA	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Graphic options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – Alert Text options for consideration to be used as DII Alert Message	RSZW/LC	RSZW Roadside Signage Data	Static	MUTCD Sign Number or Graphic and Text	Local User/Data Infrastructure	Infra Application Component	Latin Alphabet	A-Z	NA	Latin Alphabet	A-Z	NA	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – DII Alert Sign Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Optional	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.
Configuration Change/Lane Closure Begin – DII Alert Visibility Distance	RSZW/LC	RSZW Roadside Signage Data	Static	Optional	Local User/Data Infrastructure	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	Roadside Signage Revision		Determined by MUTCD and Local Policy. Static Data may be loaded through an externally generated data file.

Source: Battelle

Table A-5. Description of Candidate Data Elements for the RSZW/LC I2V Wireless Message Data Description

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
RSZW/LC Applicable Date and Time – Begin	RSZW/LC	RSZW Operational Data	Dynamic	Required	Infra Application Component	Vehicle Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
RSZW/LC Applicable Date and Time – End	RSZW/LC	RSZW Operational Data	Dynamic	Required	Infra Application Component	Vehicle Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
RSZW/LC Applicable Road Map Segments	RSZW/LC	RSZW Operational Data	Dynamic	Required	Infra Application Component	Vehicle Application Component	TBD	TBD	TBD	TBD	TBD	TBD	TBD		Data format is based upon segments in RSZW Road Map

Source: Battelle

Table A-6. Description of Candidate Data Elements for the RSZW/LC Vehicle Systems Message Data Descriptions

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
Vehicle Speed	RSZW	Speed data	Dynamic	Required	Vehicle Data Systems	Vehicle Application Component	mph	0-120	+/- 2	km/h	0-194	+/-3.2	10 Hz		
Vehicle acceleration	RSZW	Location data	Dynamic	Required, if applicable	Vehicle Data Systems	Vehicle Application Component	ft/s^2	0-50	+/- 2	m/s^2	0-15	+/-0.6	10 Hz		
Brake activation	RSZW	Vehicle operating characteristics	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	n/a	-	-	n/a	-	-	10 Hz		
Vehicle type/classification	RSZW	Vehicle operating characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	n/a	-	-	n/a	-	-	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.
Vehicle mass	RSZW	Vehicle operating characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	lb.	100-100000	+/- 25	kg	45-45360	+/- 11.3	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.
Vehicle length	RSZW	Vehicle operating characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	ft	0-200	+/- 2	m	0-61	+/-0.6	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.

Source: Battelle

Table A-7. Description of Candidate Data Elements for the RSZW/LC Driver Warning Message Data Description

Data Item Description	Application	Type of Data	Static/Dynamic	Need	Input Source	Output Recipient	Unit of Measure (English)	Valid Range (English)	Accuracy/Tolerance (English)	Unit of Measure (Metric)	Valid Range (Metric)	Accuracy/Tolerance (Metric)	Refresh Rate	References	Notes
DVI MUTCD Sign Number	RSZW/LC	RSZW/LC Driver Warning Message Data	Dynamic	At Least One Required From Group	Vehicle Application Component	Driver Warning System	Integer	TBD	NA	Integer	TBD	NA	10 Hz		Determined by MUTCD, Local Policy, and Driver Warning System manufacturer specifications
DVI Graphic	RSZW/LC	RSZW/LC Driver Warning Message Data	Dynamic	At Least One Required From Group	Vehicle Application Component	Driver Warning System	TBD	TBD	NA	TBD	TBD	NA	10 Hz		Determined by MUTCD, Local Policy, and Roadside Signage System manufacturer specifications
DVI Text	RSZW/LC	RSZW/LC Driver Warning Message Data	Dynamic	At Least One Required From Group	Vehicle Application Component	Driver Warning System	Alpha numeric, upper and lower case	A-Z, a-z, 0-9	NA	Alpha numeric, upper and lower case	A-Z, a-z, 0-9	NA	10 Hz		Determined by Roadside Signage System manufacturer specifications
DVI Message Valid Time	RSZW/LC	RSZW/LC Driver Warning Message Data	Dynamic	Required	Vehicle Application Component	Driver Warning System	min	0.01 to 1440	+/- 0.01	min	0.01 to 1440	+/- 0.01	10 Hz		Determined by Roadside Signage System manufacturer specifications
DVI Message Valid Region	RSZW	RSZW/LC Driver Warning Message Data	Dynamic	Required	Vehicle Application Component	Driver Warning System	TBD	TBD	NA	TBD	TBD	NA	10 Hz		Determined by MUTCD, Local Policy, and Driver Warning System manufacturer specifications
DVI Message Priority	RSZW/LC	RSZW/LC Driver Warning Message Data	Dynamic	Required	Vehicle Application Component	Driver Warning System	Integer	TBD	NA	Integer	TBD	NA	10 Hz		Determined by Roadside Signage System manufacturer specifications

