SURFACE VEHICLE STANDARD

J2945™/1 MAR2026

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On-Board System Requirements for V2V Safety Communications

RATIONALE

The SAE J2945/1 standard provides the functional and performance requirements for V2V safety communications between light vehicles using the basic safety message.

As this document is stabilized, it is not expected to change in the future. SAE J3161/1 may include more up-to-date features.

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1. SCOPE

This standard specifies the system requirements for an on-board vehicle-to-vehicle (V2V) safety communications system for light vehicles[1], including standards profiles, functional requirements, and performance requirements. The system is capable of transmitting and receiving the SAE J2735-defined basic safety message (BSM) [1] over a dedicated short range communications (DSRC) wireless communications link as defined in the Institute of Electrical and Electronics Engineers (IEEE) 1609 suite and IEEE 802.11 standards [2] to [6].

1.1 Purpose

This standard addresses the on-board system needs for ensuring that the exchange of BSMs in V2V safety communications provides the desired interoperability and data integrity to support the performance of the envisioned safety applications.

2. REFERENCES

2.1 Applicable Documents

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.

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.

[1] SAE J2735 Dedicated Short Range Communications (DSRC) Message Set Dictionary

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

[2] IEEE Std 802.11-2012 Standard for LAN/MAN - Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[3] IEEE Std 1609.2-2016 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages (as amended by IEEE Std 1609.2a™-2017 and IEEE Std 1609.2b™-2019)

[4] IEEE Std 1609.3-2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

[5] IEEE Std 1609.4-2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-Channel Operation

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

[1] See 3.1 for the definition of light vehicle. Other vehicle classes and trailers will be addressed in future revisions of this standard or in other standards within the SAE J2945 family of standards. These revisions or additional standards are expected to be compatible with the requirements of this standard and may define additional capabilities beyond the requirements for light vehicles.

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2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

[7] Federal Communications Commission (FCC) 47 Code of Federal Regulations (CFR) Parts 0, 1, 2, and 95 amendments for Dedicated Short Range Communications Services and Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Service in the 5.850-5.925 GHz Band (5.9 GHz Band). http://www.gpo.gov/fdsys/pkg/FR-2006-09-07/pdf/E6-14795.pdf.

[8] Mitigation Strategies for Design Exceptions. Federal Highway Administration, October 15, 2014. http://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter3/3_lanewidth.cfm.

[9] CAMP Vehicle Safety Communications Security Studies: Study 3 Final Report: Definition of Communication Protocols between SCMS Components and Specification of the Components Pseudonym Certificate Authority, Registration Authority, and Linkage Authority: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). July 31, 2014.

[10] CAMP Vehicle Safety Communications Security Studies: Study 1: Security Credential Management System (DTFH61-01-X-00014): National Highway Traffic Safety Administration. July 31, 2014.

[11] National Highway Traffic Safety Administration, "Vehicle Safety Communications - Applications (VSC-A) Final Report," DOT HS 811 492A, September 2011. http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2011/811492A.pdf.

[12] National Highway Traffic Safety Administration: Vehicle-to-Vehicle Safety System and Vehicle Build for Safety Pilot (V2V-SP) Final Report, Volume 1 of 2, Driver Acceptance Clinics: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). April 10, 2014. https://www.regulations.gov/contentStreamer?documentId=NHTSA-2014-0022-0042&attachmentNumber=1&contentType=pdf.

[13] Vehicle Safety Communications - Applications Final Report: Appendix Volume 1 System Design and Objective Test," DOT HS 811 492B, September 2011. http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2011/811492B.pdf.

[14] Vehicle-to-Vehicle Safety System Light Vehicle Builds and Model Deployment Support (V2V-MD): Test Plan and Test Procedures for Vehicle Awareness Devices and Aftermarket Safety Devices: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). March 4, 2014.

[15] ITU-R TF.460-6: Standard-Frequency and Time-Signal Emissions.

[16] FIPS PUB 140-2: Federal Information Processing Standards Publication: Security Requirements for Cryptographic Modules.

[17] H. Krishnan, A. Weimerskirch, "Verify-on-Demand - A Practical and Scalable Approach for Broadcast Authentication in Vehicle-to-Vehicle Communication," SAE Int. J. of Passeng. Cars - Mech. Syst., June 2011, 4:536-546.

[18] Interoperability Issues of Vehicle-to-Vehicle Based Safety Systems Project: Phase 1 Final Report: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). September 12, 2014.

[19] Interoperability Issues of Vehicle-to-Vehicle Based Safety Systems Project: Phase 2 Final Report Volume 1: Scalability for V2V Safety Development: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). February 24, 2015.

[20] Interoperability Issues of Vehicle-to-Vehicle Based Safety Systems Project: Phase 2 Final Report Volume 2: Scalability for V2V Safety Analysis: National Highway Traffic Safety Administration (Cooperative Agreement Number DTFH61-01-X-00014). March 31, 2015.

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3. TERMS AND DEFINITIONS

3.1 Definitions

For the purposes of this standard, the following definitions apply.

3.1.1 CRASH

A collision between two or more vehicles.

3.1.2 CRITICAL EVENT FLAG

The hard braking, ABS, traction control, and stability control event flags within DE_VehicleEventFlags.

3.1.3 CRITICAL EVENT CONDITION

When an event that corresponds to a critical event flag occurs.

3.1.4 HARD BRAKING

A light vehicle is decelerating at a level greater than 0.4 g.

3.1.5 LATENCY

The delay from an event occurrence to the desired outcome.

3.1.6 LAYER 2 ADDRESS

The DSRC radio subsystem MAC address, which is from the locally administered MAC address space [5].

3.1.7 LIGHT VEHICLE

A class 2 or class 3 vehicle as defined by FHWA, excluding ambulances, law enforcement vehicles, fire department vehicles, and construction vehicles.
(http://onlinemanuals.txdot.gov/txdotmanuals/tri/vehicle_classification_using_fhwa_13category_scheme.htm)

3.1.8 PACKET COLLISION

When two or more transmissions overlap in time at a potential receiver, causing the receiver to fail to interpret the content of any of the transmissions.

3.1.9 SECURITY CREDENTIAL MANAGEMENT SYSTEM

The public key infrastructure that issues certificates and manages other security functions.

3.2 Abbreviations and Acronyms

The abbreviations and acronyms cited below are terms used in this standard.

