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Dedicated Short Range Communications (DSRC)
Performance Requirements for V2V Safety Awareness

RATIONALE

The V2X Core committee has voted to cancel this document due to lack of industry interest and incompatibility with later versions of SAE J2735.

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SECTION 1 GENERAL [INFORMATIVE]

1.1 Scope

This SAE Document specifies DSRC interface requirements for V2V Safety Awareness applications, including detailed Systems Engineering documentation (needs and requirements mapped to appropriate message exchanges). These applications include: Emergency Vehicle Alert, Roadside Alert, and Safety Awareness Alerts for Objects and Adverse Road Conditions. This document extends the V2V Communications capabilities defined in J2945/1 to support these applications, and the National ITS Architecture.

The purpose of this SAE Document is to enable interoperability for V2V Safety Awareness communications.

1.2 References

1.2.1 Normative References

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

1.2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2945/0 Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for J2945/x Documents and Common Design Concepts™, December 2017

SAE J2945/1 On-board System Requirements for V2V Safety Communications, March 2016

SAE J2735 Dedicated Short Range Communications (DSRC) Message Set Dictionary, March 2016 [SAE J2735]

SAE J2540-2 IT IS Phrase Lists (International Traveler Information Systems), November 2009

SAE J3067 Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods, August 2014

1.2.1.2 IEEE Publications

Available from IEEE, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 1609.2™-2016 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages

IEEE 1609.3™-2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

IEEE 1609.12 1609.12-2016 - IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Identifier Allocations

It should be noted that there are additional standards in the 1609 suite which are not directly referenced here but which may also be of assistance to implementers.

1.2.1.3 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>

ISO/IEC 8824-1:1998 Information technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation.

ISO/IEC 8824-2:1998 Information technology - Abstract Syntax Notation One (ASN.1): Information objects specification

- ISO/IEC 8824-3:1998 Information technology - Abstract Syntax Notation One (ASN.1): Constraint specification.
- ISO/IEC 8824-4:1998 Information technology - Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 specifications.
- ISO/TS 19091 Intelligent transport systems -- Cooperative ITS -- Using V2I and I2V communications for applications related to signalized intersections

1.2.2 Other References

All documents cited here are considered non-normative.

Connected Vehicle Reference Implementation Architecture (CVRIA), US DOT ITS JPO, 1200 New Jersey Avenue, SE, Washington, DC 20590, <http://www.iteris.com/cvria/index.html> (last accessed November 2016).

NTCIP 8002 Annex B1 version v01, American Association of State Highway and Transportation Officials (AASHTO), 444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001
http://www.ntcip.org/library/documents/pdf/8002_AnnexB1_v01_aspublished_20160919.pdf, September 2016.

NIST SP800-122 Guide to Protecting the Confidentiality of Personally Identifiable Information (PII),
<http://csrc.nist.gov/publications/nistpubs/800-122/sp800-122.pdf>. [NIST]

INCOSE Systems Engineering Handbook v3.2.2, available from INCOSE Publications, <http://www.incose.org>

FCC 412172 D01 Guidelines For Determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF Transmitting System, August 2015. [FCC]

US DOT NHTSA Vehicle to Vehicle Communication Technology Fact Sheet 11078-101414-v2a.
https://www.safercar.gov/staticfiles/safercar/v2v/V2V_Fact_Sheet_101414_v2a.pdf [US DOT]

U.S. Department of Transportation *Privacy Impact Assessment*, National Highway Traffic Safety Administration Notice of Proposed Rulemaking (NPRM) on V2V Communications, December 2016.

1.3 General Statements

This section is included to comply with NTCIP format, but is not applicable in this document.¹

1.4 Terms

For the purposes of this document, the definitions, abbreviations and acronyms found in SAE J2735 shall apply. The following additional definitions, abbreviations and acronyms supersede those found in in SAE J2735 in the case of conflict.

1.4.1 Definitions

For the purposes of this document, the following additional definitions shall apply. Bracketed references in this section refer to the References section above.

Data Authorization Rule: The term used in this document to refer to an SSP constraint facet that operates on one or more values of the data concept in a message. While most of the defined constraint facets control the allowed value range of a single data concept, the Data Authorization Rules allows expressing more complex data relationships upon the subject message. These rules, or rule sets, are referred to by an indexing system (the SSPLocalRuleID entry) in the SSPconstraintRuleIndex data frame which is part of each SSPentry. Like all other SSP constraint facets, a message which fails to validate against any SSPconstraintRuleIndex is considered to be fraudulent and shall be discarded (see Annex H).

¹ "NTCIP format" is used throughout this document to refer to the document structure defined in NTCIP 8002 Annex B1 version v01.

EIRP (Effective Isotropically Radiated Power): The product of the power supplied to the antenna and the antenna gain (when the power and gain are represented in linear terms), where the antenna gain is expressed relative to an ideal (theoretical) isotropic antenna. [FCC]

Host Vehicle (HV): The equipped vehicle about which the use case is constructed. The Host Vehicle (HV) can be a transmitting vehicle, or a receiving vehicle, or both – this distinction is made clear in the use case description. There is typically only one Host Vehicle in any use case. This term has been selected to provide consistency among the diverse terms found in the source materials (host vehicle, remote vehicle, etc.). [SAE J2735]

Remote Vehicle (RV): The equipped vehicle (or vehicles) which play supporting roles in the use case by interacting with the Host Vehicle in some way. Each Remote Vehicle (RV) can be a transmitting vehicle, or a receiving vehicle, or both – this distinction is made clear in the use case description. There is typically more than one Remote Vehicle in any use case. This term has been selected to provide consistency among the diverse terms found in the source materials (host vehicle, remote vehicle, etc.). [SAE J2735]

Sensitive Data: Data which is necessary to support the Use Cases in this document (e.g., location of a disabled vehicle) but which may be misused for targeting vulnerable populations (e.g., stranded motorists, police officers, hazmat vehicles) and must therefore be secured to avoid this problem. Distinguished from Personally Identifiable Information (PII) (e.g., name and address of the driver of a disabled vehicle).

Personally Identifiable Information: Any information about an individual maintained by an agency, including (1) any information that can be used to distinguish or trace an individual's identity, such as name, social security number, date and place of birth, mother's maiden name, or biometric records; and (2) any other information that is linked or linkable to an individual, such as medical, educational, financial, and employment information. [NIST]

Security Authority: The combination of Authority functions supporting the SCMS or other security management system which provides trusted security credentials to users.

Security Credential Management System (SCMS): The entity that issues, distributes, and revokes security credentials for devices operating within the DSRC system. [USDOT]

Special Purpose Vehicle: A vehicle which is serving in a specifically defined role at a given time, e.g., police, fire, EMS. See section 2.2.2 for the full list of special purpose vehicle roles. A Special Purpose Vehicle also has some unique rights (as reflected by its issued security certificates) which are utilized when it participates in one or more of the application use cases which are defined by this document.

Vehicle Position Vector: A term to describe the combination of data elements sent in a BSM message which reflects the current dynamic state of the sending vehicle including its estimated time, latitude, longitude, heading, speed and various acceleration estimates as described by the DF_BSMcoreData defined in J2735.

1.5 Abbreviations

The additional abbreviations and acronyms cited below shall be a part of the terms of this document (and of the other companion volumes and guides) unless specifically cited otherwise.

BSM	Basic Safety Message
DOP	Dilution of Precision
DSRC	Dedicated Short Range Communications
EV	Emergency Vehicle
EVA	Emergency Vehicle Alert
GDOP	Geometric Dilution of Precision
HV	Host Vehicle
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
RSA	Roadside Alert
RV	Remote Vehicle

SAW-A	Safety Awareness – Adverse Road Condition
SAW-O	Safety Awareness – Object
SCMS	Security Credential Management System
SSP	Service Specific Permissions
V2V	Vehicle-to-Vehicle

SECTION 2 CONCEPT OF OPERATIONS [NORMATIVE]

This document provides a set of Requirements and a Design for the following four Use Cases:

Emergency Vehicle Alert (EVA),

Roadside Alert (RSA),

Safety Awareness – Object (SAW – O),

Safety Awareness – Adverse Road Condition (SAW – A).

These Requirements inform a set of normative messages, data concepts and data elements which are to be used to support the Use Cases. A more detailed explanation of the application areas referenced by these terms follows.

