Vehicle-to-Infrastructure (V2I) Safety Applications

Performance Requirements, Vol. 6, Spot Weather Information Warning – Diversion (SWIW-D)

www.its.dot.gov/index.htm
Final Report — August 2015
FHWA-JPO-16-253

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

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.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-16-253		

4. Title and Subtitle	5. Report Date
Vehicle-to-Infrastructure (V2I) Safety Applications Performance Requirements, Vol. 6, Spot Weather Information Warning – Diversion	August 2015
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Denny Stephens, Jeremy Schroeder, Rachel Klein	1000025516-0301-5

9. Performing Organization Name And Address	10. Work Unit No. (TRAIS)
Battelle Memorial Institute 505 King Avenue Columbus, OH 43201	11. Contract or Grant No. DTFH61-12-D-00040

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation FHWA Office of Safety Research and Development Turner-Fairbank Highway Research Center 6300 Georgetown Pike McLean, VA 22101	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 sixth 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 Spot Weather Information Warning – Diversion V2I Safety Application. This application is designed to advise drivers of road closure ahead due to adverse weather conditions and a suggested or required diversion to an alternate route to avoid the adverse weather zone and closure. 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	18. Distribution Statement
Connected vehicles, Vehicle-to-Infrastructure, V2I, V2I Safety Applications, Spot Weather Information Warning – Diversion, SWIW-D	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	77	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

List of Tables

List of Figures

Chapter 1 Scope

1.1 Document Identification

This document is the sixth 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 Spot Weather Information Warning – Diversion V2I Safety Application. This application is designed to advise drivers of road closure ahead due to adverse weather conditions and a suggested or required diversion to an alternate route to avoid the adverse weather zone and closure. Drivers are first advised of the road closure and the suggested or required diversion. If drivers continue without diverting, the application provides an advisory, alert, or warning as the vehicle approaches the road closure due to adverse weather.

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 SWIW-D 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 SWIW-D 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 SWIW-D application.

Appendices:

A. SWIW-D 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.

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 Spot Weather Information Warning – Diversion V2I Safety 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 Spot Weather Information Warning – Diversion (SWIW-D) Application Performance Requirements
  - 3.3.1 SWIW-D 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 SWIW-D Infrastructure Application Component Requirements
- 3.3.3 SWIW-D 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] RLVW 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 Requirements[1]

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).

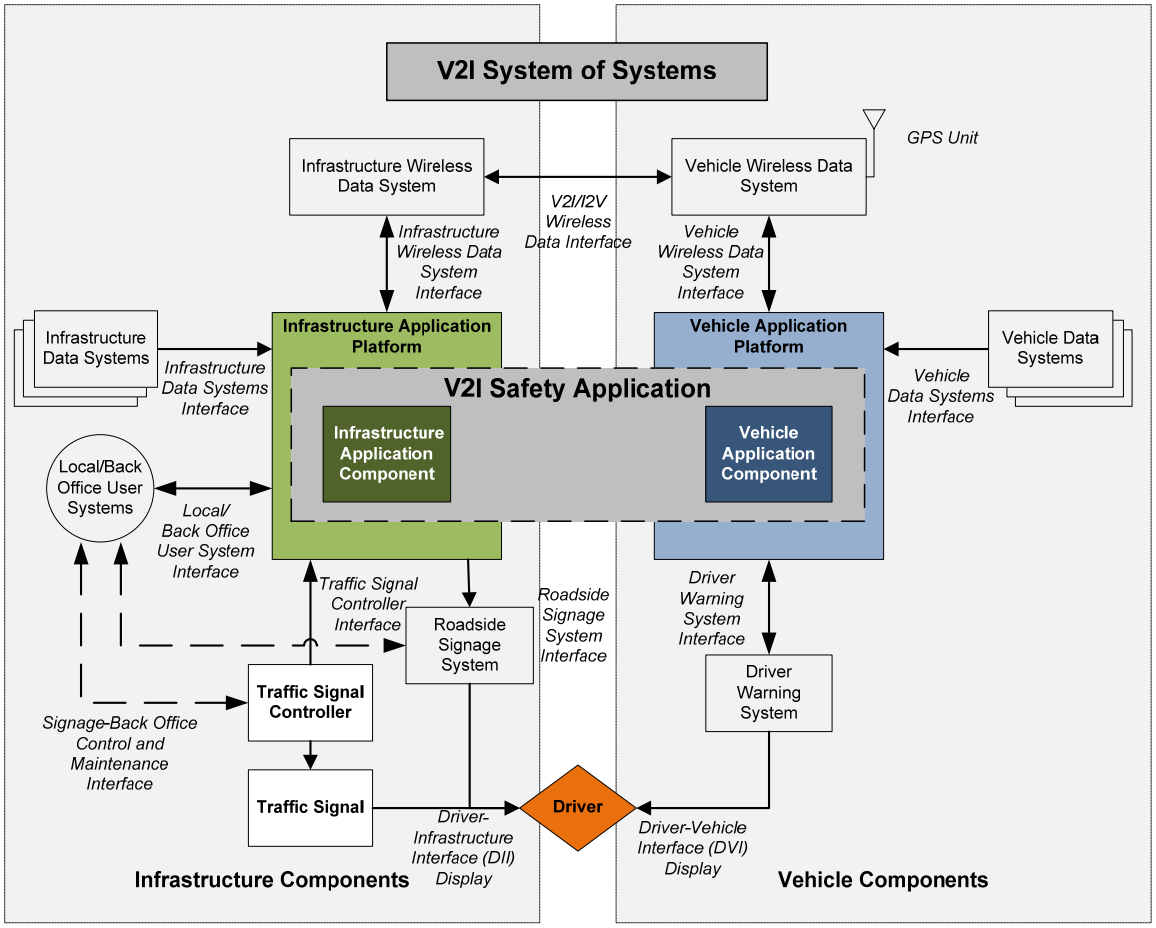
Each of the application components resides and operates on a computing platform that provides the necessary hardware and software data interfaces needed to exchange data with other systems. Each computing platform has an interface for wireless data systems that support with wireless exchange of data 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 Spot Weather Information Warning – Diversion Application Performance Requirements

3.3.1 SWIW-D Application Introduction and Overview

Spot Weather Information Warning – Diversion – Application designed to advise drivers of road closure ahead due to adverse weather conditions and a suggested or required diversion to an alternate route to avoid the adverse weather zone and closure. The application integrates data from infrastructure- and vehicle-based sensors, receives back office verification of the presence of adverse weather and/or roadway conditions, and issues advisories, alerts and warnings based upon the vehicle proximity to the diversion and closure. Drivers are first advised of the road closure and the suggested or required diversion. If drivers continue without diverting, the application provides an advisory, alert, or warning as the vehicle approaches the road closure due to adverse weather. The application is functional for multiple types of road closures due to adverse weather, including high winds and floods.

3.3.1.1 Application Purpose

The goal of the SWIW-D application is to improve roadway safety by assisting drivers in avoiding weather-related crashes by advising, alerting and warning of an upcoming closure of an unsafe road. The application uses both infrastructure- and vehicle-based sensor data, to recommend diversion given current weather conditions. Recommendations are based upon available real-time weather and roadway conditions data and vehicle performance characteristics. The application coordinates roadside messages for all vehicles with in-vehicle, vehicle-specific advisories to notify drivers in time for them to react and safely divert to an alternate route. If the driver proceeds toward the inclement weather zone without diverting, the application will issue a road closure advisory, alert, and warning, as applicable, as the vehicle approaches the crash-imminent weather hazard.

3.3.1.2 Safety Impacts of Application

There will be several impacts on drivers in the deployment of V2I safety applications:

- ***Real-Time Messaging:*** The greatest impact is that drivers will receive real-time advisories and alerts while driving based on their current driving conditions and current weather and roadway conditions.
- ***Reduction in Weather Related Incidents:*** The SWIW-D application should result in safer trips with fewer weather-related incidents on roadways.
- ***Effective Messaging (Format and Timing):*** The safety application is designed to provide drivers with a combination of haptic, visual, and/or audio messages in an effective format that does not distract or overwhelm. These messages are designed to be presented to drivers in a timeframe that provides adequate reaction time to reduce speed and safely traverse an adverse weather zone.

3.3.1.3 Summary of Improvements

- ***Reduces number of run-off-road, rollover, and stranded vehicle incidents due to inclement weather:*** SWIW-D aids drivers by encouraging diversion, which could reduce run-off-road, rollover, or stranded vehicle incidents in flooded or high wind

conditions, for example. The application will provide messages to the driver that suggest or require diversion based on current weather and roadway conditions.

- ***Increases driver awareness of current weather and roadway conditions:*** Unlike current applications, which only provide a diversion message about weather conditions, the connected vehicle application also provides a follow-up real-time advisory, alert, and warning after the driver passes the diversion point and approaches a serious weather hazard. Because of quickly changing conditions and lack of dynamic signage, signage may not otherwise be present to warn the driver of inclement conditions. The application includes the capability of recommending suggested or required diversion for specific vehicles based on weather and road conditions in real time via roadside equipment. The SWIW-D application is functional for multiple types of weather, including high winds and flood conditions.