ABS Antilock Brake System

ACR Adjacent Channel Rejection

AES Advanced Encryption Standard

ASN.1 Abstract Syntax Notation One

BSM Basic Safety Message

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BSS	Basic Service Set
BSW	Blind Spot Warning
CA	Certificate Authority
CAMP	Crash Avoidance Metrics Partnership
CAN	Controller Area Network
CBP	Channel Busy Percentage
CCH	Control Channel
CCM	Counter Mode with Cipher Block Chaining Message Authentication Code
CFR	Code of Federal Regulations
CLW	Control Loss Warning
CME	Certificate Management Entity
CPR	Certificate Provisioning Request
CRL	Certificate Revocation List
CRLG	Certificate Revocation List Generator
DCM	Device Configuration Manager
DE	Data Element
DF	Data Frame
DNS	Domain Name Services
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
DTI	Distance to Intersection
DVI	Driver Vehicle Interface
ECDSA	Elliptic Curve Digital Signature Algorithm
ECIES	Elliptic Curve Integrated Encryption Scheme
ECU	Electronic Control Unit
EDCA	Enhanced Distributed Channel Access
EEBL	Emergency Electronic Brake Lights
EGNOS	European Geostationary Navigation Overlay Service
FCC	Federal Communications Commission
FCW	Forward Crash Warning

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FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standards
GHz	Gigahertz
GNSS	Global Navigation Satellite System
HCF	Hybrid Coordination Function
HV	Host Vehicle
Hz	Hertz
ICA	Intermediate Certificate Authority
IEEE	Institute of Electrical and Electronics Engineers
IMA	Intersection Movement Assist
IPv6	Internet Protocol Version 6
ITT	Inter-Transmit Time
LCW	Lane Change Warning
LOS	Line of Sight
LTA	Left Turn Assist
MA	Misbehavior Authority
MAC	Medium Access Control
MD	Model Deployment
MHz	Megahertz
MIB	Management Information Base
MLME	MAC Sublayer Management Entity
MPR	Minimum Performance Requirements
NHTSA	National Highway Traffic Safety Administration
OBE	On-Board Equipment
OCB	Outside the Context of a BSS
OFDM	Orthogonal Frequency Division Multiplexing
OTA	Over the Air
PCA	Pseudonym Certificate Authority
PER	Packet Error Ratio
PH	Path History

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PHY	Physical Layer
PICS	Protocol Implementation Conformance Statement
PLME	Physical Layer Management Entity
PP	Path Prediction
PPS	Pulse per Second
PSDU	Physical Layer Convergence Procedure Service Data Unit
PSID	Provider Service ID
QPSK	Quadrature Phase Shift Keying
RA	Registration Authority
RF	Radio Frequency
RSE	Roadside Equipment
RP	Radiated Power
RV	Remote Vehicle
SAP	Service Access Point
SBAS	Satellite Based Augmentation System
SCH	Service Channel
SCMS	Security Credential Management System
SDEE	Secure Data Exchange Entity
STA	Station
3D	Three-Dimensional
TSF	Time Synchronization Function
TTC	Time-to-Collision[2]
TTI	Time-to-Intersection
Tx	Transmit
UPER	Unaligned Packed Encoding Rules
URL	Uniform Resource Locator
UTC	Universal Coordinated Time
V2V	Vehicle-to-Vehicle

[2] The TTC acronym uses collision instead of crash to be consistent with other industry work.

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V2V-SE Vehicle-to-Vehicle Systems Engineering and Vehicle Integration Research for Deployment (Project)

VOD Verify on Demand

VSA Vendor Specific Action

VSC-A Vehicle Safety Communication - Applications

VSC 3 Vehicle Safety Communications 3 (Consortium)

WAAS Wide Area Augmentation System

WAVE Wireless Access in Vehicular Environments

WGS World Geodetic System

WME WAVE Management Entity

WSM WAVE Short Message

WSA WAVE Service Advertisement

WSMP WAVE Short Message Protocol

3.3 Requirement Numbering Convention

Each requirement in this standard is tagged with a requirement number of the form:

<Subsection Number>-V2V-< Category Abbreviation>-<Subcategory Abbreviation>-<Number>

For example, if the requirement number is 6.5.2-V2V-SECPRIV-BSMSIGN-005, the subsection is 6.5.2, the category is Security and Privacy, the subcategory is BSM signing, and it is requirement number 5 in the subcategory. Table 1 identifies the sections in this standard and the corresponding subsections and abbreviations that are used. The abbreviation is also in parentheses following each section heading in this standard. The requirement numbering convention applies to both mandatory and optional features.

Table 1 - Requirement numbering abbreviations

Section	Subsection	Category	Category Abbreviation	Subcategory	Subcategory Abbreviation
6.1	6.1.1	Standards Profiles	STD	IEEE 802.11	802.11
	6.1.2			IEEE 1609.2	1609.2
	6.1.3			IEEE 1609.3	1609.3
	6.1.4			IEEE 1609.4	1609.4
	6.1.5			IEEE 1609.12	1609.12
	6.1.6			SAE J2735	SAE J2735
6.2	6.2.1	Positioning and Timing	POSTIM	Position Determination	POSDETER
	6.2.2			Wide Area Augmentation System	WAAS
	6.2.3			Coordinate System and Reference	COORDSYSREF
	6.2.4			System Time Coordination	SYSTIMCOORD
6.3	6.3.1	BSM Transmission	BSMTX	BSM Contents	BSMCONT

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Section	Subsection	Category	Category Abbreviation	Subcategory	Subcategory Abbreviation
	6.3.2			Channel and Data Rate	CHDATARATE
	6.3.3			First BSM after Startup and Generation Timing	GENTIM
	6.3.4			User Priority and EDCA Settings	UPEDCA
	6.3.5			Minimum Transmission Criteria	MINTX
	6.3.6			Data Element Accuracy	DATAACC
	6.3.7			Data Persistency	DATAPERSIST
	6.3.8			BSM Scheduling and Congestion Control	CONGCTRL
6.4	6.4.1	RF Performance	RFPERF	DSRC Transmit Power Accuracy and Radiated Transmit Power	DSRCTX
	6.4.2			DSRC Receive Sensitivity	DSRCRXSENS
6.5	6.5.1	Security and Privacy	SECPRIV	ID Randomization	IDRAND
	6.5.2			BSM Signing	BSMSIGN
	6.5.3			Certificate Change	CERTCHG
	6.5.4			BSM Verification	BSMVERIFY
	6.5.5			Certificate Revocation	CERTREV
6.6	6.6.1	Security Management	SECMGMT	Bootstrap: Enrollment and Initialization Processing	ENINIT
	6.6.2			Certificate Loading	CERTLOAD
	6.6.3			Certificate Storage	CERTSTORE
	6.6.4			CRL Loading	CRLLOAD
	6.6.5			Secure Hardware	SECHW

4. V2V SAFETY SYSTEMS CONCEPT OF OPERATIONS AND SYSTEM DESCRIPTION

This section provides a high-level description of the V2V safety concept of operations and system description. Section 4.1 provides an overview of the system, and 4.2 provides the system description for V2V safety features.