It is important to note that abbreviations used in this document (e.g., EVA, RSA) refer to the *use cases*, and should not be confused with current existing or prior DSRC *messages* defined in SAE J2735 which have similar names. For example, the design by which the Roadside Alert (RSA) requirements in this document are met involves sending some additional message content within the BSM Part II message. There is also a J2735 message referred to as the Roadside Alert (RSA) message that is used by DOT equipment, public safety vehicles, and other vehicles to alert travelers to events and incident conditions. It is important to differentiate between the two usage contexts to avoid confusion.

This document includes a Needs to Requirements Traceability Matrix (NRTM) which provides a mapping between the user needs and the functional requirements which have been developed to meet these needs. It also includes a Requirements Traceability Matrix (RTM), which provides a mapping from the functional requirements to the profiled data concept (dialog, message, data frame, or data element) which is required to meet those requirements. The data concepts themselves are taken (by reference) from the J2735 data dictionary, and additional constraints are applied to profile them to meet additional design requirements, when needed. The data concepts used from J2735 are listed in section 5. Unlike a typical data dictionary entry, these entries simply list the concept (referring to SAE J2735 for details) and then provide any additional profiling constraints needed. Additional content, when needed, is also defined.

This section consists of a concept of operations that identifies user needs related to the applications supported by this document. Developing and explaining these general concepts is the primary content to be found in this section of the document.

2.1 Tutorial [Informative]

This document was developed using an adaptation of the formal Systems Engineering process defined by INCOSE. The diagram below provides an overview of where System Engineering artifacts are located in this document.

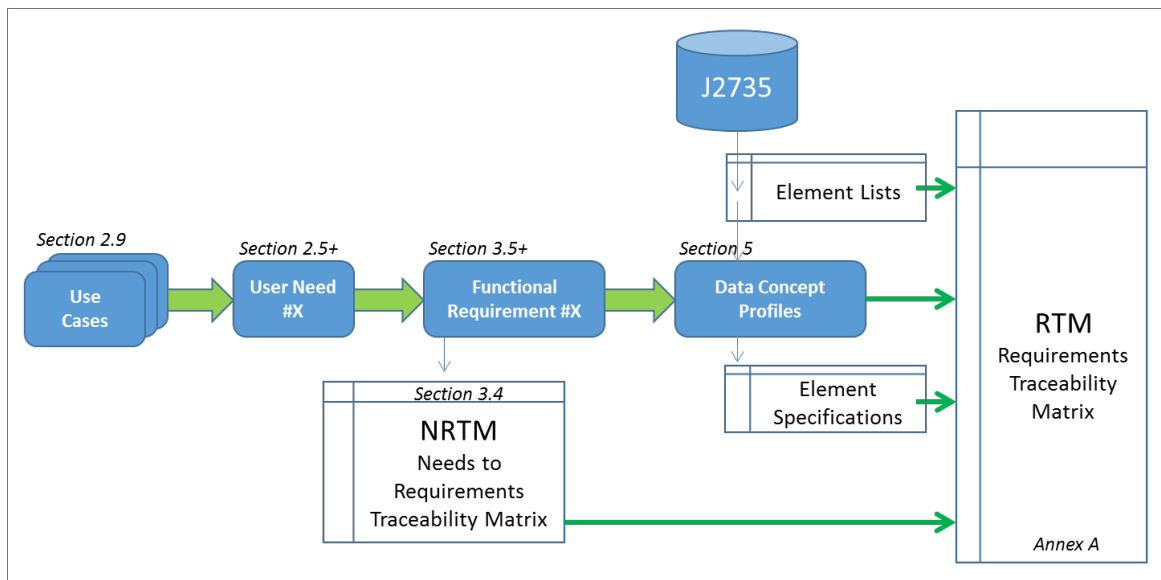


Figure 1 - Location of system engineering artifacts

An overview of how to navigate from user needs to functional requirements in the NRTM to dialogs and data elements in the Requirements Traceability Matrix (RTM) is shown in the figure below, which shows how traceability works across the various tables in this document.

User Need

User Need ID	User Need Title	User Need
2.5.2.3.1.3	Transmit Emergency Status	First Responder RVs in active service states need to transmit service state, heading, and location information under both optimal and sub-optimal conditions. This information helps the HV determine the correct response to the presence of the RV.

Requirements

FR ID	Functional Requirement Title	Functional Requirement
3.6.2.1.4	Broadcast Emergency Alert Information	First Responder RV shall broadcast the following information elements: Service State (as specified in Section 2.2.3 Service States), and Event Flags (as specified in J2945/1 Section 6.3.1).

Needs to Requirements Traceability Matrix (NRTM)

User Need ID	User Need Title	FR ID	Functional Requirement Title	Conformance	Support	Additional Specifications
2.5.2.3.1.3	Transmit Emergency Status			M	Yes	
		3.6.2.1.4	Broadcast Emergency Alert Information	M	Yes	

Requirements Traceability Matrix (RTM)

FR ID	Functional Requirement Title	Dialog ID	Data Concept ID	Data Concept Name	Additional Specifications
3.6.2.1.4	Broadcast Emergency Alert Information	4.2.1			
			5.3.2	DF_EVAvehicleExtension	
			5.4.19	DE_ServiceState	
			SAE J2735_201603 6.8	DE_BSMCoreData	Default, Value range restrictions...

J2735

Figure 2 - Needs to requirements traceability

2.2 Current Situation and Problem Statement [Informative]

The information taxonomy below provides additional context for the four Use Cases outlined in Section 2.9. This taxonomy provides a common conceptual framework that allows the technical committee to scope the problem space. The taxonomy is intended as a description of the dimensions of the problem, not a solution. This document describes the concepts as if they were messages to aid in reader comprehension of the problem, not as a proposal for how the design would actually work. Design solutions may be found in Sections 4 and 5.

In the taxonomy, the information needs of the use cases are organized into four information types. Within each of these four information categories, there are two types of actors: credentialed (those with additional permanent or temporary privileges allowing them to transmit certain information, such as a police officer's vehicle), and non-credentialed (those without special privileges, such as a typical consumer light duty passenger vehicle). The sections below provide further details about types and actors, as well as additional categories which sort and classify the use cases and informational flows, including vehicle roles, vehicle types, service states, and vehicle behaviors.

2.2.1 Information Taxonomy

Connected vehicles need to communicate certain types of information² to enable safety awareness. These information types include:

- "I'm doing something unusual." For example, a vehicle may announce that it is disabled in the roadway, for which no special communications credentials are required. This information type may also be used by an emergency or special purpose vehicle indicating a non-emergency non-standard traffic maneuver for which special communications credentials would be required. Special purpose vehicles may need to provide lane level details to help others to avoid them.
- "Clear the way." For example, an emergency vehicle may broadcast its location on the way to an incident. This information type would only be used by credentialed emergency responders. This information may be accompanied by additional information about the type of emergency.
- "I register something changed/unusual." For example, a vehicle may indicate an object or a road weather event. In the credentialed case, this might include an emergency vehicle sharing information from a hazmat site.
- "Directives and advice." A central authority may provide instruction to drivers in response to an incident or other travel situation. This information type is out of scope for this document as it is not V2V.

² In the DSRC system, the ability to control and test for valid message information content is provided by the certificate credentialing system. The certificate credentialing system allows control of additional privileges needed for these different information types. The requirements which that standard places on (are allocated to) the credentialing systems are further developed from the needs defined in Section 2.6.

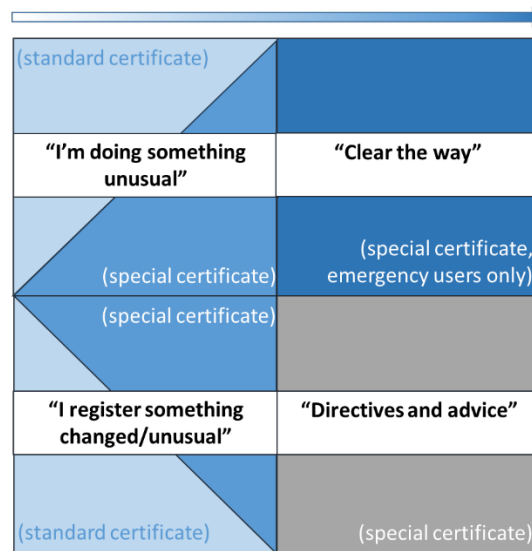


Figure 3 - Taxonomy of the primary information types

These information types are exchanged in a variety of different scenarios which are described in Use Cases (see Section 2.9). There is a need to revise existing frameworks to better support the range of information to be provided in these Use Cases and the latest technologies which are evolving to provide that information.

To address this need, this document defines a set of message contents and other related requirements which enable interoperable information-sharing between vehicles. These messages are derived from a set of Use Cases based on applications currently defined in the CVRIA and other key source materials, such as J2735, J2945/1, J3067, ISO 19091, and other formal user needs documentation from programs such as the Connected Vehicle Pilot Deployment Projects.