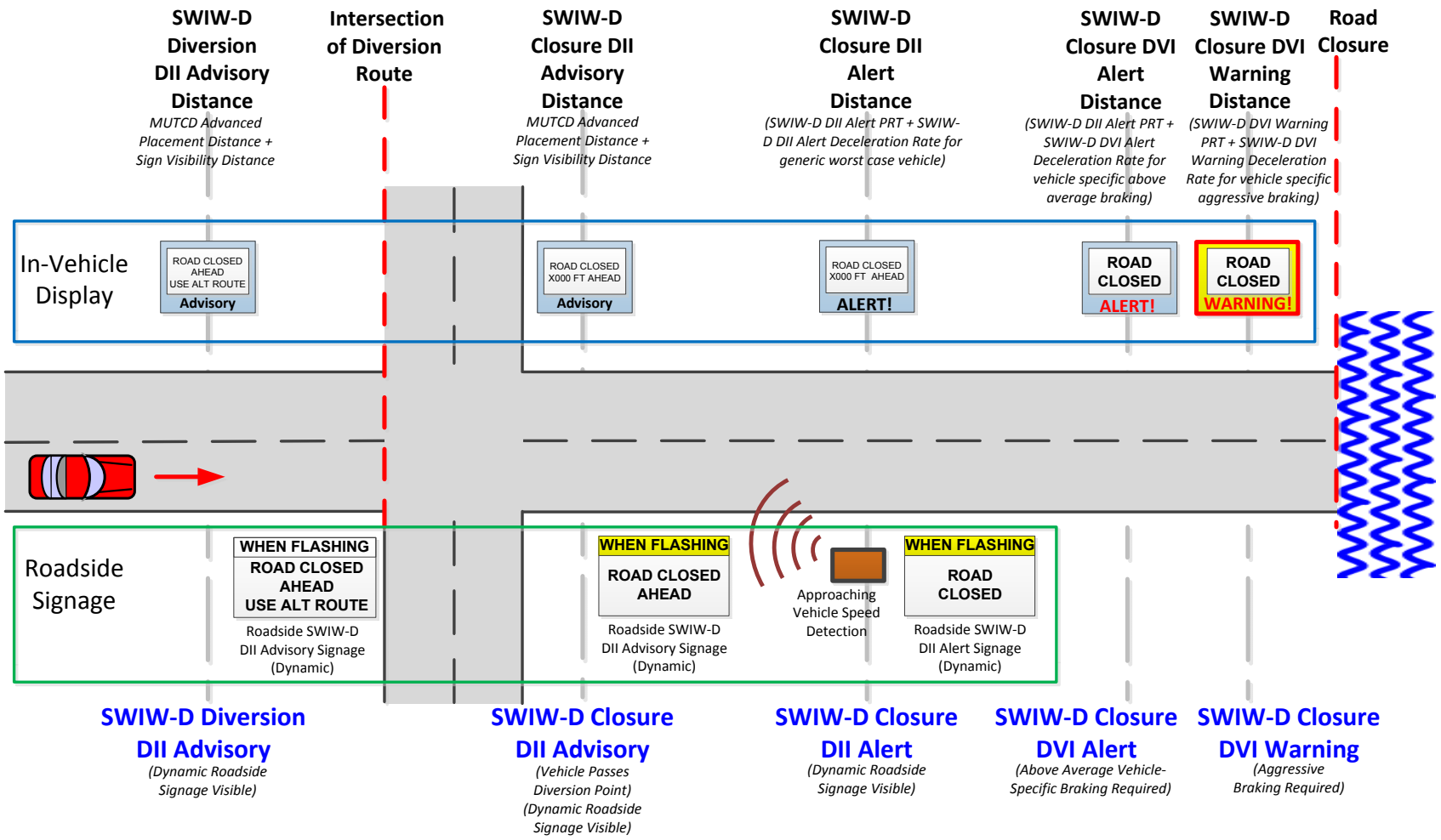
3.3.1.4 How the Application Works

The objective of SWIW-D V2I Application is to deliver coordinated infrastructure- and vehicle-based advisories when adverse weather conditions, roadway conditions, and/or a road closure are present to notify the driver in sufficient time to divert. If the vehicle proceeds beyond the mandatory diversion point when a road closure is present, the application will deliver coordinated infrastructure- and vehicle-based advisories, alerts, and warnings to notify the driver in sufficient time to stop. Figure 3-2 below illustrates the key concepts and integration of roadway and in-vehicle signage. The figure shows the vehicle approaching the diversion route and adverse weather zone. The box below the roadway illustrates roadside signage or Driver Infrastructure Interface (DII) displayed to the driver, which in this graphic is assumed to be static signage with dynamic elements, such as flashing beacons.

When there is inclement weather on the roadway ahead, the driver will first encounter DII signage with a diversion advisory message that suggests or requires using an alternate or detour route when flashing, such as signage shown in Figure 3-3 or on the right in Figure 3-4. Alternatively, DII signage on a dynamic message sign (DMS) could include a graphic representation of the adverse weather type, an alert message, and/or a specific alternate route. The location of this signage in advance of the diversion route is defined by the MUTCD advanced placement distances for guide signs, and varies for the type of roadway.

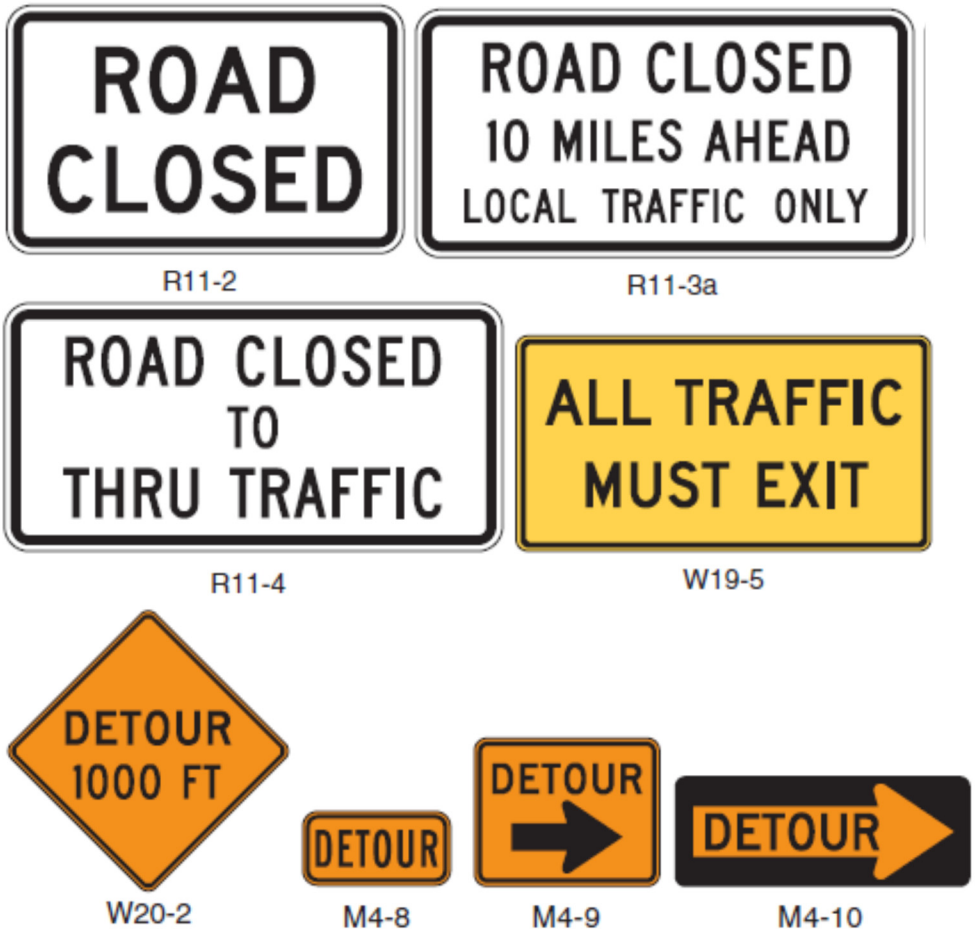
Beyond the diversion point in the event of a road closure, the driver encounters a roadside speed detection device and additional DII dynamic signage. This DII signage may be static signage with dynamic elements, such as flashing beacons like that shown on the left in Figure 3-4. If there is a road closure, a “DII Closure Advisory” will notify the driver that the road is closed ahead. Further downstream, a “DII Closure Alert” will be present at a distance for the generic worst case vehicle to apply above average braking and come to a complete stop prior to the road closure. The location of this signage in advance of the diversion route is defined by the MUTCD advanced placement distances for warning signs in Table 2C-4.

The SWIW-D Infrastructure Application component delivers roadside advisory and alert messages to the driver, based upon infrastructure-based sensor systems. The DII Alert Deceleration Rate for all vehicles, defined below, is conditional based upon available weather or road surface conditions data available from the local road-weather information system (RWIS) and other infrastructure. Infrastructure-based signage and messaging is generic, intended for display to all drivers. While intended for all drivers, DII messages may be targeted for specific vehicle classes, such as commercial trucks, and include appropriate language to identify target vehicles.



Source: Battelle

Figure 3-2. Illustration of SWIW-D Roadside and In-Vehicle Signage



Source: MUTCD 2009 Ed.

Figure 3-3. Examples of Signage used for Road Closures and Diversion Routes

Source: aaroads.com

Source: corcohighways.org

Figure 3-4. Examples of Dynamic Weather Message Signage

The box above the vehicle and road in the Figure 3-2, illustrates the coordinated in-vehicle SWIW-D signage. This illustration assumes the vehicle includes a graphical Driver Vehicle Interface (DVI) display. When adverse conditions are present on the roadway ahead, as the vehicle approaches the adverse weather zone, the SWIW-D Vehicle Application Component receives a wireless message from the infrastructure containing infrastructure-based sensor data and roadside signage messages. At approximately the same time that a driver would observe the roadside diversion advisory sign, the DVI displays a SWIW-D Diversion Advisory, containing the adverse weather condition information and a suggested or required diversion message. (The distance at which the SWIW-D Diversion Advisory is displayed in the vehicle in advance of the diversion point is the MUTCD "Sign Visibility Distance" plus the MUTCD advanced placement distance for guide signs). If adverse weather or roadway conditions do not merit a suggested or required diversion route, the DVI displays a SWIW-D Weather Advisory. If the vehicle proceeds beyond the diversion point on the impacted route after given an advisory message, the DVI continues to display either a SWIW-D Weather Advisory or, when the road is closed, a SWIW-D Closure Advisory continuously as the vehicle approaches the adverse weather zone.

As the vehicle approaches the adverse weather zone under a required diversion scenario, i.e., complete road closure, the SWIW-D Vehicle Application Component receives a wireless message from the infrastructure containing infrastructure-based sensor data and collects applicable dynamics and stability data from the vehicle. The SWIW-D Vehicle Application Component computes the SWIW-D DVI Alert and Warning Deceleration Rates (or vehicle-specific safe deceleration rates), using both infrastructure-based sensor data and vehicle-based sensor data. This rate may be above or below the infrastructure-based SWIW-D DII Alert Deceleration Rate. For example, a heavy vehicle may have a lower vehicle-specific safe deceleration rate than the generic safe deceleration rate computed by the infrastructure. In contrast, a sports car under good road surface conditions may have a safe deceleration rate above the infrastructure based deceleration rate. The lesser of the (generic) SWIW-D DII Alert Deceleration Rate or the (vehicle specific) SWIW-D DVI Alert Deceleration Rate is used as the basis for in-vehicle alerts.

As described above, at approximately the same time that a driver would observe the roadside advisory sign almost immediately after the diversion point, the DVI displays a SWIW-D Closure Advisory. (The distance at which the SWIW-D Closure Advisory is displayed in the vehicle in advance of the roadside advisory sign is the MUTCD "Sign Visibility Distance"). The DVI continues to display the SWIW-D Closure Advisory continuously as the vehicle approaches the weather hazard road closure.