4.1 V2V System Overview

V2V safety communications are designed to exchange basic safety information among vehicles for driver assistance by supporting detection of imminent crash threats and alerting the driver. V2V communications use dedicated short range communications (DSRC) radios to transmit BSMs that include a subset of the available data frames and elements in SAE J2735 [1]. On-board safety applications use the information about the host vehicle (HV) and remote vehicles (RVs) to detect potential crash threats and alert the driver. Messages can be used for additional purposes, but only the scenarios described herein were used to develop this standard. For the purposes of the crash scenarios described herein, the HV and RV terminology is used to identify which vehicle is receiving and acting on BSMs (HV), and the set of vehicles from which BSMs are being received (RVs).

V2V communications can enable improved safety system effectiveness by complementing or providing an alternative to self-contained sensors such as radar, lidar, or camera systems. V2V communications provide the vehicle and driver with 360-degree awareness and can detect potential threats at a greater distance than other types of sensors, as well as detecting potential threats to some degree even under non-line-of-sight or low visibility conditions. This enables the driver to receive alerts earlier and have more time to take action to avoid crashes.

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Because vehicles need to trust messages from each other, security is essential to protect messages from attacks such as spoofing, alteration, or replay that could cause false alerts or suppress true alerts. In addition, driver privacy is protected appropriately, so the system does not disclose identifying information about the driver, or allow for easy tracking. All BSMs are sent with a signature that enables the receiving device to verify the message. Broadcast information that could potentially be used to identify and track drivers is anonymous and randomized, and other system security measures are also incorporated to protect privacy appropriately.

Figure 1 illustrates the components of the V2V system and its interfaces. An infrastructure-based security credential management system (SCMS) is responsible for generating and delivering the security certificates that are used in the message verification process. The SCMS can also revoke certificates that cannot be trusted (e.g., the associated device may have been tampered with or is misbehaving) by placing them on a certificate revocation list (CRL) that the SCMS distributes to all systems. Section 6.6 in this standard describes the SCMS interface.

The V2V on-board equipment (OBE), which is the on-board vehicle-to-vehicle (V2V) safety communications system defined in this standard (hereafter referred to as the system), typically consists of multiple subsystem components, which may be discrete or integrated depending on the implementation. Figure 1 illustrates the following subsystems within the system:

- DSRC Radio Subsystem: Transmits and receives BSMs. In this standard, a DSRC radio subsystem is assumed to be a single-channel-at-a-time device. The OBE can include one or more DSRC radio subsystems and still comply with this standard.

- Positioning Subsystem: The subsystem that includes a global navigation satellite system (GNSS) receiver and provides vehicle position, heading, speed, and time information. The system may augment and enhance postioning using additional information and components, which are not shown in Figure 1. Examples of these are speed data from the CAN bus, dead reckoning sensors, and optical/camera based systems.

- OBE Control Processor Electronic Control Unit (ECU): Executes software that generates BSMs for transmission according to the requirements in this standard.

- Antennas: Support radio frequency (RF) links for the DSRC radio and GNSS receiver. A second diversity antenna for the DSRC Radio Subsystem is recommended to improve performance. GNSS and DSRC antennas may be integrated (dual band).

Systems communicate amongst themselves using the DSRC radio subsystem as an interface. The system (OBE) can interface to a safety application ECU that detects threats and issues alerts through a driver-vehicle interface (DVI). The DVI can provide visual, audio, and/or haptic alerts. The OBE can also interface with the vehicle controller area network (CAN) bus to obtain vehicle status information. The safety application ECU, CAN bus, and DVI are outside the scope of this standard.

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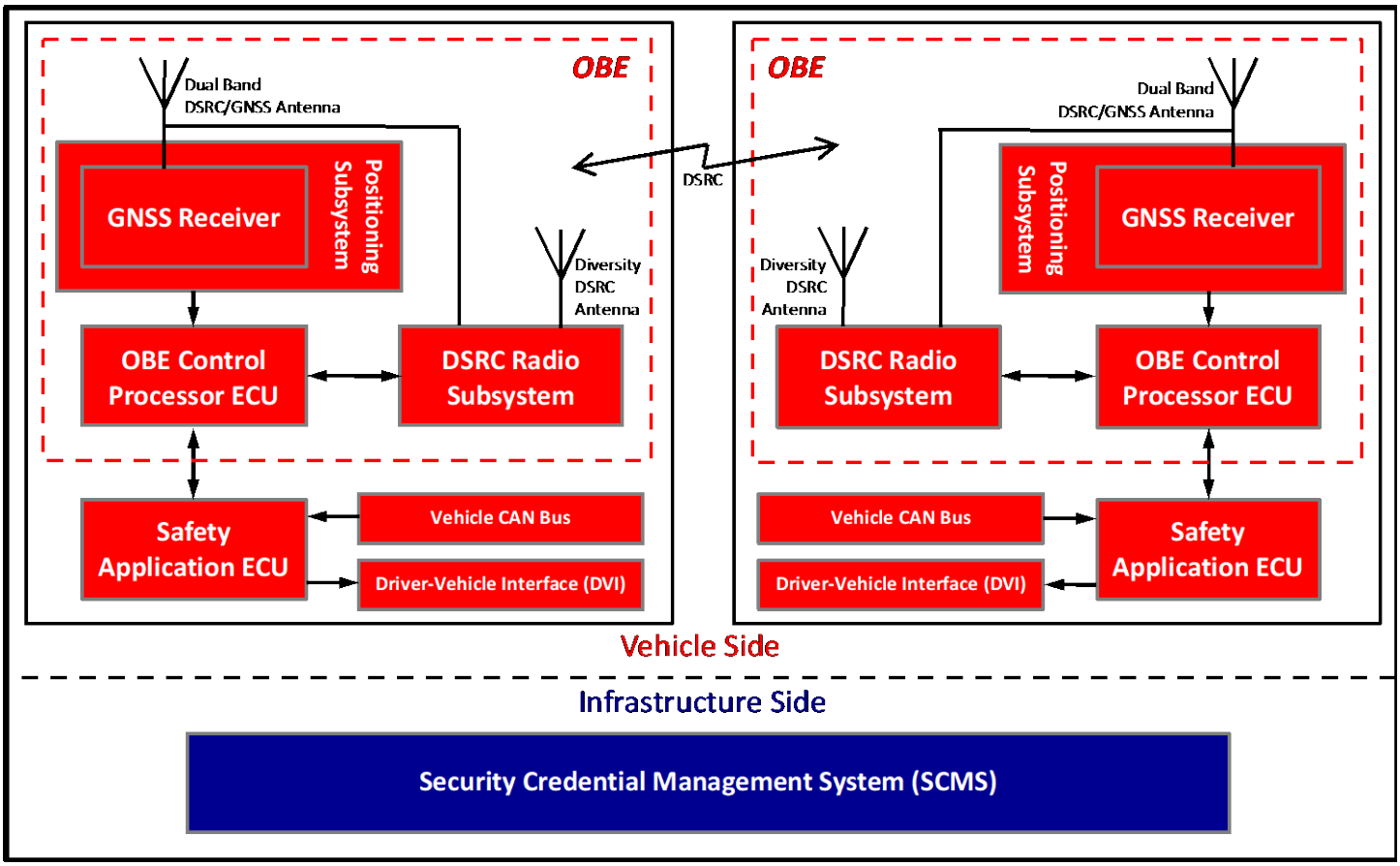