2.2.2 Vehicle Roles and Types

Additional concepts used in developing the core Use Cases include vehicle *types* and vehicle *roles*. A *type* refers to the physical nature of the vehicle, and does not change. There are several basic vehicle types, such as light duty passenger vehicles, motorcycles, and trucks. A *role* refers to the nature of what the vehicle is doing at a given time. A vehicle of a certain *type* may take on specific defined "special purpose" *role* depending on what it is then doing.

For the V2V Safety Awareness use cases covered in this document, Special Purpose vehicle roles include:

- Roadwork (Construction and repair operations)
- Towing (Towing operations in general)
- Police
- Fire
- EMS (Emergency Medical Services, e.g., ambulances)
- Limited Speed & Oversize (e.g., freight trucks, snow plows)
- Defined Service (e.g., transit, garbage trucks, mail trucks, school buses, and others that routinely disturb the flow of traffic). Some of these vehicles have behaviors which may place specific requirements on drivers, e.g., school buses.
- Military & Government (Federally owned/operated vehicles as defined by other SAE work such as J2735 definitions)

Some vehicles hold these roles at all times, while others revert to another more basic role the majority of the time. For example, a light duty passenger vehicle which is owned and operated by a local volunteer firefighter, may assume the role

of an emergency vehicle during a period of service (i.e., temporarily take on the firefighter role). The certificate(s)³ issued and associated with this vehicle would then grant the specific rights which local authorities had determined were suitable for the emergency vehicle role. One such right might be the ability to send the message content associated with the EVA use case. This concept is a core principle of the security system used to determine permissions for sending certain messages, e.g., those with special priority or credentials. For the purposes of this document, a remote vehicle (RV) is considered to be in an emergency vehicle role whenever it is transmitting message content that requires any elevated security privileges to be sent.

The Police, Fire, EMS and Military & Government roles are categorized as “First Responders” for ease of reference throughout this document. Any of the vehicle roles may be designated as “Special Purpose” per the Use Case in Section 2.9.2.

Vehicle *types* are classified as defined in J2735 with the DE_BasicVehicleClass data concept.

The term “basic role” is used here simply to imply that all vehicles have some fundamental use case to which they are assigned, and to which they revert when not engaged in one of the roles described by the four applications which are defined in this document.

2.2.3 Service States

The operational scenarios also include a number of service states. This concept typically applies to vehicles used in a public safety capacity.

The service states are:

- Out of service. Vehicle is not being used for official purposes and does not have any special rights or requirements.
- In service – no call active. Vehicle is officially on duty but not currently responding to a service request.
- In service – non-emergency call active. Vehicle is officially on duty and is actively handling a non-emergency service call.
- In service – emergency call active. Vehicle is officially on duty and is actively handling an emergency service call.
- In service – emergency call active (stealth). Vehicle is officially on duty and is actively handling an emergency service call without lightbars or sirens but still sending BSMs with Part II content. This may include the requirement for silent channel access priority. For example, a vehicle with suitable rights may send BSMs with EVA content at a higher power.

It should be noted that a public safety vehicle on duty and actively handling an emergency service call may also elect not to send any DSRC information to others about its state.

2.2.4 Driving Behaviors

These vehicle states are associated with a set of driving behaviors of the equipped vehicle which may need to be reported to other drivers:

- Stopped. Vehicle is at rest in or alongside the roadway, creating an obstacle which should be noted by drivers.
- Slow-moving. Vehicle is proceeding significantly more slowly than mainstream traffic in or along the roadway, creating a moving hazard which should be noted by drivers traveling in the same direction of flow, as defined

³ The term “certificate” is used to refer to the 1609 security certificate throughout this document.

by J2735 definitions (see section 3.1.93). For the purposes of this document, the following use cases also apply:

- when the subject vehicle speed is less than 3.0 m/s for any period of more than 5 seconds and when any other vehicles present are moving at a faster speed, or
 - when other nearby traffic is proceeding at a speed greater than 10.0 m/s faster than the subject vehicle, or
 - when the subject vehicle is moving at a speed of less than 20% of the speed of nearby vehicles.
- Stop-and-Go. Vehicle is periodically stopping and restarting, perhaps without clearing the lane, such as during roadside litter collection operations.
- Slow-Unusual maneuver. Vehicle is performing a specific slow action other than driving along the roadway, such as a truck docking or backing into roadway.
- Fast-emergency. Vehicle is operating under emergency vehicle traffic rules, including speed, direction and location of travel, creating a fast-moving hazard which may require drivers to be alert and / or to actively assist by pulling aside. The vehicle may also engage in non-standard driving such as using the opposing lanes to reach an intersection. Due to the nature of nearby traffic clearing, this may also involve erratic stop-and-go behaviors.

A matrix of the vehicle roles, service states, and driving behaviors is shown below:

Table 1 - Vehicle service states and driving behaviors

	Service State					Driving Behaviors				
	Out of service	In service – no call	In service – non-emergency call active	In service – emergency call active	In service – emergency call active (stealth)	Stopped	Slow-moving	Stop and Go	Slow-Unusual Maneuver	Fast-emergency
Roadwork	x		x	x		x	x	x	x	
Tow trucks	x	x	x	x		x	x	x	x	
Police	x	x	x	x	x	x	x	x	x	x
Fire	x	x	x	x	x	x	x	x	x	x
EMS	x	x	x	x	x	x	x	x	x	x
Limited Speed and Oversize			x	x		x	x	x	x	
Defined Service	x		x	x		x	x	x		
Military & Govt.	x	x	x	x	x	x	x	x	x	x

2.3 Reference Physical Architecture

The assumptions which developers can reasonably make in developing the more detailed design description of the system environment are described in the Connected Vehicle Reference Implementation Architecture and incorporated here by reference only.

2.3.1 Typical Physical Architecture

The functional architecture which provides the context for the system addressed by this document is shown below in a context diagram (Figure 4).

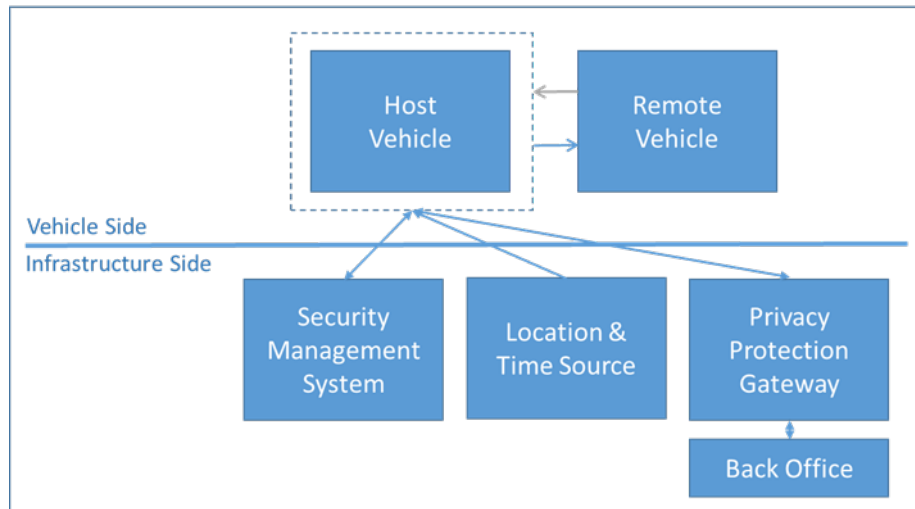


Figure 4 - Context Diagram

The elements of this context diagram include:

- **Host Vehicle (HV).** The HV is the target for the actions taken by the Remote Vehicle (RV). For example, the RV might be a police car broadcasting “clear the way” type information, and the driver of the HV would receive and may act on that information appropriately. The HV does provide information to the RV (e.g., BSM “here I am” data).
- **Remote Vehicle (RV).** The RV typically broadcasts messages which initiate actions taken by the HV in the use cases in this document.
- **Infrastructure.** Both the RV and the HV interact with the infrastructure in order to receive security, location and time, and privacy support, as well as any input required from a back office. The primary interaction in these use cases is with the HV, however, so the diagram in Figure 4 has been simplified to show only the interactions between the HV and the infrastructure.
- **Security Management System.** The interconnected systems that enable trusted communications between mobile devices and other mobile devices, roadside devices, and centers and protect data they handle from unauthorized access.⁴
- **Location and Time Source.** Location and time references are sourced from GPS/GNSS and may be augmented by other means, such as dead-reckoning and local clocks when GPS is not available.
- **Privacy Protection Gateway.** A support system that obscures the network identifiers of both roadside and mobile devices.⁵

2.4 Architectural Needs

This section is included to comply with NTCIP format, but is not applicable in this document.