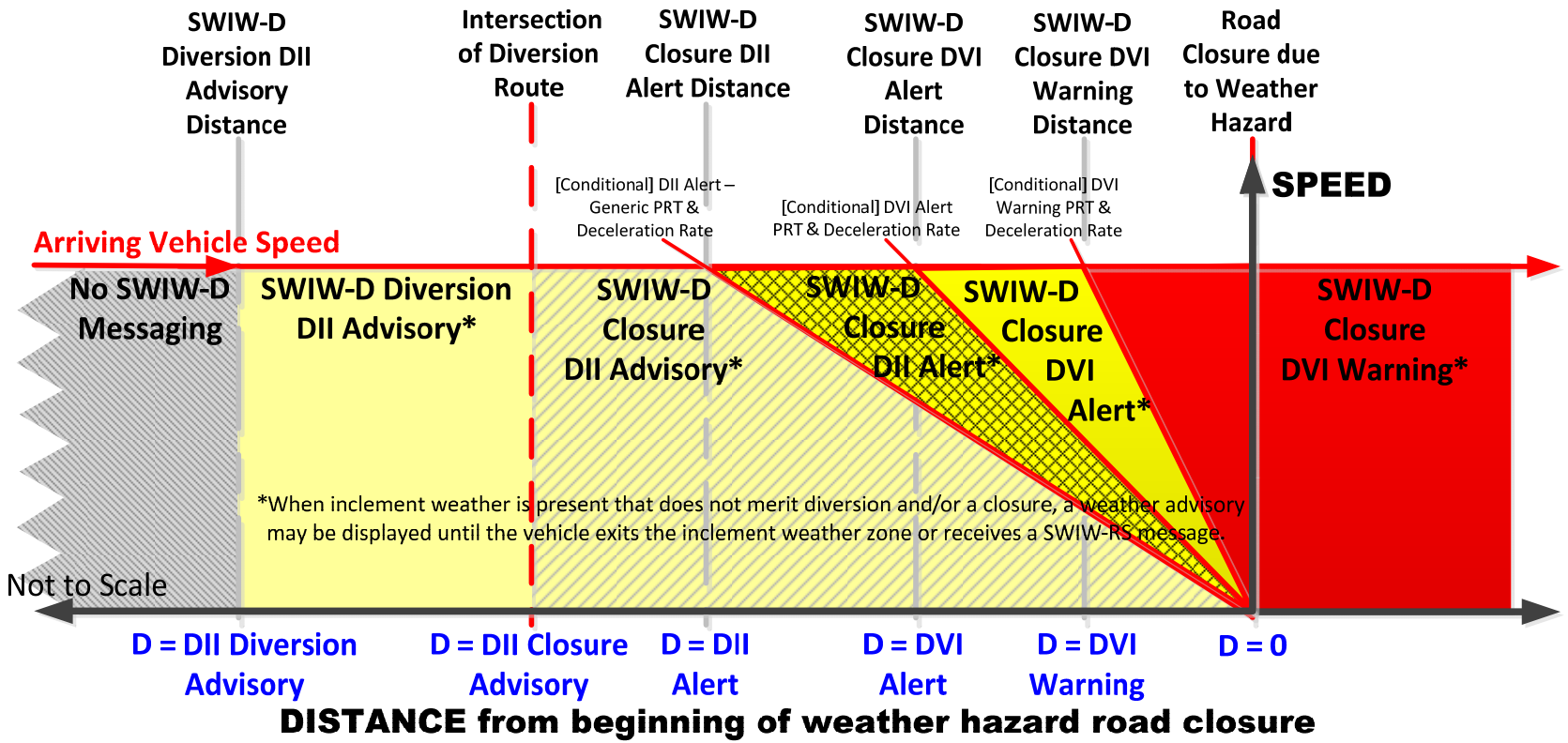
If the vehicle continues to proceed toward the weather hazard road closure, the SWIW-D Vehicle Application Component computes and continuously updates the DVI Alert and Warning Distances for the vehicle's current trajectory relative to the road closure. The DVI Alert Distance is a distance at which *above average braking* is required for the vehicle to stop prior to the road closure. The DVI Warning Distance is the distance at which *aggressive braking* is required for the vehicle to stop at the prior to the road closure. The DVI Alert and Warning Distances are vehicle specific, dependent upon the DVI Alert Perception Reaction Time (PRT), DVI Alert Deceleration Rate, DVI Warning PRT, and DVI Warning Deceleration Rate. They may also be conditional, based upon infrastructure weather or road surface conditions where data are available.

As the subject vehicle approaches the road closure, a DVI Alert is issued when the distance to the closure is below the SWIW-D Closure DVI Alert Distance, for its given speed. If the vehicle continues without sufficient deceleration, a SWIW-D Closure DVI Warning is issued when the distance to the closure is below the SWIW-D Closure DVI Warning Distance, for its given speed. The warning continues until the vehicle stops or leaves the road closure area. As noted earlier, a SWIW-D Weather Advisory is displayed by default when adverse weather or roadway conditions are present, but the road is open to traffic.

Figure 3-3 illustrates advisories, alert, and warning displayed within the vehicle as a function of vehicle speed and distance from the weather zone. It also illustrates how the DII Alert Distance and DVI Alert Distance are functions of PRT and vehicle deceleration rates. (The SWIW-D DII Alert Distance is the distance at which *above average braking* is required by a *generic worst case vehicle* to achieve the DII Alert Speed at the weather zone.)

The DII Alert Speed, DII Alert PRT and DII Alert Deceleration Rate (for generic worst case vehicles) are supplied to the vehicle application component by the infrastructure. The vehicle specific PRT and vehicle deceleration rates are computed by the vehicle. They are conditional based upon infrastructure weather or road surface conditions where data are available.

Table 3-1 provides a definition of the terms used here for the SWIW-D advisories, alert, and warning. Table 3-2 provides a tabular summary of the DII and DVI display criteria, display signage, and their distances from the diversion point and road closure.



Source: Battelle

Figure 3-5. Illustration of In-vehicle Signage as a Function of Vehicle Speed and Distance from Road Closure

Table 3-1. Definition of SWIW-D Terms

SWIW-D Diversion DII Advisory	Informative signage indicating potentially adverse weather conditions ahead and suggestion or requirement to divert to an alternate route
SWIW-D Weather DII Advisory	Informative signage indicating potentially adverse weather conditions ahead when diversion to an alternate route is neither suggested nor required.
SWIW-D Closure DII Advisory	Informative signage indicating hazardous weather conditions ahead on the vehicle's current route beyond any diversion route that resulted in a full road closure. Indicates to through traffic the need to turn around and seek an alternate route.
SWIW-D Closure DII Alert	Dynamic signage indicating the vehicle is approaching a road closure and a generic worst case vehicle must apply above average braking to stop prior to the road closure.
SWIW-D Closure DII Alert Distance	Generic, infrastructure-based recommendation for distance at which to display SWIW-D DII Alert in the vehicle DVI. Distance at which above average braking is required by a generic worst case vehicle to stop prior to the road closure. Dependent upon SWIW-D DII Alert PRT, SWIW-D DII Alert Deceleration Rate, and current environmental conditions.
SWIW-D Closure DII Alert PRT	Generic, infrastructure-based recommendation for Perception Reaction Time used in computing DII Alert Distance.
SWIW-D Closure DII Alert Deceleration Rate	Generic, infrastructure-based recommendation for vehicle deceleration rate used in computing DII Alert Distance.
SWIW-D Closure DVI Alert	In-vehicle display indicating the subject vehicle must apply above average braking to stop prior to the road closure.
SWIW-D Closure DVI Alert Distance	Vehicle specific recommendation for distance at which to display SWIW-D DVI Alert. Distance at which above average braking is required by the subject vehicle to stop prior to the road closure. Dependent upon vehicle specific SWIW-D DVI Alert PRT, SWIW-D DVI Alert Deceleration Rate, and current environmental conditions.
SWIW-D Closure DVI Alert PRT	Vehicle specific recommendation for Perception Reaction Time used in computing DVI Alert Distance.
SWIW-D Closure DVI Alert Deceleration Rate	Vehicle specific recommendation for vehicle deceleration rate used in computing DVI Alert Distance.
SWIW-D Closure DVI Warning	In-vehicle display indicating the subject vehicle must apply aggressive braking to stop prior to the road closure.
SWIW-D Closure DVI Warning Distance	Vehicle specific recommendation for distance at which to display SWIW-D DVI Warning. Distance at which aggressive braking is required by the subject vehicle to stop prior to the road closure. Dependent upon vehicle specific SWIW-D DVI Warning PRT, SWIW-D DVI Warning Deceleration Rate, and current environmental conditions.
SWIW-D Closure DVI Warning PRT	Vehicle specific recommendation for Perception Reaction Time used in computing DVI Warning Distance.
SWIW-D Closure DVI Warning Deceleration Rate	Vehicle specific recommendation for vehicle deceleration rate used in computing DVI Warning Distance.

Source: Battelle

Table 3-2. Summary of SWIW-D Infrastructure and Vehicle Displays

	Driver Infrastructure Interface			Driver Vehicle Interface		
	Display Criterion	**Display Signage**	**Distance from Entrance**	**Display Criterion**	**Display Signage***	**Distance from Entrance**
Stage 1 Weather Advisory	Approaching weather zone for which adverse weather and/or roadway conditions have been detected by the infrastructure and verified by the local/back office or traffic management center (TMC). Displayed before the diversion point if diversion is neither suggested nor required. Displayed after the diversion point the road is open to through traffic.	All vehicle Advisory of adverse weather conditions.	MUTCD Advanced Placement Distance	Received SWIW-D I2V Wireless Message	All vehicle Advisory of adverse weather conditions.	MUTCD Advanced Placement Distance + Sign Visibility Distance
Stage 1 Diversion Advisory	Approaching a diversion point prior to an adverse weather zone for which adverse weather and/or roadway conditions merit suggested or required diversion and have been detected by the infrastructure and verified by the local/back office or traffic management center (TMC)	All vehicle Advisory of adverse weather conditions that suggests or requires diversion to an alternate route.	MUTCD Advanced Placement Distance	Received SWIW-D I2V Wireless Message	All vehicle Advisory of adverse weather conditions that suggests or requires diversion to an alternate route	MUTCD Advanced Placement Distance + Sign Visibility Distance
Stage 1 Closure Advisory	Approaching a road closure due to adverse weather or roadway conditions beyond any diversion route, which has been verified by the local/back office or traffic management center (TMC)	All vehicle Advisory that road is closed ahead to through traffic.	MUTCD Advanced Placement Distance	Received SWIW-D I2V Wireless Message	All vehicle Advisory that road is closed ahead to through traffic.	MUTCD Advanced Placement Distance + Sign Visibility Distance
Stage 2a Infrastructure Alert	Infrastructure detected approaching vehicle distance to the closure is below the SWIW-D DII Alert Distance, for its given speed indicating a worst case vehicle must apply above average braking to stop prior to the road closure.	All vehicle Alert to stop prior to the road closure.	MUTCD Advanced Placement Distance B	Received SWIW-D I2V Wireless Message indicating infrastructure detected approaching vehicle distance to the closure is below the SWIW-D DII Alert Distance indicating a worst case vehicle must apply above average braking to stop prior to the road closure.	All vehicle Alert to stop prior to the road closure.	Distance at which above average braking is required by a worst case vehicle to stop prior to the road closure.