Source: Battelle

APPENDIX B. Acronyms and Abbreviations

AAHSTO	American Associated of State Highway and Transportation Officials
CAN	Controller Area Network
ConOps	Concept of Operations
CSW	Curve Speed Warning
DII	Driver-Infrastructure Interface
DMS	Dynamic Message Signs
DoCAN	Diagnostic Communication Over Controller Area Network
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
DVI	Driver-Vehicle Interface
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
GNSS	Global Navigation Satellite Systems
ISO	International Organization for Standardization
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
OEMs	Original Equipment Manufacturers
PRT	Perception Reaction Time
RLVW	Red Light Violation Warning
RSZW/LC	Reduced Speed Zone Warning with Lane Closure
RTCM	Radio Technical Commission for Maritime Services
SAE	Society of Automotive Engineers
SOI	System-of-Interest
SSGA	Stop Sign Gap Assist
SWIW-D	Spot Weather Information Warning – Diversion
SWIW-RS	Spot Weather Information Warning – Reduced Speed

TBD	To Be Determined
TMDD	Traffic Management Data Dictionary
TRB	Transportation Research Board
TSS	Transportation Sensor Systems
U.S. DOT	United States Department of Transportation
UTC	Universal Time, Coordinated
V2I	Vehicle-to-Infrastructure

APPENDIX C. Terms and Definitions

Advisory Message – An informative message to the driver regarding current roadway conditions; less urgent, i.e., not necessarily crash-imminent, than an alert or warning.

Alert – A cautionary message about an anticipated crash scenario and/or vehicle conflict; more urgent than an advisory message, less urgent than a warning.

Connected Vehicle – In the context of this document, refers to the methods, data and technologies used in the bi-directional exchange of information between infrastructure and vehicles for purposes of improving safety, mobility and environmental conditions.

Degraded – Mode of the safety application where it is capable of providing a subset of its intended function(s).

Failure – Mode of the safety application where the safety application is incapable of providing any of its intended function(s).

False Alarm – Situation where the safety application provides an alert/warning to the driver when the conditions do not warrant an alert/warning.

Functional Class of Roadway – The functional class of roadways are defined in FHWA “Functional Classification Guidelines”. Revised 1989.

Missed Alarm – Situation where the safety application does not provide an alert/warning to a driver when the conditions warrant an alert/warning.

Non-volatile Storage – Type of storage that remains intact even when there is no power.

Offline – State of the safety application where the safety application is not processing data or providing advisories, alerts and/or warnings.

Online – State of the safety application where the safety application is functioning and providing advisories, alerts and/or warnings.

Operational – Mode of the safety application where the safety application is capable of providing all of its intended function(s).

Perform – To work in a manner to achieve the desired outcome.

Physical Security – Describes measures that are designed to deny access to unauthorized personnel (including attackers or even accidental intruders) from physically accessing a building, facility, resource, or stored information; and guidance on how to design structures to resist potentially hostile acts.² Physical security can be as simple as a locked door on a roadside cabinet.

Prohibitive Reference Frame – Indicates when *unsafe* conditions are present, as opposed to “safe” conditions; “unsafe” is much easier to quantify than “safe,” indicates the requirement that users also apply their own judgment, and can lessen liability issues as compared to indicating a more definitive ‘permissive’ notification of when conditions are “safe”.

² Task Committee; Structural Engineering Institute (1999). *Structural Design for Physical Security*. ASCE. [ISBN 978-0-7844-0457-7](https://doi.org/10.1061/(ASCE)1098-0784(2000)10:4(457-7)).

Roadside Configuration Data – Data provided from the infrastructure data equipment or back office that details the lane(s), roadway geometry, and/or map of the area needed by a safety application

Road Weather Information – Data on road and weather conditions that may impact vehicle safety including visibility, wind speed, precipitation, air and road surface temperature, road surface condition, etc.

Roadway Work Zone Configuration Information – Data on work zone configuration elements that may impact vehicle safety including lane shifts, lane reductions, etc.

Roadway Work Zone Operations Information – Data on work zone operational elements that may impact vehicle safety including buffer zones, traffic control setup, temporary pavement markings, temporary traffic barriers, road closures, changed lighting conditions (during night work), etc.

Threshold – A point in both time and/or location, depending on the specific application, that the application would reach a decision point resulting in an action being taken. This action would typically be expected to include alerts and/or warnings issued to the driver, but could also include additional actions.

Vehicle Type – Identification of vehicle role (e.g., ambulance, police cruiser, maintenance vehicle, etc.) as specific class of vehicle satisfies in the surface transportation system. A specific, standardized nomenclature does not exist.

Vehicle Class – One of 13 FHWA designations of motorized vehicles ranging in size from a Class 1 Motorcycle through a Class 13 – Seven or more axle truck.³

Vehicle Telematics Data – Data made available from vehicle electronic systems that could be utilized by the connected vehicle in-vehicle application. Examples include vehicle operating speed; operational status of windshield wipers, headlights, etc.; driver application of brakes or accelerator; etc.

Warning – An urgent message for a more immediate, potentially crash imminent scenario and/or vehicle conflict; more urgent than both an advisory message and alert.

³ Traffic Monitoring Guide, U.S. DOT, May 2001, <http://www.fhwa.dot.gov/ohim/tmguidetmg4.htm#app4c>

U.S. Department of Transportation, FHWA Office of Safety Research and Development, Turner Fairbank Highway Research Center

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487
www.its.dot.gov

FHWA-JPO-16-251



U.S. Department of Transportation