2.5 Features

This section includes the user needs associated with the specific applications covered by the CVRIA's V2V Safety Awareness use case group⁶

⁴ <http://www.iteris.com/cvria/html/physobjects/physobj86.html> (last accessed November 2016).

⁵ <http://www.iteris.com/cvria/html/physobjects/physobj119.html> (last accessed November 2016).

⁶ See <http://local.iteris.com/cvria/html/applications/applications.html> for a further definition of a use case group. (last accessed November 2016).

2.5.1 V2V Safety Awareness scope

The use cases included in the CVRIA V2V Safety Awareness use case group⁷ are:

1. Blind Spot Warning – Lane Change Warning (BSW-LCW)
2. Control Loss Warning (CLW)
3. Electronic Emergency Brake Light (EEBL)
4. Forward Collision Warning (FCW)
5. Intersection Movement Assist (IMA)
6. Emergency Vehicle Alert (EVA)
7. Situational Awareness
8. Slow Vehicle Warning
9. Stationary Vehicle Warning
10. Do Not Pass Warning
11. Pre-crash Actions
12. Tailgating Advisory
13. Vehicle Emergency Response
14. Motorcycle Approaching Indication

Use cases 1-5 are covered in J2945/1, and incorporated here *by reference only*. Use cases 6-9 are provided in Section 2.9 of this document. It should be noted that the use case naming in this document is slightly different than that used in the CVRIA. In this document, “Situational Awareness” has been changed to “Safety Awareness” in deference to the First Responder community. “Roadside Alert” includes both slow and stationary vehicle warnings. Use cases 10-14 are not covered in any SAE J2945/x document in development at the time of publication.

It is presumed that the core communications capabilities and performance described in J2945/1 are implemented by any device conforming to this document, in addition to the normative requirements of this document. (The J2945/1 document was developed for use by light duty passenger vehicles. Other J2945/x documents, such as this one, support additional vehicle types and roles.)

It is also presumed that fleet managers may have additional requirements for exchanging information and command/control information with their fleets. Some accommodation for this exchange has been made in this document, but it is expected that further work (beyond this document) will be needed to address these requirements.

Table 2 - Use Case High Level Descriptions

Use Case	High Level Description
----------	------------------------

⁷ <http://local.iteris.com/cvria/html/applications/applications.html> (last accessed November 2016)



Emergency Vehicle Alert (EVA)	This use case allows emergency responders to communicate with other drivers while engaged in fast-emergency behaviors. This may require drivers to be alert or take action to avoid obstructing emergency response activities. ⁸
Roadside Alert (RSA)	This use case allows special purpose or disabled vehicles to communicate stopped or slow-moving behaviors which may obstruct or complicate mainstream traffic. This may require drivers to be alert or take action to provide additional clearance to roadside activities.
Safety Awareness – Object (SAW-O)	This use case describes a vehicle broadcasting the potential presence of an object in the roadway.
Safety Awareness – Adverse road condition (SAW – A)	This use case describes a vehicle broadcasting potentially adverse road conditions which are of immediate potential safety impact.

To place these Use Cases in the context of the information taxonomy described in Section 2.2.1, see figure below:

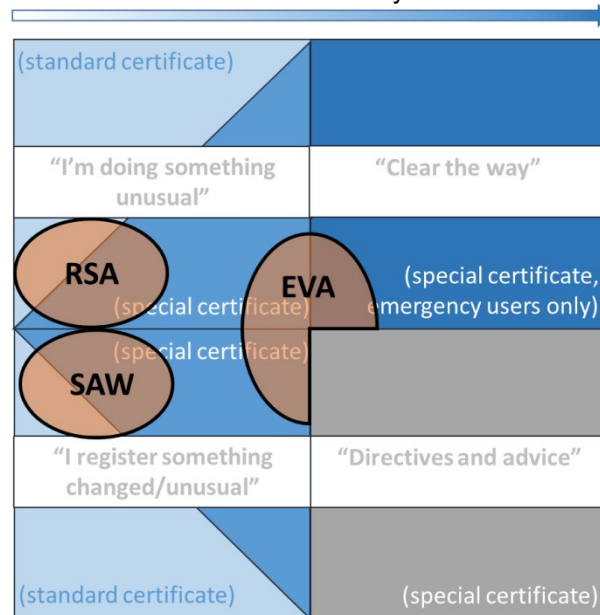


Figure 5 - Taxonomy with use case overlay

2.5.2 User Needs

Participation in any of the applications described in this document is optional. Vehicles that transmit the additional information described in this document must conform to the message content requirements defined herein.

2.5.2.1 Common User Needs

The following user needs apply to all of the use cases in this document.

2.5.2.1.1 Maximize Position Vector Transmission

Vehicles need to be able to share their position vector in optimal and sub-optimal GNSS conditions (e.g., urban canyons, tree cover, near buildings, directly after power up). This will help ensure effective sharing of position information in the broadest possible range of environmental conditions.

⁸ As noted in Section 2.2.4, a vehicle using fast-emergency behaviors is operating under emergency vehicle traffic rules.

2.5.2.1.2 Meet Basic Communications Performance Metrics

All vehicles in this system (as defined in Figure 4 Context Diagram) need to be able to support the basic communications capabilities and performance requirements described in J2945/1.

2.5.2.1.3 Support Basic V2V Safety Awareness Communications

All vehicles in this system need to be able to send the basic communications content described in J2945/1.

2.5.2.1.4 Enable Secure Communications

Vehicles need to be properly authorized to send content for the applications described in this document.

2.5.2.2 Use Case-Specific User Needs

2.5.2.2.1 Emergency Vehicle Alert (EVA)

2.5.2.2.1.1 Provide Emergency Vehicle Alert

Help drivers to avoid collisions with nearby emergency vehicles and to clear the roadway so that emergency vehicles can proceed more effectively. The driver needs to receive information about the location and status of nearby emergency vehicles responding to an incident.

2.5.2.2.1.1.1 Authorize Emergency Communication

RVs taking on the First Responder role need a method to become authorized to communicate as First Responders in a variety of connectivity scenarios, e.g., in implementations involving local and remote certificate authorizations. This helps prevent misuse of these messages.

2.5.2.2.1.1.2 Initiate Emergency Alert

First Responder RVs need a way to indicate active Service States (e.g., "emergency call active"). This helps ensure that their communications will generate appropriate responses from HVs.

2.5.2.2.1.1.3 Transmit Emergency Status

First Responder RVs in active service states need to transmit service state, heading, speed, and location information under both optimal and sub-optimal conditions. This information helps the HV determine the correct response to the presence of the RV.

2.5.2.2.1.1.4 Transmit Emergency Detail

First Responders in active service states need to transmit additional information about the emergency to which they are responding. This information helps the HV determine the correct response to the presence of the RV.

2.5.2.2.1.1.5 Receive Emergency Messages

First Responder RVs should notify HVs of their presence quickly enough that the HV can take appropriate action to move out of the First Responder RV's path. This ensures that the system provides an acceptable minimum level of reliability.

2.5.2.2.1.1.6 Determine Emergency Vehicle Position

HVs need information from the RV sufficient to determine the relative position of the emergency vehicle under both optimal and sub-optimal conditions. This information helps the HV determine the relevance of the RV broadcast.

2.5.2.2.1.1.7 Receive Approaching or Stationary

The HV driver should be provided with Emergency Vehicle Alerts from all surrounding angles of approach. This helps ensure an acceptable minimum level of radio communications reliability.

2.5.2.2.1.1.8 Provide Authorized Driver Instructions

The HV drivers within radio reception range should be provided with authorized instructions from the RV (e.g., "clear right lane"). This allows the RV additional opportunities to optimize travel time to an emergency.

2.5.2.2.1.1.9 Determine Emergency Alert Awareness

First Responder RVs need a way to determine whether the HVs have received the Emergency Alert information. This will allow First Responders to better predict the behavior of surrounding HVs.

2.5.2.2.1.1.10 Return to Normal Communications

After the First Responder RV exits from an active Service State, it should revert to the normal/non-emergency state of sending messages. This helps HVs manage their responses to surrounding vehicles.

2.5.2.2.2 Roadside Alert (RSA)

2.5.2.2.2.1 Provide Roadside Alert

Warn drivers about Special Purpose vehicles engaged in stopped or slow-moving behaviors which may require drivers to be alert or take action to provide additional clearance to roadside activities.