Figure 1 - On-board V2V system

4.2 V2V Safety Features

4.2.1 Critical Crash Scenarios for V2V Safety

The set of crash scenarios that could be addressed by the system were initially analyzed and documented in the Crash Avoidance Metrics Partnership (CAMP) Vehicle Safety Communications-Applications (VSC-A) project [11]. Table 2 lists the seven scenarios selected based on a composite ranking of crash frequency, crash cost, and functional years lost[3]. Scenario 7 was subsequently added to address left-turn-across-path intersection crashes during the CAMP VSC 3 driver acceptance clinics project [12].

[3] Functional years lost is a composite measure of crash severity. It measures the loss of an individual's productive time due to injuries sustained in a crash.

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Table 2 - Selected crash-imminent scenarios

Crash Imminent Scenario	Crash Category		
	Frequency	Cost	Functional Years Lost
Lead vehicle stopped	✓	✓	✓
Control loss without prior vehicle action	✓	✓	✓
Vehicle(s) turning at non-signalized junctions	✓	✓	
Straight crossing paths at non-signalized junctions			✓
Lead vehicle decelerating	✓	✓	
Vehicle(s) changing lanes - same direction	✓		
Left turn across path - opposite direction			

✓ Denotes top five ranking for the crash category.

4.2.2 Mapping Between Critical Crash Scenarios and the Selection of V2V Safety Applications

In [11] and [12], V2V safety applications were developed to address the selected scenarios. Table 3 illustrates the mapping between the crash-imminent scenarios identified in Table 2 and the list of safety applications. These safety applications are defined and discussed in more detail below. The decision thresholds used to determine when to warn the driver are not specified in this standard and are left to the implementer.

Table 3 - Crash-imminent scenario to V2V safety application mapping

Safety Applications / Crash Scenarios	EEBL	FCW	BSW/ LCW	IMA	LTA	CLW
Lead vehicle stopped		✓				
Control loss without prior vehicle action						✓
Vehicle(s) turning at non-signalized junctions				✓	✓	
Straight crossing paths at non-signalized junctions				✓		
Lead vehicle decelerating	✓	✓				
Vehicle(s) changing lanes - same direction			✓			
Left turn across path - opposite direction					✓	

4.2.3 Emergency Electronic Brake Lights (EEBL)

4.2.3.1 Definition

The EEBL safety application warns the driver of the HV in the case of a hard-braking event by an RV that is ahead and in the same lane or an adjacent lane. The RV broadcasts a hard-braking event in the BSM upon a hard braking maneuver. Upon receiving such event information, the HV determines the relevance of the event to its own travel path and provides a warning to the driver, if appropriate.

4.2.3.2 EEBL Use Case Scenario

a. EEBL: Abruptly Slowing RV (Figure 2)

- The HV follows a moving RV-2, which in turn follows RV-1 that abruptly brakes hard. RV-2 may or may not be equipped with V2V communications, but RV-1 is equipped with V2V capability.
- The HV may receive a warning from the EEBL feature when RV-1 applies brakes and decelerates at a level greater than the threshold that corresponds to hard braking (see the definition in 3.1).
- The timing of the warning is expected to be set such that the driver of the HV can avoid a rear-end crash with the vehicle (RV-2) in front.

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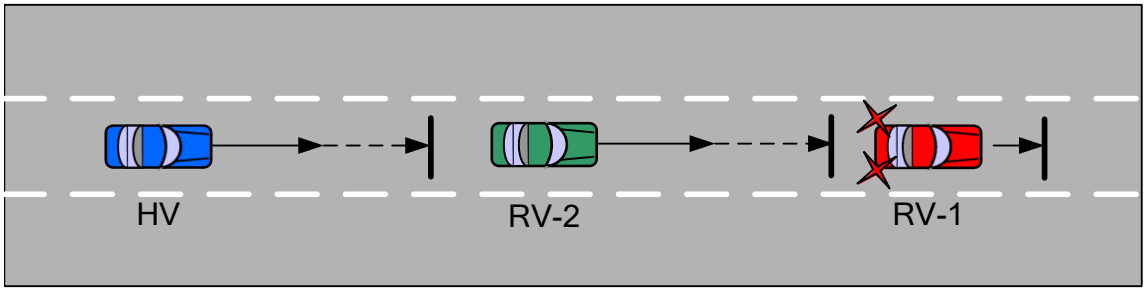


Figure 2 - EEBL - abruptly slowing RV

4.2.3.3 EEBL Feature Systems Description

The EEBL feature warns the driver of the HV in the case of a hard-braking event by an RV that is ahead and in the same lane or in an adjacent lane. The relevant RV zones for the EEBL feature are illustrated in Figure 3. The EEBL feature is expected to function in both straight and curved roadway geometries.