Table 3-2. Summary of SWIW-D 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**
Stage 2b Vehicle Specific Alert	N/A	N/A	N/A	Distance of the subject vehicle to the closure is less than the SWIW-D DVI Alert Distance indicating the vehicle must apply above average braking to stop prior to the road closure.	Vehicle-specific Alert to reduce speed to stop prior to the road closure.	Distance at which above average braking is required by subject vehicle to stop prior to the road closure.
Stage 3 Vehicle Specific Warning	N/A	N/A	N/A	Distance of the subject vehicle to the closure is less than the SWIW-D DVI Warning Distance indicating the vehicle must apply aggressive braking to stop prior to the road closure.	Vehicle-specific Warning to stop prior to the road closure.	Distance at which aggressive braking is required by subject vehicle to stop prior to the road closure.

* If applicable, DVI displays Stage 3 Vehicle-specific Warning; otherwise if applicable DVI displays Stage 2b Vehicle-specific Alert; otherwise if applicable DVI displays Stage 2a Infrastructure Alert; otherwise if applicable, DVI displays DII Diversion Advisory ; otherwise, DVI displays DII Weather Advisory.

Source: Battelle

3.3.1.5 Application Assumptions and Considerations

Assumptions

- The vehicle is driving along a route equipped with a SWIW-D application.
- The vehicle is en-route to a destination requiring it to traverse a stretch of roadway with adverse weather conditions that disproportionately impact safety.
- The SWIW-D application is intended for a variety of weather conditions, which could require minor modifications during deployment for adaptation to local conditions.
- Time thresholds for weather data being communicated from the infrastructure to the vehicle and the location of infrastructure component relative to the weather zone and/or road closure must allow for the vehicle application to calculate and issue timely and valid advisory, alert, and warning messages at the beginning of the weather zone.
- Issuance of diversion routes will vary by local policy and weather type and severity. Message may indicate the need to divert or name a specific route. Severity of weather may influence whether diversion is required or suggested for all or certain vehicle types.
- The SWIW-D application will be unable to determine that a vehicle is or is not diverting in time to issue alerts or warnings prior to the diversion point.
- The SWIW-D application will issue advisory messages whenever adverse weather conditions are present that could impact safety, regardless of the absence of a road closure or suggested diversion route. These messages will be displayed continuously on the DVI from the Diversion DII Advisory Distance until the vehicle exits the weather zone.
- The SWIW-D application might be used in conjunction with other connected vehicle applications.
- In the case of an equipped vehicle, if any data element is unavailable for calculating appropriate deceleration rates, a previously determined default value will be used by the application to compute deceleration rates.
- Weather data from local RWIS and sensors, and diversion routes are first validated by the local/back office or TMC before being used to compute SWIW-D advisories, alerts, or warnings.
- The SWIW-D DII Roadside Signage is connected to the back office and may be used for non-SWIW-D messages if DMS are used.

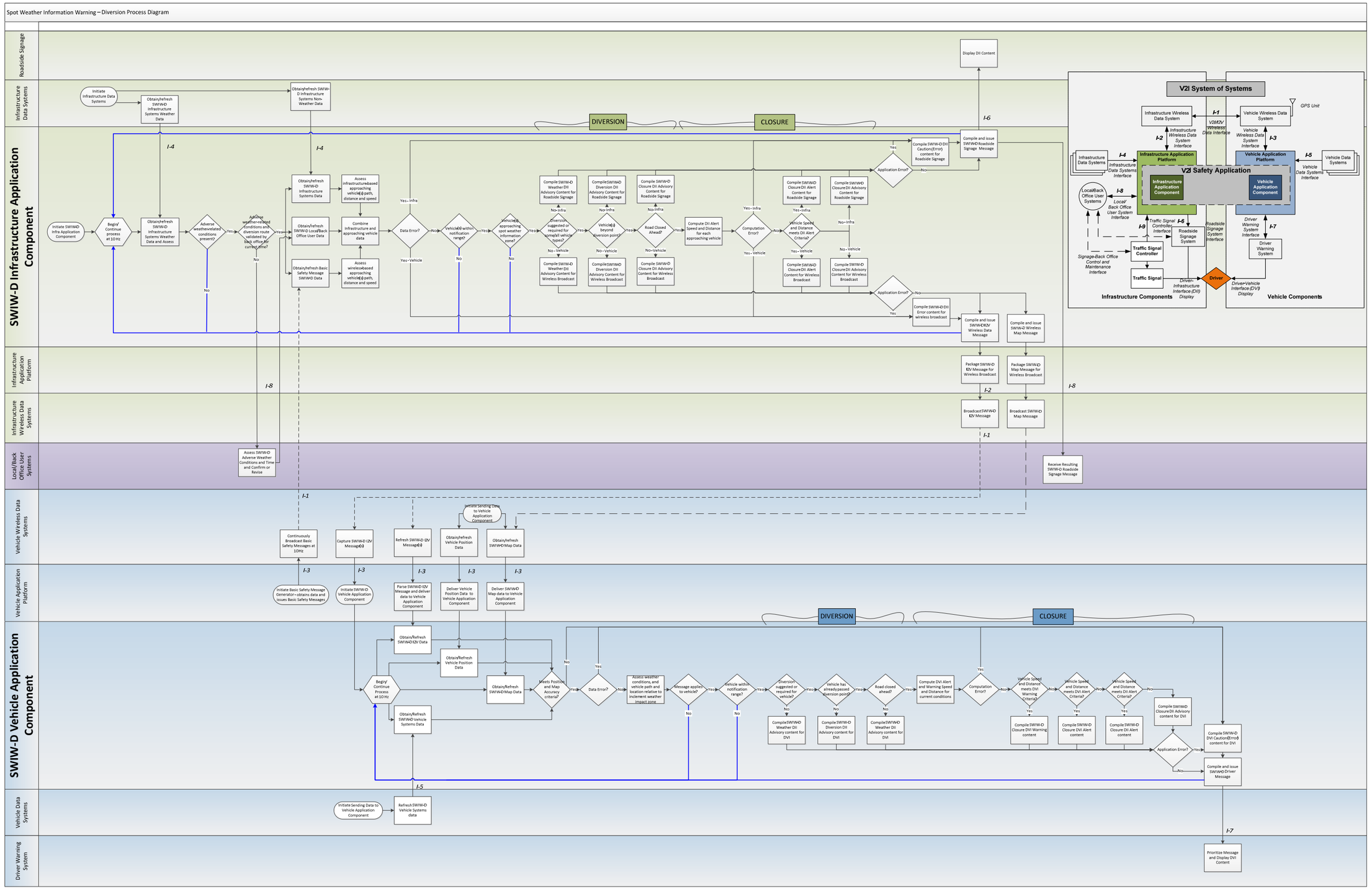
Considerations

The SWIW-D system is intended to advise and alert the equipped vehicle only about possible weather-related conditions and the need to divert or stop. The system does not account for 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 SWIW-D Application, Figure 3-6 provides a swim-lane process diagram for the SWIW-D application illustrating the sequence of data flows and processing by the SWIW-D Infrastructure Application Component and the SWIW-D Vehicle Application Component. The figure includes the V2I Systems architecture diagram presented earlier for reference.

At a high level, the SWIW-D Infrastructure Application Component monitors current weather data and if adverse conditions are present receives back office validation of those conditions and, if applicable, for diversion. The SWIW-D Infrastructure Application Component then obtains remaining infrastructure, local/back office, and vehicle data inputs, determines if an advisory, alert, or warning is warranted. If so, a SWIW-D Roadside Signage Message is issued to the Roadside Signage System for display and a SWIW-D I2V Wireless Data Message is issued to the Infrastructure Wireless Data System for broadcast to nearby vehicles. Upon receipt of a SWIW-D I2V Wireless Data Message, the Vehicle Application Platform initiates the SWIW-D Vehicle Application Component. The SWIW-D Vehicle Application Component obtains I2V, position and map data inputs, determines if a driver alert or warning is warranted and, if so, issues a SWIW-D DVI Alert or Warning Message to the Driver Warning System. These processes are performed at a rate of 10 Hz to update SWIW-D Roadside Signage Message and the SWIW-D Driver Alert and Warning Message to drivers whose vehicles are rapidly approaching the diversion point and a road closure due to hazardous weather conditions and may need to take action to divert or stop the vehicle. This diagram illustrates the concepts that are the basis for SWIW-D application requirements enumerated in section 3.7.2.



Source: Battelle

Figure 3-6. Swim-lane Process Diagram for the SWIW-D Application

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 SWIW-D 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 SWIW-D Application Components

Message	Input Source	Output Recipient	Content Utilized	Data Description	Purpose
Infrastructure Component Messages					
SWIW-D Infrastructure Systems Message	External Vehicle Detection System, Infra Data System – Road Surface, Infra Data System – Local Weather	Infra Application Component	Detection of approaching vehicles and their speed, road surface conditions, local weather conditions	Table A-2 SWIW-D Infrastructure Systems Message Data Description	Used as input by SWIW-D Infrastructure Application Component to determine if vehicles are approaching the diversion point and/or adverse weather zone and suggested or required diversion. Road surface and weather data are forwarded to the Vehicle Application Component through the SWIW-D I2V Wireless Message.
SWIW-D Roadside Signage Message	Infra Application Component	Roadside Signage System	SWIW-D Roadside Signage message content	Table A-3 SWIW-D Roadside Signage Message Data Description	SWIW-D message content to be displayed on dynamic roadside signage.
SWIW-D Infrastructure Map Message	Local-Back Office Users Systems Interface	Infrastructure Map Message Handler	Detailed map of weather zone, roadside diversion location & signage, road closure location & signage.	Table A-4 SWIW-D Map Message Data Description	Used as input by SWIW-D Vehicle Application Component to determine if subject vehicle is approaching the weather zone and road closures and the vehicle-specific diversion recommendation. 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 adverse weather diversion zone and, if so, their speed.
SWIW-D I2V Wireless Message	Infra Application Component	Vehicle Application Component	SWIW-D Operational Data, Road Surface Condition, Local Weather Data	Table A-5 SWIW-D I2V Wireless Message Data Description	Data used by vehicle application component to determine vehicle-specific diversion recommendation, assess weather conditions, and content and distance at which to issue advisories, alerts, and warnings.