2.5.2.2.2.1.1 Authorize Roadside Alert Communication

Special Purpose RVs need a way to become authorized to communicate Special Purpose vehicle messages in a variety of connectivity scenarios, e.g., implementations involving local and remote certificate authorizations. This helps prevent misuse of these messages (spoofing).

2.5.2.2.2.1.2 Initiate Roadside Alert

Special Purpose RVs need a way to select the vehicle role in which they are engaged (e.g., "I am a tow truck"), and related vehicle state. This helps ensure that their communications will generate situationally appropriate responses from HVs.

2.5.2.2.2.1.3 Transmit Roadside Alert Information

Special Purpose RVs need to transmit role, heading and location information under both optimal and sub-optimal conditions. Disabled Vehicles need to transmit their location under both optimal and sub-optimal conditions. This information helps the HV determine the correct response to the presence of the RV.

2.5.2.2.2.1.4 Transmit Extended Roadside Alert Information

Additional descriptive information about special purpose vehicles may be transmitted. This includes movement type (e.g., slow moving) and the nature of the vehicle type or operation (e.g., tree trimming). This helps the HV determine how to respond to the information being sent.

2.5.2.2.2.1.5 Receive Roadside Alert Messages

Special Purpose RVs should notify HVs of their presence quickly enough that the HV can appropriately respond to the Special Vehicle RV's non-standard behavior, regardless of current channel congestion. This ensures that the system provides an acceptable minimum level of radio communications reliability.

2.5.2.2.2.1.6 Determine Special Purpose Vehicle Position

HVs need information from the RV sufficient to determine the relative position of the special purpose vehicle under both optimal and sub-optimal conditions. This information helps the HV determine the relevance of the RV broadcast.

2.5.2.2.2.1.7 Receive Approaching or Stationary

The HV driver should be provided with Roadside Alerts from all surrounding areas of approach. This helps ensure an acceptable minimum level of radio communications reliability.

2.5.2.2.2.1.8 Return to Normal Communications

After the RV returns to normal driving behavior (e.g., not stopped nor slow-moving), it should revert to the normal state of sending messages. This helps HVs manage their responses to surrounding vehicles.

2.5.2.2.3 Situational Awareness - Object (SAW-O)

2.5.2.2.3.1 Provide Object Alert

Any RV needs to be able to recognize and report objects blocking the roadway.

2.5.2.2.3.1.1 Broadcast upon Object Detection

The RV needs to be able to broadcast the time the vehicle detected the object, the distance from the object to the vehicle, the direction of the object from the vehicle, the vector of the obstacle, the current location of the vehicle upon detection of a potential object in the roadway, and any known object properties, as derived from the vehicle's sensors; to an accuracy sufficient to support collision avoidance applications. This allows proper filtering and aggregation of this information.

2.5.2.2.3.1.2 Determine Object Relevance

The HV needs information from the RV sufficient to determine that whether the object is in its current path or not. This will help the HV use the object information appropriately.

2.5.2.2.3.1.3 Receive Object Warning & Advisory

HVs should be notified by the RV of the presence of Objects quickly enough that the HV can appropriately respond to the presence of the Object. This ensures that the system provides an acceptable minimum level of reliability.

2.5.2.2.3.1.4 Cease Broadcast After Passing Object

When the detected object is no longer in the path of the RV, the RV should return to the normal state of sending messages.

2.5.2.2.4 Safety Awareness – Adverse Road Segment Condition (SAW – A)

2.5.2.2.4.1 Provide Adverse Road Condition Alert

Any RV needs to be able to report adverse road conditions to nearby vehicles.

2.5.2.2.4.1.1 Broadcast upon Adverse Condition Detection

The RV needs to be able to broadcast an alert when the vehicle detects the onset of an adverse event significant enough to create immediate adverse driving conditions (as derived from the vehicle's sensors). This allows proper filtering and aggregation of this information.

2.5.2.2.4.1.2 Transmit Adverse Condition Information

The RV needs to be able to convey adverse condition information such as road surface friction, road surface conditions and visibility along with the time and position vector (i.e., location, heading, speed) of the event. Additional information

might include road surface conditions (e.g., flooded road). These types will provide a minimum level of functionality for systems which use this data.

2.5.2.2.4.1.3 Broadcast Condition Persistence

The RV needs to be able to broadcast information about continued condition persistence (e.g., icy bridge). This ensures that ongoing information about adverse conditions is available to nearby HVs.

2.5.2.2.4.1.4 Transmit to Area of Relevance

The RV needs to be able to share information with vehicles which are in the area of relevance for the condition (e.g., vehicles behind, ahead, and/or alongside) for ranges consistent with the nature of the condition being transmitted (e.g., ice on Northbound lane of bridge).

2.5.2.2.4.1.5 Determine Adverse Condition Relevance

The HV needs information from the RV sufficient to determine if the Adverse Condition relates to (is in and is ahead of) its current path or not. This will help the HV use the information appropriately.

2.5.2.2.4.1.6 Receive Adverse Condition Warning & Advisory

HVs should be notified by the RV of the presence of Adverse Conditions quickly enough that the HV can appropriately respond to the presence of the Adverse Condition. This helps ensure an acceptable minimum level of radio communications reliability.

2.5.2.2.4.1.7 Cease Broadcast on Condition End

After the detected adverse road condition ceases, and the geographic relevance area has passed, the RV should revert to the normal state of sending messages.

2.6 Security

The general Security needs for these Use Cases are described in J2945/0. Additional security constraints are shown below.

These security constraints reflect the sensitive nature of certain data which is necessary to support the Use Cases in this document (e.g., location of a disabled vehicle). Sensitive data is distinguished from personally identifiable data (name and address of the driver of a disabled vehicle). Sensitive data may be used for targeting vulnerable populations (e.g., stranded motorists, police officers, hazmat vehicles) and must therefore be secured appropriately.

2.6.1 Support Secure First Responder Operations

First Responders, including police, need communications and data security sufficient to protect their operations. This serves to allow the public to appropriately respond to First Responder users of this system.

2.6.2 Protect Sensitive Data and MetaData

All actors must adequately secure information which may be used for malicious targeting of vulnerable populations (e.g., hazmat and disabled vehicles) to a level consistent with federal and local public safety policy. Secure information could be clear or encrypted signed data to protect privacy and anonymity. This serves to protect the public.

2.6.3 Enable Vehicle Role Assignments

Regional authorities need to be able to issue temporary and permanent security credentials in support of roles they will allow vehicles to assume (and when). This allows local authorities to manage and allocate the responsibility and scope of authority for such assignments in a managed way.

2.6.4 Manage Public and Private User Credentialing

Regional authorities need to be able to distribute credentials which will support both public safety and consumer users, and those users who play both roles (e.g., volunteer firefighters). This serves to establish a scalable process to deploy.

2.6.5 Manage First Responder Anonymity

Regional authorities need to be able to provide appropriate credentials to support First Responders when in active duty mode. These may require different levels of anonymity from consumer users. Both processes must interact in the case of volunteers who play both roles (e.g., volunteer firefighters). This serves to protect the responder personnel.

2.7 Operational Policies and Constraints

The content in this section is included to document external constraints on this system. These constraints reflect national policy decisions set by NHTSA.⁹

It should be noted that the DSRC message (the BSM which is used in this document) and the associated IEEE 1609 lower layers which are used to send it, are designed to obscure both vehicle identity and driver identity.

2.7.1 Forbid Data Collection and Storage

The system will strictly limit collection and/or storage of any data on individuals or individual vehicles.¹⁰

2.7.2 Limit Use of V2V Data

There is no data in the basic safety messages broadcast by V2V devices or collected by the V2V security system intended to be used by law enforcement or private entities to personally identify a speeding or erratic driver.

2.7.3 Forbid Identified Vehicle Tracking

The system will not permit tracking through space or time of vehicles linked to specific owners or drivers or persons.

2.7.4 Forbid Individual-Linked Information

The system will not collect financial information, personal communications, or other information linked to individuals.

2.7.5 Forbid Data Extraction

The system will not provide a pathway into the vehicle for extracting data.

2.8 Relationship to the ITS National Architecture [Informative]

The following are the architecture flows from the National ITS Architecture are addressed by J2945/2:

- Vehicle intersection safety data (Architecture Flow) - Vehicle path and acceleration data provided by vehicles approaching or occupying an intersection. It identifies the intersection, vehicle position and motion, the anticipated lane and movement that will be used in the intersection, and notification of potential violations or other detected safety hazards.
- Vehicle safety data (Architecture Flow) - Vehicle safety data indicating vehicle location, vehicle motion (speed, heading, acceleration), vehicle control (brakes, steering, throttle, exterior lights), basic vehicle characteristics

⁹ The most current policy guidance available at time of publication is contained in U.S. Department of Transportation's *Privacy Impact Assessment*, National Highway Traffic Safety Administration Notice of Proposed Rulemaking (NPRM) on V2V Communications, December 2016.