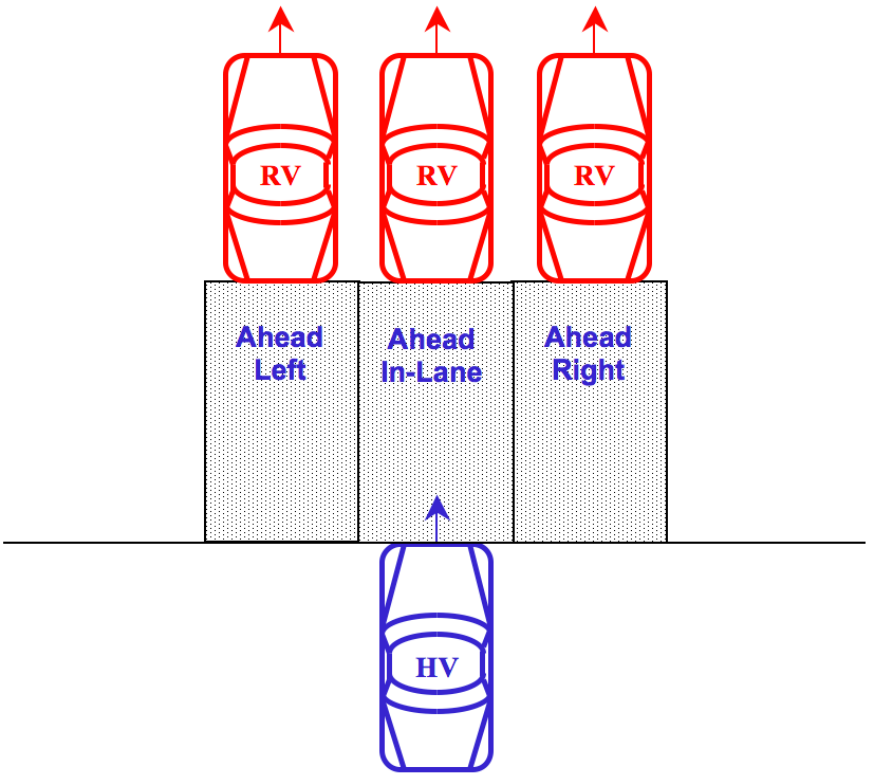


Figure 3 - Relevant RV zones for the EEBL feature

EEBL performs the following operations:

- The RV includes a hard-braking event in the broadcasted BSM during a hard-braking maneuver.

Upon receiving such event information, the HV performs the following operations:

- Determines which, if any, RVs have reported a hard-braking event.
- For each RV that has reported a hard-braking event and is classified as “ahead in-lane,” “ahead left,” or “ahead right,” determines if the distance between the vehicles is less than an implementation-specific threshold value.

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- Calculates the EEBL threat levels among all RVs identified above, determines the principal threat, and sets the appropriate threat status.
- Provides a warning to the driver via a DVI.

4.2.4 Forward Crash Warning (FCW)

4.2.4.1 Definition

The FCW safety application warns the driver of the HV in the case of an impending rear-end crash with an RV directly ahead in the same lane and direction of travel. The FCW is intended to help drivers avoid or mitigate rear-end vehicle crashes in the forward path of travel.

4.2.4.2 FCW Use Case Scenarios

a. FCW: Stopped RV in Same Lane (Figure 4)

- The HV approaches RV-1, which is stopped in the same lane as the HV.
- The HV receives a warning from the FCW feature when there is imminent danger of a rear-end crash with the stopped RV-1 in its lane of travel.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a rear-end crash with the stopped RV-1.

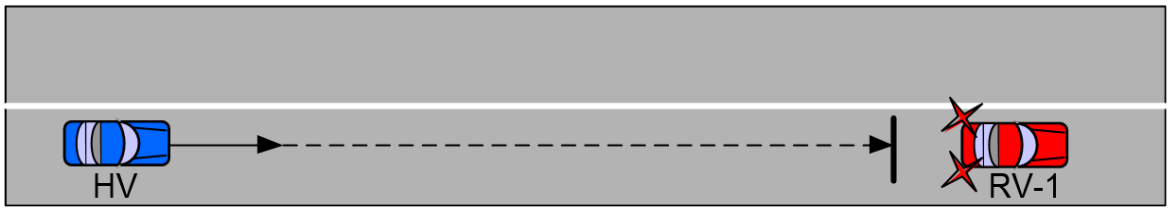


Figure 4 - FCW - stopped RV in same lane

b. FCW: Stopped RV in Adjacent Lane (Figure 5)

- The HV approaches RV-1, which is stopped in the lane adjacent to the HV.
- The driver of the HV does not receive a warning from the FCW feature since there is no imminent danger of a rear-end crash.

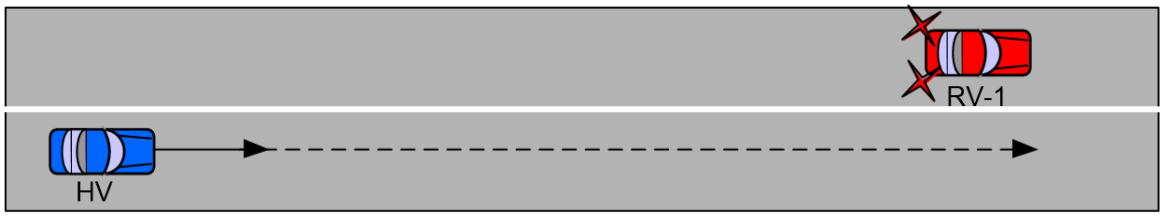


Figure 5 - FCW - stopped RV in adjacent lane

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c. FCW: Slower-Moving or Decelerating RV in Same Lane (Figure 6)

- The HV approaches RV-1, which is moving slower and/or decelerating in the same lane as the HV.
- The HV driver receives a warning from the FCW feature when there is imminent danger of a rear-end crash with the slow-moving RV-1 in its lane of travel.
- The timing of the warning is expected to be set such that the driver can avoid a rear-end crash with the slow-moving RV-1.

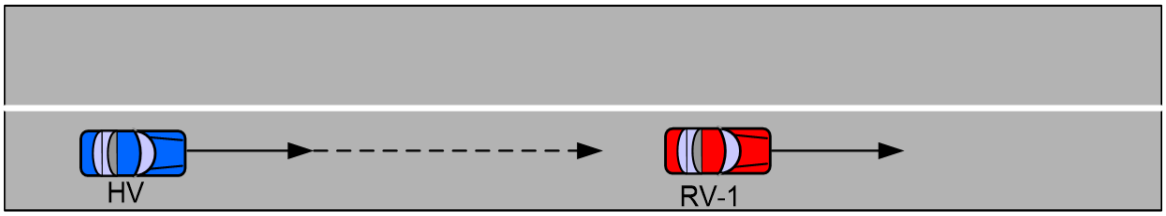


Figure 6 - FCW - slow-moving RV in same lane

d. FCW: Stopped and Obstructed RV (Figure 7)

- The HV follows a moving RV-2, which in turn approaches RV-1 that is stopped in the same lane. RV-2 may or may not be equipped with V2V communications, but RV-1 is equipped with V2V capability.
- RV-2 makes a lane change to avoid the stopped RV-1.
- The HV driver receives a warning from the FCW feature when there is imminent danger of a rear-end crash with the stopped RV-1 in its lane of travel.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a rear-end crash with the stopped vehicle RV-1.