Table 3-3. Summary of Messages used by SWIW-D Application Components (Continued)

Message	Input Source	Output Recipient	Content Utilized	Data Description	Purpose
SWIW-D Wireless Map Message	Infrastructure Map Message Handler	Vehicle Application Component	Detailed map of weather zone, roadside diversion location & signage, road closure location & signage.	Table A-4 SWIW-D Map Message Data Description	Used as input by SWIW-D Vehicle Application Component to determine if subject vehicle is approaching the weather zone and road closures and the vehicle-specific diversion recommendation.
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 SWIW-D Vehicle Application Component to determine vehicle position, speed and heading to determine if and when to issue advisories, alerts, or warnings.
SWIW-D Vehicle Systems Message	Vehicle Data Systems	Vehicle Application Component	Vehicle Characteristics, Vehicle Functional Status, Vehicle Environmental Data	Table A-6 SWIW-D Vehicle Systems Message Data Description	Used as input by SWIW-D Vehicle Application Component to determine the vehicle-specific diversion recommendation.
SWIW-D Driver Warning Message	Vehicle Application Component	Driver Warning System	SWIW-D in-vehicle message content	Table A-7 SWIW-D Driver Warning Message Data Description	SWIW-D message content to be displayed on in-vehicle displays.

Source: Battelle

3.3.2 SWIW-D Infrastructure Application Component Requirements

Table 3-4 catalogs the performance requirements for the SWIW-D 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. SWIW-D Infrastructure Application Component Performance Requirements

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
6.01	**SWIW-D Infrastructure Application Component Requirements**			
6.01.01	**SWIW-D Infrastructure Application Component Interfaces and Interface Specifications**			
[6.01.01.01]	**SWIW-D Infrastructure Systems Message Interface**	**The SWIW-D Infrastructure Application Component shall obtain SWIW-D Infrastructure Systems Messages through the Infrastructure Data Systems Interface.**		D
[6.01.01.02]	**Basic Safety Message Interface**	**The SWIW-D Infrastructure Application Component shall obtain Basic Safety Messages through the Infrastructure Wireless Data Systems Interface.**		D
[6.01.01.03]	**SWIW-D Local/Back Office User Data Interface**	**The SWIW-D Infrastructure Application Component shall obtain SWIW-D Local/Back Office User Data through the Local/Back Office User Systems Interface.**		D
[6.01.01.04]	**SWIW-D I2V Wireless Message Interface**	**The SWIW-D Infrastructure Application Component shall issue SWIW-D I2V Wireless Messages through the Infrastructure Wireless Data Systems Interface.**		D
[6.01.01.05]	**SWIW-D Roadside Signage Message Interface**	**The SWIW-D Infrastructure Application Component shall issue SWIW-D Roadside Signage Messages through the Roadside Signage System Interface.**		D
6.01.02	**SWIW-D Infrastructure Application Component Functional Requirements**			
[6.01.02.01]	**Common Infrastructure Application Component Requirements**	**The SWIW-D Infrastructure Application Component shall adhere to Common Infrastructure Application Component Requirements.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.02]	**SWIW-D Infrastructure Systems Message Initiation**	**The SWIW-D Infrastructure Application Component shall obtain SWIW-D Infrastructure Systems Messages upon initiation of the component.**		D
[6.01.02.03]	**SWIW-D Infrastructure Systems Data – Vehicle Speed**	**The SWIW-D Infrastructure Application component shall obtain speed and distance of approaching vehicles from Infrastructure Data Systems before the vehicles are within the SWIW-D DII Advisory Distance of the diversion segment entrance.**	*The SWIW-D DII Advisory Distance is the distance from the beginning of the diversion segment defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.* *The SWIW-D 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.*	D
[6.01.02.04]	**SWIW-D Infrastructure Systems Message Refresh Rate**	**The SWIW-D Infrastructure Application Component shall refresh the SWIW-D Infrastructure Systems Message at a configurable frequency.**	*Table (SWIW-D Infrastructure) SWIW-D Infrastructure Systems Data Description is referenced for guidance.*	D
[6.01.02.05]	**Basic Safety Message Initiation**	**The SWIW-D Infrastructure Application Component shall obtain Basic Safety Messages upon initiation of the component.**	*The SWIW-D 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.*	D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.06]	**Basic Safety Message Vehicle Speed**	**The SWIW-D Infrastructure Application component shall obtain speed and distance of approaching vehicles from Basic Safety Messages before the vehicles are within the SWIW-D DII Advisory Distance of the diversion segment entrance.**	*The SWIW-D DII Advisory Distance is the distance from the beginning of the diversion segment entrance defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.* *The SWIW-D 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.*	D
[6.01.02.07]	**Basic Safety Message Refresh Rate**	**The SWIW-D Infrastructure Application Component shall refresh Basic Safety Messages at a configurable frequency.**	*Table (SWIW-D Local-Back Office) SWIW-D Local-Back Office User Systems Data Description is referenced for guidance.*	D
[6.01.02.08]	**SWIW-D Local/Back Office User Data Initiation**	**The SWIW-D Infrastructure Application Component shall obtain SWIW-D Local/Back Office User Data upon initiation of the component.**		D
[6.01.02.09]	**GPS Position Accuracy**	**GPS Position data used by the SWIW-D Vehicle Application Component shall be of at least Road Level Position Accuracy.**	*Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.*	D
[6.01.02.10]	**SWIW-D Local/Back Office User Data Refresh Rate**	**The SWIW-D Infrastructure Application Component shall refresh SWIW-D Local/Back Office User Data at a configurable frequency.**	*Table (SWIW-D Local-Back Office) SWIW-D Local-Back Office User Systems Data Description is referenced for guidance.*	D
[6.01.02.11]	**Map Data Accuracy**	**Map data used by SWIW-D Vehicle Application Component shall be of at least Road Level Position Accuracy.**	*Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.*	D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.12]	**Map Data Accuracy**	**Map data used by the SWIW-D Infrastructure Application Component shall be of at least Road Level Position Accuracy.**	*Road Level Position Accuracy is defined under Common Infrastructure Application Component Requirements.*	D
[6.01.02.13]	**Determine Presence of Adverse Weather Conditions**	**The SWIW-D Infrastructure Application Component shall determine the real-time weather conditions for the specified inclement road weather zone from infrastructure systems weather data.**		D
[6.01.02.14]	**Determine Diversion Requirements**	**If the SWIW-D Infrastructure Application Component determines adverse weather conditions, then it shall assess the SWIW-D Infrastructure Systems Weather Data and SWIW-D Infrastructure Systems Non-Weather Data to determine whether a diversion is required or suggested for some or all vehicle types.**		D
[6.01.02.15]	**Receive Back Office Verification of Adverse Weather Conditions and Diversion Route**	**If the SWIW-D Infrastructure Application Component determines adverse weather conditions are present in the inclement road weather zone, with or without need for a diversion, the local/back office shall assess current weather conditions, either confirming the weather conditions found by the infrastructure systems along with associated road closure(s) and diversion route(s), or revising the conditions based on back office information.**		D
[6.01.02.16]	**Approaching Vehicle Characterization**	**The SWIW-D Infrastructure Application Component shall assess SWIW-D Infrastructure Systems Non-Weather Data and SWIW-D Vehicle Data and determine if vehicle(s) are approaching the intersection of the diversion route, and, if so, the distance and approaching speed of each.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.17]	**Determine SWIW-D DII Weather Advisory Distance**	**The SWIW-D DII Weather Advisory Distance shall be the distance from the intersection of the diversion route defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.**		D
[6.01.02.18]	**Determine SWIW-D Diversion DII Advisory Distance**	**The SWIW-D Diversion DII Advisory Distance shall be the distance from the intersection of the diversion route defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.**	*The Diversion DII Advisory and Weather DII Advisory are expected to be located prior to the last opportunity for diversion. They may be displayed on the same roadside signage and therefore the distances may coincide.*	D
[6.01.02.19]	**Determine SWIW-D Closure DII Advisory Distance**	**The SWIW-D Closure DII Advisory Distance shall be the distance from the beginning of the road closure defined in the MUTCD Table 2C-4, Guidelines for Advance Placement of Warning Signs plus the sign visibility distance.**		D
[6.01.02.20]	**Determine SWIW-D Closure DII Alert Deceleration Rate**	**If diversions are required or suggested and a vehicle is detected beyond the diversion point, the SWIW-D Infrastructure Application Component shall determine the SWIW-D Closure DII Alert Deceleration Rate based on real-time conditions for the specified inclement road weather zone.**		D
[6.01.02.21]	**Determine SWIW-D Closure DII Alert Perception Reaction Time**	**If diversions are required or suggested and a vehicle is detected beyond the diversion point, the SWIW-D Infrastructure Application Component shall determine the SWIW-D Closure DII Alert Perception Reaction Time based on real-time conditions, for the specified inclement road weather zone.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.22]	**Compute SWIW-D Closure DII Alert Distance**	**The SWIW-D Infrastructure Application Component shall compute the SWIW-D Closure DII Alert Distance for each vehicle the Road Closure by determining the distance traveled during the SWIW-D Closure DII Alert Perception Reaction Time plus the distance required to slow the subject vehicle from its current speed to a speed of zero, at a uniform deceleration equal to the SWIW-D Closure DII Alert Deceleration Rate.**	*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.*	D
[6.01.02.23]	**SWIW-D DII Content General**	**SWIW-D DII content shall use a prohibitive frame, indicating that conditions may be unsafe.**	*SWIW-D DII content shall not indicate that conditions are safe.*	D
[6.01.02.24]	**SWIW-D Weather DII Advisory Criterion for Roadside Signage**	**If no diversions are required or suggested and if the distance of any approaching vehicle from the Diversion Intersection is less than the SWIW-D Weather DII Advisory Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D Roadside Signage Message containing a current SWIW-D Weather DII Advisory to the (Diversion) Roadside Signage System Interface.**		D
[6.01.02.25]	**SWIW-D Diversion DII Advisory Criterion for Roadside Signage**	**If diversions are required or suggested and if the distance of any approaching vehicle from the Diversion Intersection is less than the SWIW-D Diversion DII Advisory Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D Roadside Signage Message containing a current SWIW-D Diversion DII Advisory to the (Diversion) Roadside Signage System Interface.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.26]	**SWIW-D Closure DII Alert Criterion for Roadside Signage**	**If diversions are required or suggested and a vehicle is detected beyond the diversion point and if the distance of any approaching vehicle from the Road Closure is less than its SWIW-D Closure DII Alert Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D Roadside Signage Message containing a current SWIW-D Closure DII Alert to the (Closure) Roadside Signage System Interface.**		D
[6.01.02.27]	**SWIW-D Closure DII Advisory Criterion for Roadside Signage**	**If diversions are required or suggested and if a vehicle is detected beyond the diversion point and if the distance of any approaching vehicle from the Road Closure is less than the SWIW-D Closure DII Advisory Distance and greater than or equal to its SWIW-D Closure DII Alert Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D Roadside Signage Message containing a current SWIW-D Closure DII Advisory to the (Closure) Roadside Signage System Interface.**		D
[6.01.02.28]	**SWIW-D Weather DII Advisory Criterion for I2V Message**	**If no diversions are required or suggested and if the distance of any approaching vehicle from the Diversion Intersection is less than the SWIW-D Weather DII Advisory Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D I2V Message containing a current SWIW-D Weather DII Advisory to the Infrastructure Wireless Data Systems Interface.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.29]	**SWIW-D Diversion DII Advisory Criterion for I2V Message**	**If diversions are required or suggested and if the distance of any approaching vehicle from the Diversion Intersection is less than the SWIW-D Diversion DII Advisory Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D I2V Message containing a current SWIW-D Diversion DII Advisory to the Infrastructure Wireless Data Systems Interface.**		D
[6.01.02.30]	**SWIW-D Closure DII Alert Criterion for I2V Message**	**If diversions are required or suggested and a vehicle is detected beyond the diversion point and if the distance of any approaching vehicle from the Road Closure is less than its SWIW-D Closure DII Alert Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D I2V Message containing a current SWIW-D Closure DII Alert to the Infrastructure Wireless Data Systems Interface.**		D
[6.01.02.31]	**SWIW-D Closure DII Advisory Criterion for I2V Message**	**If diversions are required or suggested and a vehicle is detected beyond the diversion point and if the distance of any approaching vehicle from the Road Closure is less than the SWIW-D Closure DII Advisory Distance and greater than or equal to its SWIW-D Closure DII Alert Distance then the SWIW-D Infrastructure Application Component shall issue a SWIW-D I2V Message containing a current SWIW-D Closure DII Advisory to the Infrastructure Wireless Data Systems Interface.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.32]	**SWIW-D Infrastructure Application Component Caution (Error) Message for Roadside Signage Criterion**	**In the event of an input data, computational or other recoverable SWIW-D Infrastructure Application Component error, preventing issuing of SWIW-D Weather DII advisories, SWIW-D Diversion DII advisories, SWIW-D Closure DII advisories, or SWIW-D Closure DII alerts, the SWIW-D Infrastructure Application Component shall issue a SWIW-D Roadside Signage Message containing a SWIW-D DII Caution (Error) and an indication of SWIW-D Infrastructure Application Component Error to the Roadside Signage System Interface.**	*Caution message is displayed when denoting an error.*	D
[6.01.02.33]	**SWIW-D Infrastructure Application Component Caution (Error) Criterion for I2V Message**	**In the event of an input data, computational or other recoverable SWIW-D Infrastructure Application Component error, preventing issuing of SWIW-D Weather DII advisories, SWIW-D Diversion DII advisories, SWIW-D Closure DII advisories, or SWIW-D Closure DII alerts, the SWIW-D Infrastructure Application Component shall issue a SWIW-D I2V Message containing a SWIW-D DII Caution (Error) and an indication of SWIW-D Infrastructure Application Component Error to the Infrastructure Wireless Data Systems Interface.**	*Caution message is displayed when denoting an error.*	D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.02.34]	SWIW-D Weather Condition Input Data Refresh Frequency	The SWIW-D Infrastructure Application Component shall repeat validation of adverse weather conditions, road closures, and route diversions at a configurable frequency based on local TMC guidelines (e.g., time threshold, weather type).	*The time thresholds for weather data being communicated from the infrastructure to the vehicle and the location of infrastructure component relative to the weather zone must allow for the vehicle application to calculate and issue timely and valid advisory, alert, and warning messages at the beginning of the weather zone.*	D
6.01.03	**SWIW-D Infrastructure Application Component Data Input Requirements**			
[6.01.03.01]	SWIW-D Infrastructure Systems Message Content	The SWIW-D Infrastructure Systems Message shall contain data required to perform the calculations specified under SWIW-D Infrastructure Application Functional Requirements.	*Table (SWIW-D Infrastructure) SWIW-D Infrastructure Systems Message Data Description is referenced for guidance.*	D
[6.01.03.02]	SWIW-D Infrastructure Systems Message Specification for Vehicle Speed Sensors	The SWIW-D 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
[6.01.03.03]	SWIW-D Infrastructure Systems Message Specification for Environmental Sensor Stations	The SWIW-D Infrastructure Systems Message for capturing data from local ESS Interface shall conform to NTCIP 1204 v03 Object Definitions for Environmental Sensor Stations (ESS) Standard.		D
[6.01.03.04]	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