¹⁰ Per US DOT *Privacy Impact Assessment*: "The system and V2V devices will not collect or store the contents of messages sent or received except for the limited time required for a vehicle's V2V system to provide its driver with crash avoidance warnings, if appropriate... or to deal with device malfunction."

(length, width). This architecture flow may also include additional vehicle status information (e.g., anti-lock brake activation, stability control system activation).

Table 3 shows how these architecture flows are mapped to the Service Packages providing ITS services that are supported by the user needs in Section 2.5. A Service Package is the subset of the National ITS Architecture that provides a specific ITS Service.

Table 3 - National ITS architecture mapping - V2V

Architecture Flow	Service Packages
vehicle intersection safety data	AVSS05- Intersection Safety Warning AVSS10- Intersection Collision Avoidance
vehicle safety data	AVSS06- Pre-Crash Restraint Deployment AVSS12- Cooperative Vehicle Safety Systems

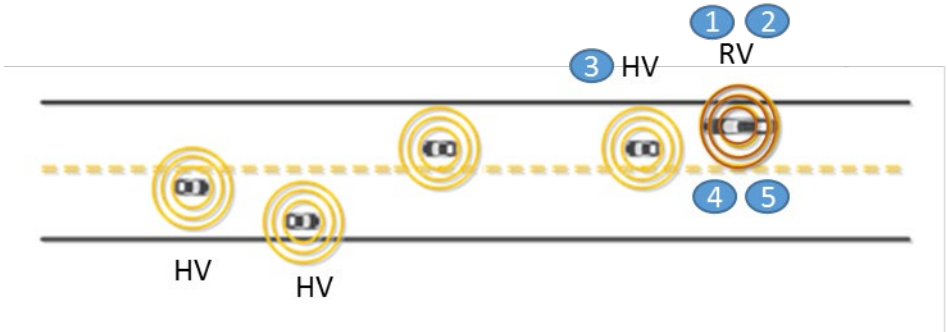
2.9 Operation Scenarios [Informative]

The operational scenarios in this document relate to the following scenarios noted in J2945/0:

- Vehicle-to-vehicle
- General Conditions (host vehicle)
- Vehicle Maneuver (remote vehicle)
- Situational Awareness: Infrastructure Conditions
- Emergency Vehicle Operations

2.9.1 Emergency Vehicle Alert (EVA)

Use Case Name	Emergency Vehicle Alert (EVA)
Category	Safety
Short Description	Alerts the driver about the location of and the movement of First Responder vehicles responding to an incident so the driver does not interfere with the emergency response. In this context, the term “First Responder” refers to any vehicle that has a local regulatory right to drive in an unusual manner and which other nearby drivers must respond or to be aware of. This Use Case describes V2V communication between First Responder vehicles en route to an emergency, and nearby vehicles.
Actors	Drivers, Vehicles
Infrastructure Roles	This use case requires no infrastructure involvement. Note that related use cases outside of the current scope of this document make use of the infrastructure to allow authorized First Responder Vehicle to traverse a signalized intersection.
Vehicle Roles	There are two vehicle roles involved in this use case: • Host Vehicle (HV) • Remote Vehicle (RV) For definitions of HV and RV, see Section 1.4.1 Definitions
Goal	Help drivers to avoid collisions with nearby First Responder vehicles and to clear the roadway so that First Responder vehicles can proceed more effectively.
Needs	The driver needs to receive information about the location and status of nearby First Responder vehicles responding to an incident.
Constraints / Presumptions	• HV and RV meet common Security scenarios and needs as outlined in J2945/0. • HV and RV meet operational and policy constraints as noted in Section 2.7 • HV and RV meet basic communications capabilities and performance requirements described in J2945/1 Sections 5-7 for sending and receiving messages

	- HV and RV meet user priority and latency requirements as per J2945/1. - RV has properly obtained EV credentials from an authorized entity, on either a permanent basis (ambulance vehicle which performs its assigned function exclusively) or a temporary basis (e.g., volunteer firefighters, tow trucks, state DOT general purpose vehicle). - Additional conveyances, (e.g., police motorcycles) may also be authorized as Public Safety Vehicles.
Geographic Scope	National. At any and all signalized and un-signalized intersections and along roadways where vehicles equipped with V2V capabilities are present.
Illustrations	
Pre-Conditions	Working OBE equipment meeting the general performance requirements outlined in the core use cases defined by J2945/0 and related J2945/x documents First Responder Vehicle messages are properly signed and authorized.
Main Event Flow	- A First Responder vehicle (the RV) on a call activates call active state (may include but does not require activation of warning lights or sirens and alerts). - The First Responder vehicle transmits emergency status, vehicle location and heading. - Each host vehicle (HV)¹¹ receives the message, determines the relative position of the First Responder vehicle, and confirms suitable certificate as a trusted message. - The HV vehicle driver is provided with this information regardless of the direction of approach of the RV - After the RV exits en route emergency service activity (arrives at its destination), it reverts to the normal state of sending messages.
Alternative Event Flow ¹²	
Post-Conditions	The HV(s) are aware of the en route First Responder Vehicles and have taken any action necessary to avoid obstructing their path.
Information Requirements	BSM Part I and Part II per J2945/1

2.9.2 Roadside Alert (RSA)

Use Case Name	Roadside Alert (RSA)
Category	Safety
Short Description	Used by special purpose or disabled vehicles to communicate stopped or slow-moving behaviors which may obstruct or complicate mainstream traffic for other drivers and vehicles. This may require drivers to be alert or take action to provide additional clearance to roadside activities. This Use Case includes concepts from the European Slow Vehicle and Stationary Vehicle Warning applications as described in the CVRIA.¹³

¹¹ It is possible that an emergency vehicle acts as the HV in this use case, receiving the EVA information from a fellow emergency vehicle which is acting as an RV.

¹² Alternative Event Flows in this document are not intended as replacements for the Main Event Flow. They are intended to represent different possible flows.

Actors	Drivers, Vehicles
Infrastructure Roles	This use case requires no infrastructure involvement.
Vehicle Roles	There are two vehicle roles involved in this use case: • Host Vehicle (HV) • Remote Vehicle (RV) For definitions of HV and RV, see Section 1.4.1 Definitions
Goal	Help drivers to avoid collisions with nearby disabled vehicles and special purpose vehicles such as school buses, construction vehicles, and others that may disturb the free flow of traffic as part of their routine operations; and to provide additional clearance for roadside activities
Needs	The driver needs to receive information about the location and status of nearby special purpose vehicle operations.
Constraints / Presumptions	• HV and RV meet common Security scenarios and needs as outlined in J2945/0. • HV and RV meet operational and policy constraints as noted in Section 2.7 • HV and RV meet basic communications capabilities and performance requirements described in J2945/1 Sections 5-7 for sending and receiving messages • HV and RV meet priority and latency requirements as per J2945/1. • Disabled Vehicle alerting is always Optional to allow consumer vulnerability management.
Geographic Scope	National. At any and all signalized and un-signalized intersections and along roadways where vehicles equipped with V2V capabilities are present.
Illustrations	
Pre-Conditions	• Working OBE equipment meeting the general performance requirements outlined in the core use cases defined by J2945/0 and related J2945/x other documents. • Special purpose messages are properly signed and authorized. • The remote vehicle is capable of sending various event flags as defined in J2945/1.
Main Event Flow	1. A special purpose or disabled vehicle (the RV) engages in stopped or slow-moving behavior. 2. The special purpose or disabled vehicle transmits behavior type (including lane use details), vehicle location and heading. 3. The host vehicles (HVs) receive the message, determine the relative position of the RV, and confirm certifications. 4. The HV vehicle driver is provided with this information regardless of the direction of approach of the RV 5. After the RV returns to normal driving behavior, it reverts to the normal state of sending messages.
Alternative Event Flow	None.