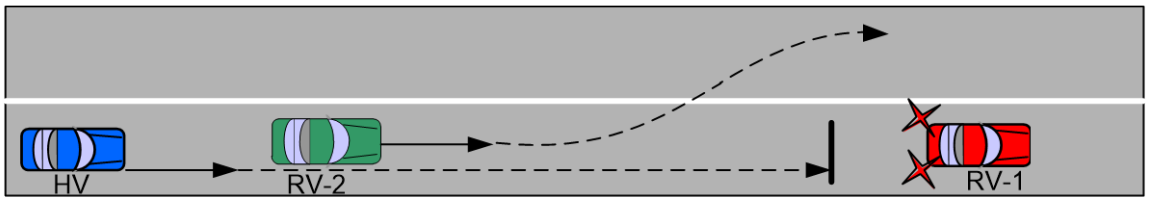


Figure 7 - FCW - stopped and obstructed RV

4.2.4.3 FCW Feature Systems Description

The FCW warns the driver of the HV when there is imminent danger of a rear-end crash with a remote lead vehicle in its lane of travel. The FCW feature is expected to function in both straight and curved roadway geometries. The relevant RV zones for the FCW feature are illustrated in Figure 8.

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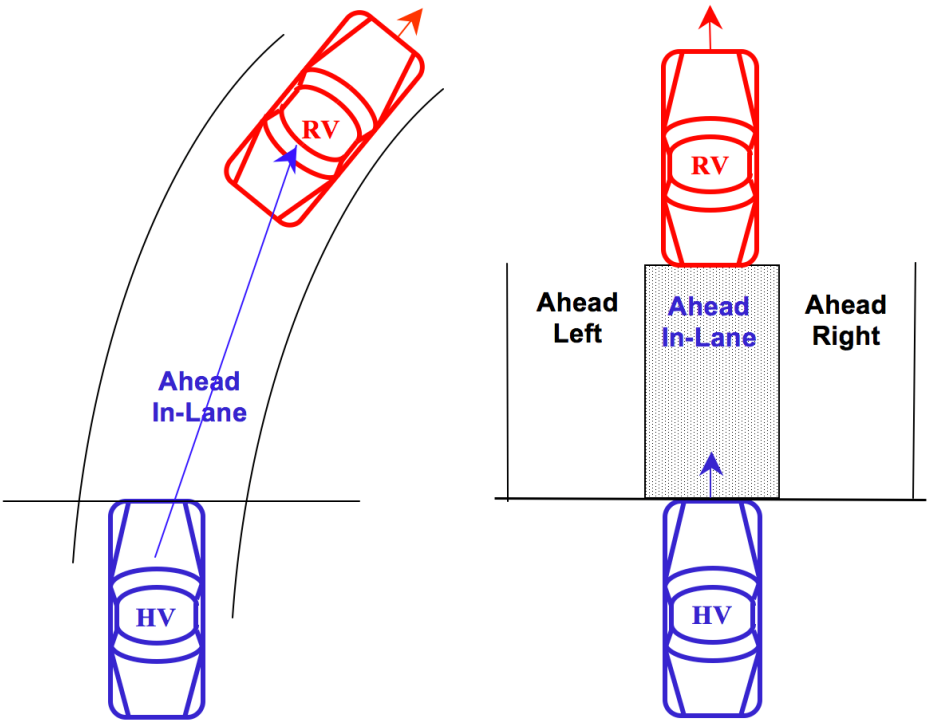


Figure 8 - Relevant RV zones for FCW feature

FCW performs the following operations:

- Analyzes received BSMs from each of the RVs and determines which of the RVs are classified as “ahead in-lane” to determine if the HV is at risk of being involved in a rear-end crash with an RV located in the same lane of travel.
- Determines which, if any, RVs classified as “ahead in-lane” are within a range threshold.
- Calculates time to crash (TTC) and/or crash avoidance range for each “ahead in-lane” RV to determine potential forward crash threats.
- Identifies the principal threat, if at least one RV is determined to be a threat.
- Provides a warning to the driver via a DVI.

4.2.5 Blind Spot Warning/Lane Change Warning (BSW/LCW)

4.2.5.1 Definition

The BSW/LCW safety application warns the driver of the HV during a lane change attempt if the blind-spot zone into which the HV intends to move is, or will soon be, occupied by another vehicle traveling in the same direction. Moreover, the application may also provide advisory information that is intended to inform the driver of the HV that a vehicle in an adjacent lane is positioned in a blind-spot zone of the HV when a lane change is not being attempted.

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4.2.5.2 BSW/LCW Use Case Scenarios

a. BSW/LCW: RV in Blind-Spot Zone (Figure 9)

- The HV drives in its lane while RV-1 is alongside the HV within the blind-spot zone.
- The HV driver may receive an advisory warning from the BSW/LCW feature indicating the presence of RV-1 in the blind-spot zone.
- The HV driver receives a warning if the HV detects the driver's intent to change lanes into the lane occupied by RV-1 (for example, through the use of the turn signal).
- The timing of the warning is expected to be set such that the driver of the HV can avoid a crash with RV-1 in the adjacent lane.

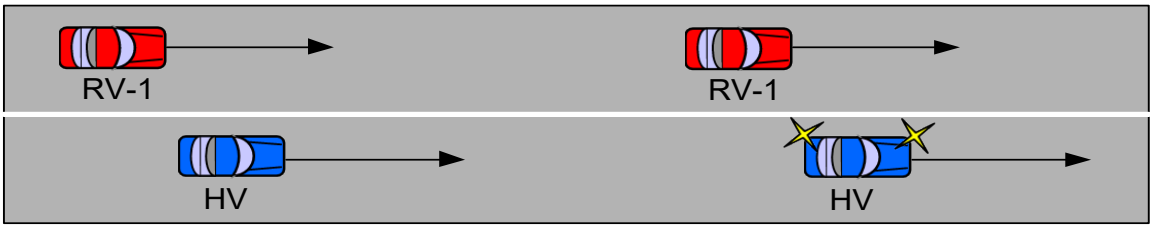


Figure 9 - BSW - RV in blind-spot zone

b. BSW/LCW: Approaching RV in Adjacent Lane (Figure 10)

- The HV drives in its lane. A faster moving RV-1 traveling in the same direction in an adjacent lane will soon occupy the HV's blind-spot zone.
- The HV driver may receive an advisory warning from the BSW/LCW feature anticipating the presence of RV-1 in the blind-spot zone.
- The HV driver receives a warning if the HV detects the driver's intent to change lanes into the lane that will soon be occupied by RV-1.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a crash with a faster-moving RV-1 in the adjacent lane.