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.03.05]	**SWIW-D Local/Back Office User Data Content**	**The SWIW-D Local/Back Office User Data shall contain data required to perform the calculations specified under SWIW-D Infrastructure Application Functional Requirements.**	*Table (SWIW-D Infrastructure) SWIW-D Infrastructure Systems Message Data Description is referenced for guidance.*	D
[6.01.03.06]	**SWIW-D Local/Back Office User Data Specifications**	**The SWIW-D 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
[6.01.03.07]	**SWIW-D Local/Back Office User Data Content Text**	**The SWIW-D Local/Back Office User Data shall contain text used in SWIW-D DII Advisory and SWIW-D DII Alert roadway signage.**		D
[6.01.03.08]	**SWIW-D Local/Back Office User Data Content Prohibitive Frame**	**SWIW-D DII advisory and SWIW-D DII alert text shall use a prohibitive frame indicating when unsafe conditions may exist.**	*Prohibitive frame means that DII advisory and DII alert messages shall not indicate that conditions may be safe.*	D
[6.01.03.09]	**SWIW-D Local/Back Office User Data Content Graphics**	**The SWIW-D Local/Back Office User Data shall contain shapes and graphics used in SWIW-D DII Advisory and SWIW-D DII Alert roadway signage.**		D
6.01.04	**SWIW-D Infrastructure Application Component Data Output Requirements**			
[6.01.04.01]	**SWIW-D I2V Wireless Message Content**	**The SWIW-D I2V Wireless Message shall contain data required to perform the calculations specified under SWIW-D Vehicle Application Functional Requirements.**	*Table (SWIW-D Wireless) SWIW-D I2V Wireless Message Data Description is referenced for guidance.*	D
[6.01.04.02]	**SWIW-D I2V Wireless Message Specification**	**The SWIW-D I2V Wireless Message shall conform to SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary.**		D

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

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

Table 3-4. SWIW-D Infrastructure Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.01.04.09]	**SWIW-D Roadside Signage Message Prohibitive Frame**	**The SWIW-D Roadside Signage Message (SWIW-D DII advisory and SWIW-D DII alert messages) shall use a prohibitive frame indicating when unsafe conditions may exist.**	*Prohibitive frame means that DII advisory and alert messages shall not indicate that conditions may be safe.*	D
[6.01.04.10]	**SWIW-D Roadside Signage Message Graphics**	**The SWIW-D Roadside Signage Message shall contain SWIW-D DII Advisory, SWIW-D DII Alert, and SWIW-D DII Caution shapes and graphics.**	*The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.*	D

Source: Battelle

3.3.3 SWIW-D Vehicle Application Component Requirements

Table 3-5 catalogs the performance requirements for the SWIW-D 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. SWIW-D Vehicle Application Component Performance Requirements