Post-Conditions	None.
Information Requirements	Event Type, Event Priority, Vehicle Heading, Event Extent, Event Position

2.9.3 Safety Awareness - Object (SAW - O)

Use Case Name	Safety Awareness - Object
Category	Safety
Short Description	A vehicle broadcasting the presence of a potential static or dynamic object in the roadway. This use case addresses the V2V sharing of information about obstacles, not the V2P interface.
Actors	Drivers, Vehicles
Infrastructure Roles	This use case requires no infrastructure involvement.
Vehicle Roles	There are two vehicle roles involved in this use case: • Host Vehicle (HV) • Remote Vehicle (RV) For definitions of HV and RV, see Section 1.4.1 Definitions
Goal	Warnings to alert road users to a potential object in the roadway.
Needs	The driver needs to be warned about potential objects in the roadway.
Constraints / Presumptions	• HV and RV can use DSRC or other medium that will meet the performance requirements for this use case • This use case assumes that the remote vehicle will broadcast the time and location of a detected object, and possibly the rate of change of its steering wheel angle and/or speed. • The alternative flow use case assumes that the host vehicle has the capability to determine the sudden movements and location of multiple remote vehicles. • This use case assumes automated data capture and transmission (not initiated by driver input). • Lack of data due to low vehicle density will be handled at the application level.
Geographic Scope	Localized to a region
Illustration	
Preconditions	• The remote vehicle is capable of detecting a potential object in the roadway, derived from the vehicle's sensors. • The host vehicle is capable of receiving information from a remote vehicle that may be indicative of a potential object in the vehicle's path trajectory, and can process that information to provide warnings or advisories to the driver.
Main flow	Vehicle to Vehicle - Direct 1. The use case begins when a remote vehicle's sensors detect an object while traveling on a roadway. 2. The RV transmits information indicating the time the vehicle detected the object, the distance from the obstacle to the vehicle, the direction of the object from the vehicle, and the current location of the vehicle. 3. A HV receives the information and determines if the object is in its current path or not.

	4. If the host vehicle determines that the object is potentially in the vehicle's current path, the host vehicle provides the driver with a warning that it has detected a potential object in its path. The host vehicle may also advise the driver to slow the vehicle's speed or provide the driver with the location of the potential object. The host vehicle may also take action and begin to slow the vehicle's speed without the assistance of the driver, if a collision with the object is imminent. The case ends.
Post-conditions	None.
Information Requirements	BSM Vehicle Location, Vehicle Heading, Vehicle Speed, Vehicle Acceleration, Rate of change of the vehicle's steering wheel

2.9.4 Safety Awareness - Adverse road condition (SAW – A)

Use Case Name	Safety Awareness – Adverse Road Condition
Category	Safety
Short Description	A vehicle broadcasting adverse road conditions which are highly localized and of immediate potential safety impact, e.g., reduced friction, reduced visibility.
Actors	Drivers, Vehicles
Infrastructure Roles	This use case requires no infrastructure involvement.
Vehicle Roles	There are two vehicle roles involved in this use case: • Host Vehicle (HV) • Remote Vehicle (RV) For definitions of HV and RV, see Section 1.4.1 Definitions
Goal	Warnings to alert road users to a potential adverse road condition
Needs	The driver needs to be warned about adverse road conditions.
Constraints / Presumptions	• HV and RV can use DSRC or other medium that will meet the performance requirements for this use case • This use case assumes that the host vehicle has the capability to determine the current environmental conditions around itself, compare it to the environmental conditions in the host vehicle's anticipated path, as reported by remote vehicles, and provide advisories or warnings to the driver. • The use case assumes that the host vehicle has the capability to track the location and path trajectories of multiple remote vehicles. • This use case assumes automated data capture and transmission (not initiated by driver input).
Geographic Scope	Localized to a region
Illustration	
Preconditions	• The remote vehicle is capable of providing its path history, location, heading, antilock brake status, yaw, and vertical acceleration. • The host vehicle is capable of receiving information from numerous remote vehicles and can track each vehicle's path trajectory. • The remote vehicle is capable of sensing information that is indicative of the road conditions in its surrounding environment, e.g., the status of the vehicle's headlights or its wipers, and/or the sensor readings from its sensor.

	- The host vehicle is capable of receiving and acting upon information from a remote vehicle that is indicative of the upcoming road conditions in front of the vehicle, and can process that information to provide warnings or advisories to the driver. - The remote vehicle is capable of sending various event flags as defined in J2945/1
Main flow	Vehicle to Vehicle - Direct - The use case begins when a remote vehicle encounters adverse road conditions, e.g., low friction. For this use case, the remote vehicle is in the same or adjacent lane of the host vehicle. - The remote vehicle's sensors detect unusual braking and yaw (e.g., anti-lock brake system is activated, and the remote vehicle's yaw rate (rotation) fluctuates between negative and positive values (indicating possible loss of control)). - The remote OBE sends messages providing its current speed, current location, current heading, that the antilock brake status has activated, and its yaw rate. - A host vehicle OBE receives the messages from the remote vehicle. - The host vehicle may provide the driver with a warning of potential adverse road conditions ahead. - The host vehicle may also advise the driver to change lanes and/or reduce the vehicle's speed. - The case ends.
Alternate Event Flow 2	- The use case begins when a remote vehicle detects uneven road conditions. - The remote vehicle's sensors identify unusual pitch, roll, yaw, and/or suspension activity. - The remote OBE sends messages providing its current speed, current location, current heading, yaw rate, and pitch rate, roll rate, and/or suspension activity. - A host vehicle OBE receives the messages from numerous host vehicles. - The host vehicle notes that multiple vehicles experience unusual motion indicative of uneven road surface. The host vehicle determines if the conditions are in the vehicles trajectory and whether they are also in adjacent lanes. - The host vehicle notifies the driver of uneven road conditions ahead and may also advise the driver to change lanes and/or reduce the vehicle's speed. - The case ends.
Alternate Flow 3	Vehicle to Vehicle - Direct - The use case begins when a remote vehicle becomes aware of inclement weather. - The remote vehicle is traveling on a roadway when it encounters inclement weather, e.g., severe rain. - The remote vehicle turns its wipers and headlights on. - The RV sends messages indicating that the status of its wipers and external lights has changed: e.g., its headlights are on, its front wipers are on, the rate that the front wipers are sweeping, the intensity of precipitation as detected by its rain sensor, and/or the level of ambient light as detected by its sun sensor. - A HV traveling towards the RV receives the messages and provides the driver with a warning that it has detected inclement weather ahead. The host vehicle may also advise the driver to slow the vehicle's speed, and/or to turn on the vehicle's headlights if the vehicle's headlights are currently off. Or, taking its own rain sensor and sun sensor readings into consideration, the host vehicle may turn on its headlights and/or front wipers without driver intervention. - The case ends.
Post-conditions	None.
Information Requirements	BSM Vehicle Identifier (to track vehicle paths), Vehicle Location, Vehicle Heading, Vehicle Speed, Vehicle Acceleration, Yaw rate, Vertical acceleration, and skid detection and/or and Antilock brake status, Vehicle External Light Status, Vehicle Front Wiper Status, Vehicle Front Wiper Rate, Vehicle Rain Sensor, Vehicle Sun Sensor, Vehicle External Lights Changed, Vehicle Wiper Status Changed, Pitch Rate and/or Roll Rate

SECTION 3 FUNCTIONAL REQUIREMENTS [NORMATIVE]

The section defines the set of functional requirements used to meet the needs for the subject applications.

It should be noted that, unless specifically stated otherwise within a Requirement, the Target for each Requirement in this document is the HV.

3.1 Tutorial [Informative]

Detailed information about Requirements may be found in NTCIP 8002 Annex B1 Section 3.

Information about NRTM notation may be found in NTCIP 8002 Annex B1 Section 3.3. Text appearing in Sections 3.3.1 through 3.3.2.3 implements NTCIP 8002 Annex B1 Section 3.3, and is reprinted with permission © 2016 AASHTO / ITE / NEMA from NTCIP 8002 Annex B1 and NTCIP 1204 v03.

3.2 Scope of the Interface [Informative]

This section is included to comply with NTCIP format, but is not applicable in this document.

3.3 Needs to Requirements Traceability Matrix (NRTM)

As noted above, the NRTM provides a mapping between the user needs and the functional requirements which have been developed to meet these needs.

3.3.1 Notation [Informative]

Information about NRTM notation may be found in NTCIP 8002 Annex B1 Section 3.3.

3.3.1.1 Conformance Symbols

The following symbols are used to indicate status in the Conformance column of the NRTM table:

Table 4 - Conformance symbols

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

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

3.3.1.2 Conditional Status Notation

The following predicate notation may be used:

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

The <predicate>: notation means that the status following it applies only when the NRTM states that the feature or features identified by the predicate are supported. In the simplest case, <predicate> is the identifying tag of a single NRTM item. When the group predicate is true then the associated section shall be completed. The symbol <predicate> also may be a Boolean expression composed of several indices. .AND., .OR., and .NOT. shall be used to indicate the Boolean logical operations. For example, in this document, a predicate of <1stRp>:M indicates the feature is mandatory ONLY if the vehicle role is categorized as a "First Responder." If the vehicle role is not a "First Responder", that feature does not apply (is Not Applicable).