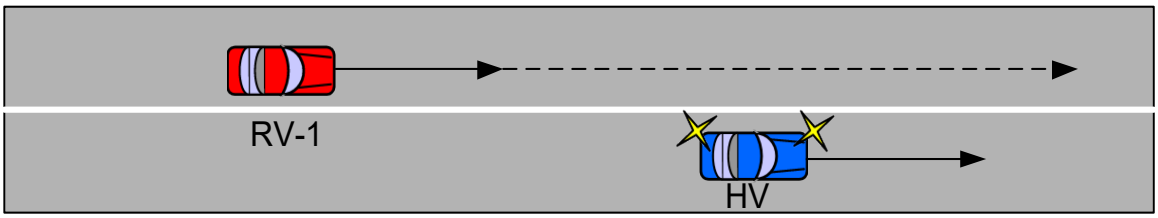


Figure 10 - LCW - approaching RV in adjacent lane

4.2.5.3 BSW/LCW Feature Systems Description

The BSW/LCW safety application warns the driver of the HV during an attempted lane change if the blind-spot zone into which the HV intends to move is, or will soon be, occupied by another vehicle traveling in the same direction. The relevant RV zones to the BSW/LCW feature are illustrated in Figure 11. The BSW/LCW feature is expected to function in straight and curved roadway geometries.

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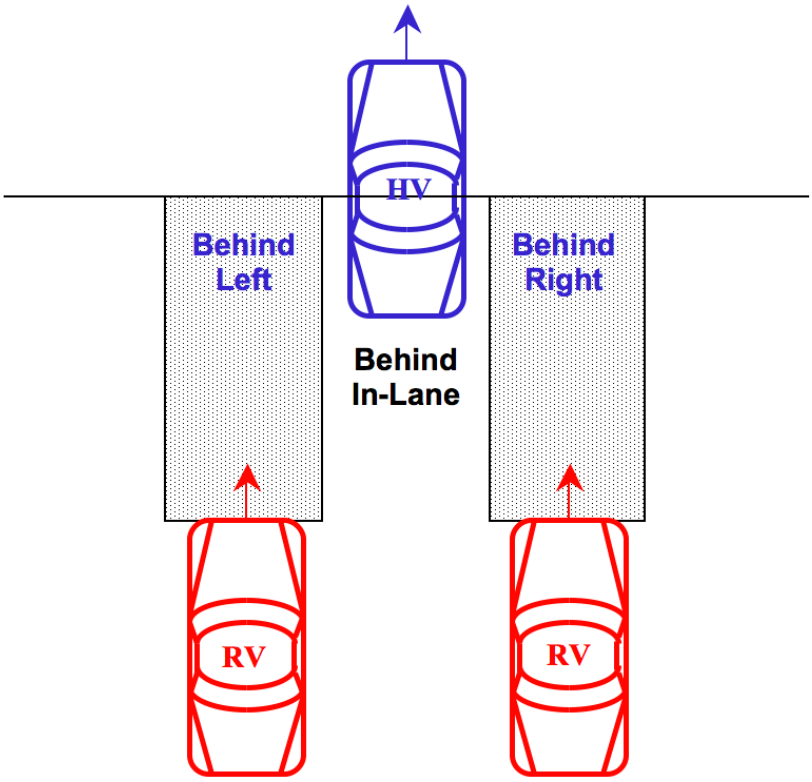


Figure 11 - Relevant RV zones for BSW/LCW feature

BSW/LCW performs the following operations:

- Determines which RVs have been classified as behind in the adjacent left lane or behind in the adjacent right lane relative to the HV.
- Evaluates the position of each RV relative to the HV to determine if that RV is currently positioned within the HV's blind-spot zone or if that RV is predicted to soon be within the HV's blind-spot zone.
- Sets the threat status corresponding to each side (left and right) to advise the HV driver if an RV is or will be located in the corresponding left or right blind spot.
- Sets the threat status to warn the HV driver of the current or predicted presence of a threat in an adjacent lane during an attempted lane-change maneuver.
- Provides an advisory or warning to the driver via a DVI.

4.2.6 Intersection Movement Assist (IMA)

4.2.6.1 Definition

The IMA safety application warns the driver of an HV when it is not safe to enter an intersection due to a crash possibility with RVs.

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4.2.6.2 IMA Use Case Scenarios

a. IMA: Stopped HV at Intersection (Figure 12)

- The HV is stopped at an intersection and visibility may be limited by the presence of RV-2. RV-2 may or may not be equipped with V2V communications, which has no impact on the scenario, but RV-1 is equipped with V2V capability.
- RV-1 approaches the intersection from the left or right of the HV.
- The HV driver receives a warning from the IMA feature indicating that a crash is predicted with RV-1 if the HV begins to enter the intersection.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a crash with the approaching RV-1.

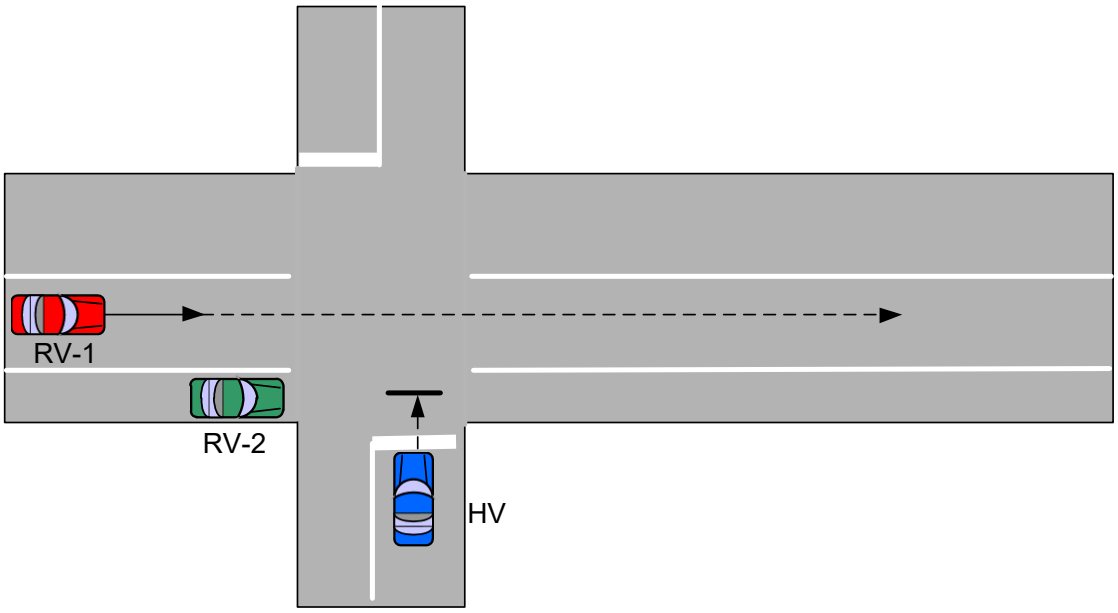


Figure 12 - IMA - stopped HV at the intersection

b. IMA: Both Vehicles Approaching Intersection (Figure 13)

- The HV approaches the intersection and visibility may be limited by the presence of RV-2. RV-2 may or may not be equipped with V2V communications, but RV-1 is equipped with V2V capability.
- RV-1 approaches the intersection from the left or right of the HV.
- The HV driver receives a warning from the IMA feature indicating that a conflict is predicted with RV-1 if the HV tries to enter the intersection.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a crash with the approaching vehicle, RV-1.