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
6.02	**SWIW-D Vehicle Application Component Requirements**			
6.02.01	**SWIW-D Vehicle Application Component Interfaces and Interface Specifications**			
[6.02.01.01]	**SWIW-D I2V Wireless Message Interface**	**The SWIW-D Vehicle Application Component shall obtain SWIW-D I2V Wireless Messages through the Vehicle Wireless Data Systems Interface.**		D
[6.02.01.02]	**SWIW-D Vehicle Data Interface**	**The SWIW-D Vehicle Application Component shall obtain SWIW-D Vehicle Data through the Vehicle Data Systems Interface.**		D
[6.02.01.03]	**SWIW-D Driver Message Interface**	**The SWIW-D Vehicle Application Component shall issue SWIW-D Driver Messages through the Driver Warning System Interface.**		D
6.02.02	**SWIW-D Vehicle Application Component Functional Requirements**			
[6.02.02.01]	**Common Vehicle Application Component Requirements**	**The SWIW-D Vehicle Application Component shall adhere to Common Vehicle Application Component Requirements.**		D
[6.02.02.02]	**SWIW-D Vehicle Application Component Initiation**	**The SWIW-D Vehicle Application Component shall be initiated upon receipt of an SWIW-D I2V Wireless Message by the Vehicle Wireless Data Systems.**		D
[6.02.02.03]	**SWIW-D I2V Wireless Message Initiation**	**The SWIW-D Vehicle Application Component shall obtain SWIW-D I2V Wireless Messages upon initiation of the component.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.04]	**SWIW-D I2V Wireless Message Refresh Rate**	**The SWIW-D Vehicle Application Component shall refresh the SWIW-D I2V Wireless Message Input at a configurable frequency.**		D
[6.02.02.05]	**SWIW-D Vehicle Data Initiation**	**The SWIW-D Vehicle Application Component shall obtain SWIW-D Vehicle Data upon initiation of the component.**		D
[6.02.02.06]	**Vehicle Data Systems Refresh Rate**	**The SWIW-D Vehicle Application Component shall refresh SWIW-D Vehicle Data at a configurable frequency.**		D
[6.02.02.07]	**SWIW-D Infrastructure Data**	**Upon receipt of a SWIW-D I2V Wireless Message, the SWIW-D Vehicle Application Component shall open the message and parse it for relevant SWIW-D data.**		D
[6.02.02.08]	**SWIW-D Positioning Accuracy Determination**	**The SWIW-D Vehicle Application Component shall determine if the received Position Data and the Map Data meet the position accuracy requirements for the received SWIW-D I2V Wireless Message.**		D
[6.02.02.09]	**SWIW-D Positioning Accuracy Assessment**	**If the received Position Data and Map Data do not meet the position accuracy requirements for the SWIW-D I2V Wireless Message, the SWIW-D Vehicle Application Component shall refresh the Position Data and Map Data and continue processing.**	*The application should continue iteratively obtaining position and map data until SWIW-D application position accuracy requirements are satisfied for the SWIW-D I2V Wireless Message.*	D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.10]	**SWIW-D Positioning Accuracy Message – Advisory**	**If the received Position Data and Map Data do not meet the position accuracy requirements for the received SWIW-D I2V Wireless Message, the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D DII Advisory to the Driver Warning System.**	*The SWIW-D Application issues only advisory messages if position and map accuracy are not sufficient to support alert and warning calculations.*	D
[6.02.02.11]	**SWIW-D I2V Message Applicability Determination**	**The SWIW-D Vehicle Application Component shall determine if the received SWIW-D 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
[6.02.02.12]	**SWIW-D I2V Message Applicability Assessment**	**If the received SWIW-D I2V Wireless Message is not applicable, the SWIW-D Vehicle Application Component shall refresh the SWIW-D I2V Wireless Message and continue processing.**	*The application should continue iteratively obtaining SWIW-D I2V Wireless Messages until a message applicable to current vehicle conditions is received.*	D
[6.02.02.13]	**Determine Diversion Requirements**	**The SWIW-D Vehicle Application Component shall assess the SWIW-D Infrastructure Data and SWIW-D Vehicle Data to determine whether a diversion is required or suggested for the vehicle.**		D
[6.02.02.14]	**SWIW-D Weather DII Advisory Criterion**	**If no diversions are required or suggested and if the distance of the subject vehicle from the Diversion Intersection is less than the SWIW-D Weather DII Advisory Distance then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Weather DII Advisory to the Driver Warning System.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.15]	**SWIW-D Diversion DII Advisory Criterion**	**If diversions are required or suggested and if the distance of the subject vehicle from the Diversion Intersection is less than the SWIW-D Diversion DII Advisory Distance then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Diversion DII Advisory Message to the Driver Warning System.**		D
[6.02.02.16]	**Compute SWIW-D Closure DVI Alert and Warning Deceleration Rates**	**If diversions are required or suggested and the subject vehicle is beyond the Diversion Intersection, the SWIW-D Vehicle Application Component shall compute the SWIW-D Closure DVI Alert Deceleration Rate and DVI Warning Deceleration Rate for the subject vehicle based upon available SWIW-D infrastructure and SWIW-D vehicle data and published industry or OEM guidelines.**		D
[6.02.02.17]	**Compute SWIW-D Closure DVI Alert and Warning Perception Reaction Times**	**If diversions are required or suggested and the subject vehicle is beyond the Diversion Intersection, the SWIW-D Vehicle Application Component shall compute the SWIW-D Closure DVI Alert Perception Reaction Time and the DVI Warning Perception Reaction Time for the subject vehicle based upon available SWIW-D infrastructure and SWIW-D vehicle data and published industry or OEM guidelines.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.18]	**SWIW-D Closure DVI Alert Distance Equation**	**The SWIW-D Closure DVI Alert Distance shall be the distance traveled during the SWIW-D Closure DVI Alert Perception Reaction Time plus the distance required to slow the subject vehicle from its current speed to a speed of zero, at a uniform deceleration equal to the SWIW-D Closure DVI Alert Deceleration Rate.**	*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.*	D
[6.02.02.19]	**SWIW-D Closure DVI Warning Distance Equation**	**The SWIW-D Closure DVI Warning Distance shall be the distance traveled during the SWIW-D Closure DVI Warning Perception Reaction Time plus the distance required to slow the subject vehicle from its current speed to a speed of zero, at a uniform deceleration equal to the SWIW-D Closure DVI Warning Deceleration Rate.**	*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.*	D
[6.02.02.20]	**SWIW-D Closure DVI Warning Criterion**	**If diversions are required or suggested and the subject vehicle is beyond the Diversion Intersection and the distance of the subject vehicle from the Road Closure is less than the SWIW-D Closure DVI Warning Distance for its current speed, then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Closure DVI Warning to the Driver Warning System.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.21]	**SWIW-D Closure DVI Alert Criterion**	**If diversions are required or suggested and the subject vehicle is beyond the diversion point and the distance of the subject vehicle from the Road Closure is less than the SWIW-D Closure DVI Alert Distance for its current speed and greater than or equal to the SWIW-D Closure DVI Warning Distance for its current speed, then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Closure DVI Alert to the Driver Warning System.**		D
[6.02.02.22]	**SWIW-D Closure DII Alert Criterion**	**If diversions are required or suggested and the subject vehicle is beyond the Diversion Intersection and the distance of the subject vehicle to the road closure is less than SWIW-D Closure DII Distance and greater than the SWIW-D Closure DVI Alert Distance then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Closure DII Alert to the Driver Warning System.**		D
[6.02.02.23]	**SWIW-D Closure DII Advisory Criterion**	**If diversions are required or suggested the subject vehicle is beyond the Diversion Intersection and the distance of the subject vehicle to the Road Closure is less than the SWIW-D Closure DII Advisory Distance and greater than or equal to the SWIW-D Closure DII Alert Distance, then the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D Closure DII Advisory to the Driver Warning System.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.24]	**SWIW-D Diversion DII Advisory Termination**	**The SWIW-D Vehicle Application Component shall cease issuing SWIW-D Diversion DII Advisories when the vehicle passes the Diversion Intersection.**		D
[6.02.02.25]	**SWIW-D Weather DII Advisory, SWIW-D Closure DII Advisory, SWIW-D Closure DII Alert, and SWIW-D Closure DVI Alert Termination**	**The SWIW-D Vehicle Application Component shall cease issuing SWIW-D Weather DII Advisories, SWIW-D Closure DII Advisories, SWIW-D Closure DII Alerts, and SWIW-D Closure DVI Alerts when the vehicle passes the Road Closure.**		D
[6.02.02.26]	**SWIW-D Closure DVI Warning Termination**	**The SWIW-D Vehicle Application Component shall cease issuing SWIW-D Closure DVI Warnings when the vehicle exits the weather hazard.**		D
[6.02.02.27]	**SWIW-D DVI and SWIW-D DII Message Consistency**	**The SWIW-D Vehicle Application Component shall not issue a less cautious SWIW-D DII Advisory, DII Alert, DVI Alert, or DVI Warning than the SWIW-D Infrastructure Application components.**		D
[6.02.02.28]	**SWIW-D DVI Message Precedence**	**The SWIW-D Vehicle Application Component shall govern the message to be delivered to the Driver Warning System, based upon available SWIW-D infrastructure and SWIW-D vehicle data.**		D
[6.02.02.29]	**SWIW-D Caution (Error) Message Definition**	**The SWIW-D DVI Caution (Error) Message shall contain a blank or generic caution and an indication that the system is not operational.**		D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.02.30]	**SWIW-D Vehicle Application Component Error**	**In the event of an input data error, a computational error or other non-recoverable SWIW-D Vehicle Application Component Error preventing issuing of SWIW-D weather, diversion, and closure DII advisories, SWIW-D closure DVI alerts, SWIW-D closure DVI warnings, or position and map accuracy requirements not being met, the SWIW-D Vehicle Application Component shall issue a SWIW-D Driver Message containing a SWIW-D DVI Caution (Error) to the Driver Warning System.**		D
6.02.03	**SWIW-D Vehicle Application Component Data Input Requirements**			
[6.02.03.01]	**SWIW-D I2V Wireless Message Content**	**The SWIW-D I2V Wireless Message shall contain the data required to perform the calculations specified under SWIW-D Vehicle Application Functional Requirements**	*Table (SWIW-D Wireless) SWIW-D I2V Wireless Message Data Description is referenced for guidance.*	D
[6.02.03.02]	**SWIW-D I2V Wireless Message Specification**	**The SWIW-D I2V Wireless Message shall conform to SAE J2735:2009-11 Dedicated Short Range Communications (DSRC) Message Set Dictionary**		I
[6.02.03.03]	**SWIW-D I2V Wireless Message Content Text**	**The SWIW-D I2V Wireless Message shall contain SWIW-D DII Advisory, SWIW-D DII Alert, and SWIW-D DII Caution (Error) text used in roadway signage.**	*The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.*	D
[6.02.03.04]	**SWIW-D I2V Wireless Message Graphics**	**The SWIW-D I2V Wireless Message shall contain SWIW-D DII Advisory, SWIW-D DII Alert, and SWIW-D DII Caution (Error) shapes and graphics used in roadway signage.**	*The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) is referenced for guidance.*	D

Table 3-5. SWIW-D Vehicle Application Component Performance Requirements (Continued)

Rqmt. No.	Requirement Title	Performance Requirement	Elaboration	Verif. Method (I,D,T,A)
[6.02.03.05]	**SWIW-D Vehicle Systems Message Content**	**The SWIW-D Vehicle Systems Message shall contain data required to perform the calculations specified under SWIW-D Vehicle Application Functional Requirements.**	*Table (SWIW-D Vehicle) SWIW-D Vehicle Systems Message Data Description is referenced for guidance.*	D
[6.02.03.06]	**Vehicle Data Systems Message Specifications**	**The SWIW-D Vehicle Systems Message shall conform to the standards and guidelines specified by the vehicle Original Equipment Manufacturer.**	*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*	D
6.02.04	**SWIW-D Vehicle Application Component Data Output Requirements**			
[6.02.04.01]	**SWIW-D Driver Message Content**	**The SWIW-D Driver Message shall contain the SWIW-D DII Advisory, SWIW-D DII Alert, SWIW-D DII Caution, SWIW-D DVI Alert, SWIW-D DVI Warning, or SWIW-D DVI Caution content to be displayed on the Driver Warning Interface.**	*Table (SWIW-D Driver) SWIW-D Driver Message Data Description is referenced for guidance.*	D
[6.02.04.02]	**SWIW-D Driver Message Specifications**	**The following is referenced for guidance pertaining to SWIW-D 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. SWIW-D Application Message Candidate Data Elements