The predicates used in this document are as follows:

1stRp = The vehicle role is categorized as a "First Responder" as defined in Section 2.2.2

3.3.1.3 Support Column Symbols

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

Table 5 - Support column symbols

Yes	To be supported (or supported) by the implementation.
No	Does not have to be supported (or not supported) by the implementation.
NA	Not applicable.

3.3.2 Instructions for Completing the NRTM [Informative]

The columns in the NRTM Table are the User Need ID and User Need Title columns, FR ID (Functional Requirement ID) and FR Title (Functional Requirement Title) columns, the Conformance column, the Support column, and the Additional Specifications column.

3.3.2.1 User Need ID and User Need Title Columns

The NRTM is based upon the user needs defined in each J2945/x document. The section number and user need name are indicated within these columns.

3.3.2.2 FR ID and FR Title Columns

The requirements are defined within Sections 3.5-3.6. The NRTM references the traces from user needs to these requirements. The section number and requirements name are indicated within these columns.

3.3.2.3 Additional Specifications Columns

The Additional Specifications column may (and should) be used by a procurement specification to provide additional notes and requirements for the product to be procured or may be used by an implementer to provide any additional details about the implementation. In some cases, default text already exists in this field, which the user should complete in order to fully

specify the implementation. However, additional text can be added to this field as needed to fully specify a feature. Performance requirements should also be specified in this column.

3.3.3 Needs to Requirements Traceability Matrix (NRTM)

Needs to Requirements Traceability Matrix (NRTM)						
User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
2.5.2.1	Common User Needs			M	Yes	
2.5.2.1.1	Maximize Position Vector Transmission			M	Yes	
		3.5.1.1	Transmit Position Vector in Sub-optimal Conditions	M	Yes	
		3.5.1.2	Support GNSS Time to First Fix	M	Yes	
2.5.2.1.2	Meet Basic Communications Performance Metrics			M	Yes	
		3.5.1.3	Meet J2945/1 Performance Metrics	M	Yes	
2.5.2.1.3	Support Basic V2V Safety Awareness Communications			M	Yes	
		3.5.1.4	Transmit Basic Safety Information	M	Yes	
2.5.2.1.4	Enable Secure Communications			M	Yes	
		3.5.1.5	Require Suitable Authorization	M	Yes	
2.5.2.2	Use Case-Specific User Needs			M	Yes	
2.5.2.2.1	Emergency Vehicle Alert (EVA)			O.1 (1..*)	Yes/No	
2.5.2.2.1.1	Provide Emergency Vehicle Alert			M	Yes	
2.5.2.2.1.1.1	Authorize Emergency Communication			M	Yes	
		3.5.2.1.1	Transmit Authorization Request - EVA	M	Yes	
2.5.2.2.1.1.2	Initiate Emergency Alert			M	Yes	
		3.5.2.1.1.1	Select Vehicle Role - EVA	M	Yes	
		3.5.2.1.1.2	Select Vehicle State - EVA	M	Yes	
		3.5.2.1.2	Broadcast First Responder Credentials	M	Yes	

		3.5.2.1.3	Select Rights in Certificate - EVA	M	Yes	
2.5.2.2.1.1.3	Transmit Emergency Status			M	Yes	
		3.5.2.1.4	Broadcast Basic Emergency Alert Information	M	Yes	
		3.5.2.1.5	Broadcast Basic Emergency Alert Information Detail	O	Yes/No	
		3.5.2.1.6	Broadcast Accurate Position Vector - EVA	M	Yes	
2.5.2.2.1.1.4	Transmit Emergency Detail			M	Yes	
		3.5.2.1.7	Transmit Emergency Event Information	O	Yes/No	
2.5.2.2.1.1.5	Receive Emergency Messages			M	Yes	
		3.5.2.1.8	Use Emergency Alert User Priority	M	Yes	
		3.5.2.1.9	Use Emergency Alert Transmission Power	M	Yes	Maximum Power Level: (0-33) dBm (EIRP)
		3.5.2.1.10	Use Emergency Alert Repeat Rate	M	Yes	Message Repeat Rate = 10Hz
2.5.2.2.1.1.6	Determine Emergency Vehicle Position			M	Yes	
		3.5.2.1.11	Provide First Responder RV Intended Path	O	Yes/No	
2.5.2.2.1.1.7	Receive Approaching or Stationary			M	Yes	
		3.5.2.1.12	Broadcast Multidirectional Alert - EVA	M	Yes	
2.5.2.2.1.1.8	Provide Authorized Driver Instructions			M	Yes	
		3.5.2.1.13	Transmit Path Clearance Information	O	Yes/No	

2.5.2.2.1.1.9	Determine Emergency Alert Awareness			O	Yes/No	
		3.5.2.1.14	Monitor for Alert Reception	O	Yes/No	
2.5.2.2.1.1.10	Return to Normal Communications			M	Yes	
		3.5.2.1.15	Select Non-call-active State	M	Yes	
		3.5.2.1.16	Broadcast Default BSMs	M	Yes	
2.5.2.2.2	Roadside Alert (RSA)			O.1 (1..*)	Yes/No	
2.5.2.2.2.1	Provide Roadside Alert			M	Yes	
2.5.2.2.2.1.1	Authorize Roadside Alert Communication			M	Yes	
		3.5.2.2.1	Transmit Authorization Request - RSA	M	Yes	
2.5.2.2.2.1.2	Initiate Roadside Alert			M	Yes	
		3.5.2.2.1.1	Select Vehicle Role - RSA	M	Yes	
		3.5.2.2.1.2	Select Vehicle State - RSA	M	Yes	
		3.5.2.2.2	Broadcast Special Purpose Credentials	M	Yes	
		3.5.2.2.3	Select Rights in Certificate - RSA	M	Yes	
2.5.2.2.2.1.3	Transmit Roadside Alert Information			M	Yes	
		3.5.2.2.4	Broadcast Basic Roadside Alert	M	Yes	
		3.5.2.2.5	Broadcast Roadside Alert Detail	O	Yes/No	
		3.5.2.2.6	Transmit Accurate Position Vector - RSA	M	Yes	
2.5.2.2.2.1.4	Transmit Extended Roadside Alert Information			M	Yes	
		3.5.2.2.7	Provide Additional Roadside Alert Information	O	Yes/No	
2.5.2.2.2.1.5	Receive Roadside Alert Messages			M	Yes	
		3.5.2.2.8	Use Roadside Alert	M	Yes	

			Transmission Power			
		3.5.2.2.9	Use Roadside Alert User Priority	M	Yes	
		3.5.2.2.10	Use Roadside Alert Repeat Rate	M	Yes	Message Repeat Rate = 10Hz
2.5.2.2.2.1.6	Determine Special Purpose Vehicle Position			M	Yes	
		3.5.2.2.6	Transmit Accurate Position Vector - RSA	M	Yes	
2.5.2.2.2.1.7	Receive Approaching or Stationary			M	Yes	
		3.5.2.2.11	Broadcast Multidirectional Alert - RSA	M	Yes	
2.5.2.2.2.1.8	Return to Normal Communications			M	Yes	
		3.5.2.2.12	Broadcast Default BSMs	M	Yes	
2.5.2.2.3	Situational Awareness – Object (SAW-O)			O.1 (1..*)	Yes/No	
2.5.2.2.3.1	Provide Object Alert			M	Yes	
		3.5.2.3.1	Identify Object Presence	M	Yes	
		3.5.2.3.2	Initiate from Normal - SAW-O	M	Yes	
2.5.2.2.3.1.1	Broadcast upon Object Detection			M	Yes	
		3.5.2.3.3	Broadcast Object Alert	M	Yes	
		3.5.2.3.3.1	Broadcast Object Detection Time	M	Yes	
		3.5.2.3.3.2	Broadcast Object Position	M	Yes	
		3.5.2.3.3.3	Broadcast Object Position Detail	O	Yes/No	
		3.5.2.3.3.4	Broadcast Object Motion Vector	M	Yes	
		3.5.2.3.3.5	Broadcast Object Size	M	Yes	
		3.5.2.3.3.6	Broadcast Object Property Detail	O	Yes/No	
		3.5.2.3.4	Send to Area of Relevance	M	Yes	
2.5.2.2.3.1.2	Determine Object Relevance			M	Yes	