Appendix A suggests candidate data elements which may be included in these messages to support the SWIW-D 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, SWIW-D
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 SWIW-D 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
Approaching Vehicle Data (Required)															
Target (#)	SWIW-D	Approaching Vehicle	Dynamic	Required	External Vehicle Detection on 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	SWIW-D	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	SWIW-D	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
Local Spot Weather Data															
Air Temperature	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	°F	(-30)-120	+/- 2	°C	(-35)-49	+/-3.6	1 min		Temperature may be measured locally or estimated from nearby sensors
Temperature tolerance (if estimated)	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	°F	(-30)-120	+/-5	°C	(-35)-49	+/-9	5 min		Temperature may be measured locally or estimated from nearby sensors
Current precipitation condition	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	n/a	-	-	n/a	-	-	1 min		Precipitation may be measured locally or estimated from nearby sensors
Precipitation tolerance (if estimated)	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	n/a	-	-	n/a	-	-	5 min		Precipitation may be measured locally or estimated from nearby sensors
Visibility	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	1 min		
Visibility tolerance	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	1 min		
Wind Speed	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	mph	0-100	+/- 5	km/h	0-160	+/-9	1 min		

Table A-2. Description of Candidate Data Elements for the SWIW-D Infrastructure Data Systems 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
Precipitation rate	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in./hr	0-20	+/- 0.5	cm/hr	0-51	+/-1.3	1 min		
Precipitation accumulation	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	1 min		
Water depth	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	10 min		
Snow depth	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	10 min		
Local Weather Data Applicable Road Map Segments	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
Local Weather Data Applicable Date and Time – Begin	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Local Weather Data Applicable Date and Time – End	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Local Road Surface Data															
Road surface temperature	SWIW-D	Road Surface Condition	Dynamic	One required from group	Infra Data System – Road Surface	Infra Application Component	°F	(-30)-120	+/- 2	°C	(-35)-49	+/-3.6	1 min		
Road surface wetness	SWIW-D	Road Surface Condition	Dynamic	One required from group	Infra Data System – Road Surface	Infra Application Component	n/a	-	-	n/a	-	-	5 min		
Road surface friction coefficient	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	coefficient	-	+/- 0.01	coefficient	-	+/- 0.01	1 min		
Road Condition Data Applicable Road Map Segments	SWIW-D	Road Surface Condition	Dynamic	Required	Infra Data System – Road Surface	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	1 min		

Table A-2. Description of Candidate Data Elements for the SWIW-D Infrastructure Data Systems 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
Road Condition Data Applicable Date and Time – Begin	SWIW-D	Road Surface Condition	Dynamic	Required	Infra Data System – Road Surface	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Road Condition Data Applicable Date and Time – End	SWIW-D	Road Surface Condition	Dynamic	Required	Infra Data System – Road Surface	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		

Source: Battelle

Table A-3. Description of Candidate Data Elements for the SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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 SWIW-D Infrastructure Map Message and SWIW-D 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
Adverse Weather Diversion Zone Geometry															
Adverse Weather Diversion Zone Begin – Latitude	SWIW-D	Diversion 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.
Adverse Weather Diversion Zone Begin – Longitude	SWIW-D	Diversion 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.
Adverse Weather Diversion Zone Begin – Elevation	SWIW-D	Diversion 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.
Adverse Weather Diversion Zone End – Latitude	SWIW-D	Diversion 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.
Adverse Weather Diversion Zone End – Longitude	SWIW-D	Diversion 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.
Adverse Weather Diversion Zone End – Elevation	SWIW-D	Diversion 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.
SWIW-D Operational Data															
Posted Speed Limit	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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.

Table A-4. Description of Candidate Data Elements for the SWIW-D Infrastructure Map Message and SWIW-D 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
SWIW-D Roadside Signage Data															
Adverse Weather Diversion Zone Begin – MUTCD Sign Number options for consideration to be used as DII Advisory Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – Graphic options for consideration to be used as DII Advisory Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – Advisory Text options for consideration to be used as DII Advisory Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – DII Advisory Sign Distance	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – DII Advisory Visibility Distance	SWIW-D	SWIW-D 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 SWIW-D Infrastructure Map Message and SWIW-D 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
Adverse Weather Diversion Zone Begin – MUTCD Sign Number options for consideration to be used as DII Alert Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – Graphic options for consideration to be used as DII Alert Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – Alert Text options for consideration to be used as DII Alert Message	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – DII Alert Sign Distance	SWIW-D	SWIW-D 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.
Adverse Weather Diversion Zone Begin – DII Alert Visibility Distance	SWIW-D	SWIW-D 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 SWIW-D 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
SWIW-D Operational Data															
SWIW-D Applicable Date and Time – Begin	SWIW-D	SWIW-D 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		
SWIW-D Applicable Date and Time – End	SWIW-D	SWIW-D 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		
SWIW-D Applicable Road Map Segments	SWIW-D	SWIW-D Operational Data	Dynamic	Required	Infra Application Component	Vehicle Application Component	TBD	TBD	TBD	TBD	TBD	TBD	TBD		Data format is based upon segments in SWIW-D Road Map
Local Spot Weather Data															
Air Temperature	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	°F	(-30)-120	+/- 2	°C	(-35)-49	+/-3.6	1 min		Temperature may be measured locally or estimated from nearby sensors
Temperature tolerance (if estimated)	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	°F	(-30)-120	+/-5	°C	(-35)-49	+/-9	5 min		Temperature may be measured locally or estimated from nearby sensors
Current precipitation condition	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	n/a	-	-	n/a	-	-	1 min		Precipitation may be measured locally or estimated from nearby sensors
Precipitation tolerance (if estimated)	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	n/a	-	-	n/a	-	-	5 min		Precipitation may be measured locally or estimated from nearby sensors
Visibility	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	1 min		
Visibility tolerance	SWIW-D	Local Weather Data	Dynamic	Optional	Infra Data System – Local Weather	Infra Application Component	ft	1-1000	+/- 2	m	0.3-305	+/-0.6	1 min		
Wind Speed	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	mph	0-100	+/- 5	km/h	0-160	+/-9	1 min		
Precipitation rate	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in./hr	0-20	+/- 0.5	cm/hr	0-51	+/-1.3	1 min		

Table A-5. Description of Candidate Data Elements for the SWIW-D I2V Wireless Message Data Description (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
Precipitation accumulation	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	1 min		
Water depth	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	10 min		
Snow depth	SWIW-D	Local Weather Data	Dynamic	One required from group	Infra Data System – Local Weather	Infra Application Component	in.	0-20	+/- 0.5	cm	0-51	+/-1.3	10 min		
Local Weather Data Applicable Road Map Segments	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
Local Weather Data Applicable Date and Time – Begin	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Local Weather Data Applicable Date and Time – End	SWIW-D	Local Weather Data	Dynamic	Required	Infra Data System – Local Weather	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Road Surface Condition Data															
Road surface temperature	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	°F	(-30)-120	+/- 2	°C	(-35)-49	+/-3.6	1 min		
Road surface wetness	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	1 min		
Road Condition Data Applicable Date and Time – Begin	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Road Condition Data Applicable Date and Time – End	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	Date & Time	Current + 30 days	+/- 1 min	Date & Time	Current + 30 days	+/- 1 min	1 min		
Road Condition Data Applicable Road Map Segments	SWIW-D	Road Surface Condition	Dynamic	Optional	Infra Data System – Road Surface	Infra Application Component	TBD	TBD	TBD	TBD	TBD	TBD	TBD		Road Condition Data format is based upon segments in SWIS-RS Road Map

Source: Battelle

Table A-6. Description of Candidate Data Elements for the SWIW-D 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 Characteristics															
Vehicle mass	SWIW-D	Vehicle 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	SWIW-D	Vehicle 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.
Vehicle CG Height	SWIW-D	Vehicle Characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	in	0-300	+/- 2	cm	0-7620	+/- 50.8	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.
Average Deceleration Rate	SWIW-D	Vehicle Characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	ft/s^2	0-32.2	+/- 1	m/s^2	0-9.81	+/- 0.304	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.
Maximum Deceleration Rate	SWIW-D	Vehicle Characteristics	Quasi-Static (per vehicle trip)	Optional	Vehicle Data Systems	Vehicle Application Component	ft/s^2	0-32.2	+/- 1	m/s^2	0-9.81	+/- 0.304	Upon Power On		Assumes Mass, Length and Height are constant during trip, defined as vehicle start up/shut down cycle.
Vehicle Functional Status															
Vehicle Speed Current	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	mph	0-120	+/- 2	km/h	0-194	+/-3.2	10 Hz		
Vehicle acceleration Current	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	ft/s^2	0-50	+/- 2	m/s^2	0-15	+/-0.6	10 Hz		
Brake activation	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	on/off	n/a	n/a	on/off	n/a	n/a	10 Hz		
Steering wheel angle	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	degrees	(-70)-70	+/- 2	degrees	(-70)-70	+/- 2	10 Hz		

Table A-6. Description of Candidate Data Elements for the SWIW-D Vehicle Systems Message Data Descriptions (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
Vehicle traction control activation	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	on/off	n/a	n/a	on/off	n/a	n/a	10 Hz		
Antilock brake system activation	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	on/off	n/a	n/a	on/off	n/a	n/a	10 Hz		
Electronic stability control activation	SWIW-D	Vehicle Functional Status	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	on/off	n/a	n/a	on/off	n/a	n/a	10 Hz		
Vehicle Environmental Data															
Temperature (Air)	SWIW-D	Vehicle Environmental Data	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	°F	(-30)-120	+/- 2	°C	(-35)-49	+/-3.6	1 Hz		Potential for Ice
Rain Sensor Status	SWIW-D	Vehicle Environmental Data	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	0,1,2,3,4	n/a	n/a	0,1,2,3,4	n/a	n/a	1 Hz		Potential for Slippery Roads/Low Visibility
Windshield Wiper Status	SWIW-D	Vehicle Environmental Data	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	0,1,2,3,4	n/a	n/a	0,1,2,3,4	n/a	n/a	1 Hz		Potential for Slippery Roads/Low Visibility
Headlight Status	SWIW-D	Vehicle Environmental Data	Dynamic	Optional	Vehicle Data Systems	Vehicle Application Component	0,1,2,3,4	n/a	n/a	0,1,2,3,4	n/a	n/a	1 Hz		Potential for Low Visibility

Source: Battelle

Table A-7. Description of Candidate Data Elements for the SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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	SWIW-D	SWIW-D 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 Priority	SWIW-D	SWIW-D 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
RWIS	Road-Weather Information System
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
TMC	Traffic Management Center
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 to 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

[2] Task Committee; Structural Engineering Institute (1999). *Structural Design for Physical Security*. ASCE. ISBN 978-0-7844-0457-7.

apply their own judgment, and can lessen liability issues as compared to indicating a more definitive 'permissive' notification of when conditions are "safe".

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/tmguide/tmg4.htm#app4c

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-16-253

U.S. Department of Transportation