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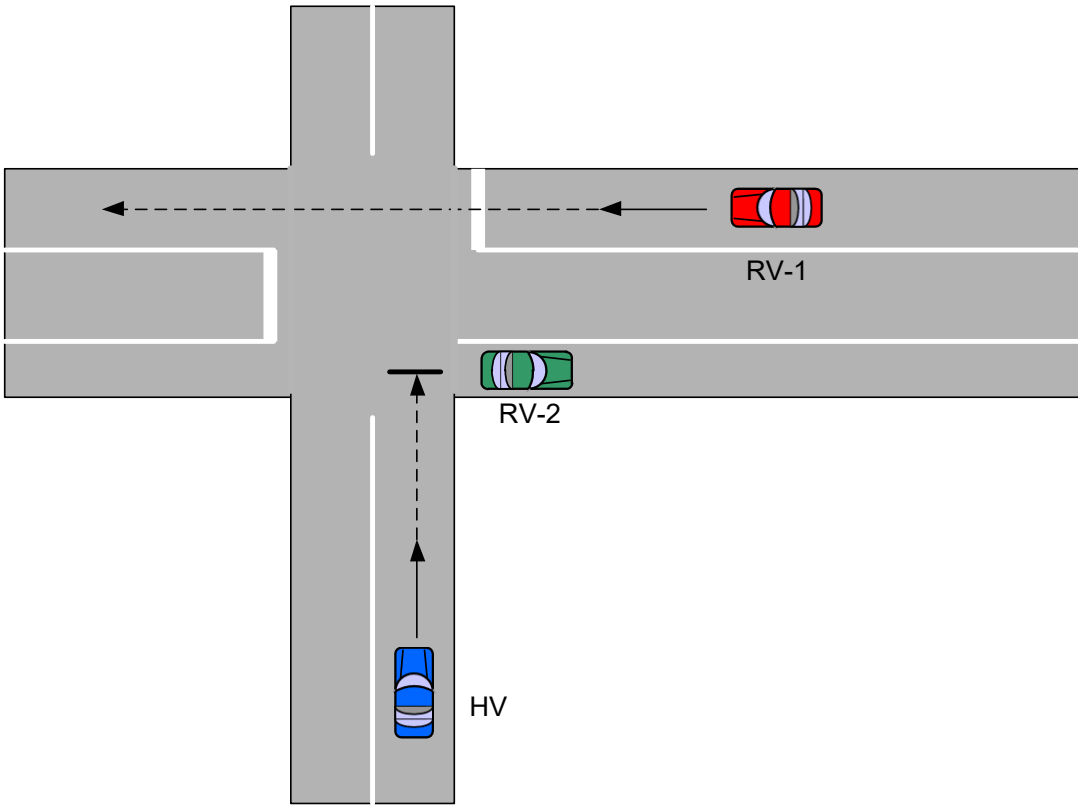


Figure 13 - IMA - both vehicles approaching intersection

4.2.6.3 IMA Feature Systems Description

IMA warns the driver of the HV when there is imminent danger of a crash with a remote vehicle that is approaching the same intersection. The relevant RV zones for the IMA feature are illustrated in Figure 14.

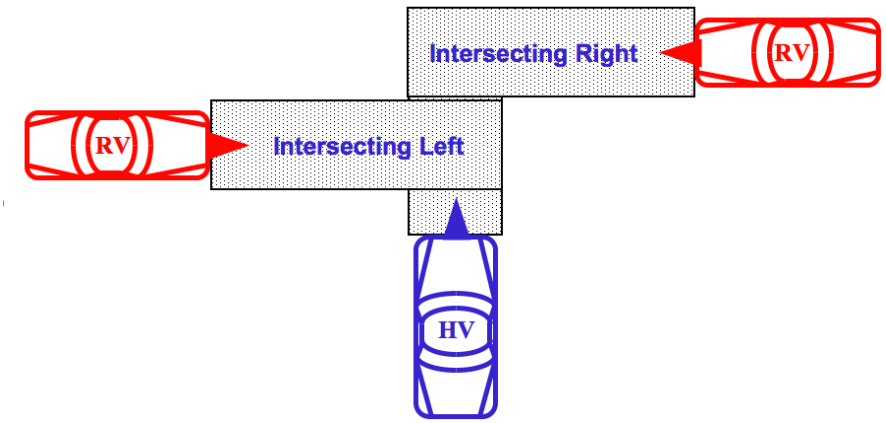


Figure 14 - Relevant RV zones for IMA feature

IMA performs the following operations:

- Analyzes received BSMs from RVs approaching the intersection and determines which of the RVs are classified as “intersecting left” or “intersecting right.”
- Determines which, if any, RVs classified as “intersecting left” or “intersecting-right” are within a lateral range threshold.

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- Calculates time-to-intersection (TTI) and distance-to-intersection (DTI) for each “intersecting left” or “intersecting right” RV to determine if the HV is at risk of being involved in a crash with an RV traveling toward the same intersection.
- Identifies the principal threat, if at least one RV is determined to be a threat.
- Provides a warning to the driver via a DVI.

4.2.7 Left Turn Assist (LTA)

4.2.7.1 Definition

The LTA safety application warns the driver of an HV that, due to oncoming traffic, it may not be safe to proceed when attempting a left turn.

4.2.7.2 LTA Use Case Scenarios

a. LTA: Left Turn Across Path (Figure 15)

- The HV approaches an intersection to make a left turn and visibility may be limited or obstructed by RV-2. RV-2 may or may not be equipped with V2V communications, but RV-1 is equipped with V2V capability.
- RV-1 approaches the intersection from the opposite direction.
- The HV driver receives a warning from the LTA feature when the HV driver attempts a left turn.
- The timing of the warning is expected to be set such that the driver of the HV can avoid a crash with the approaching vehicle, RV-1.

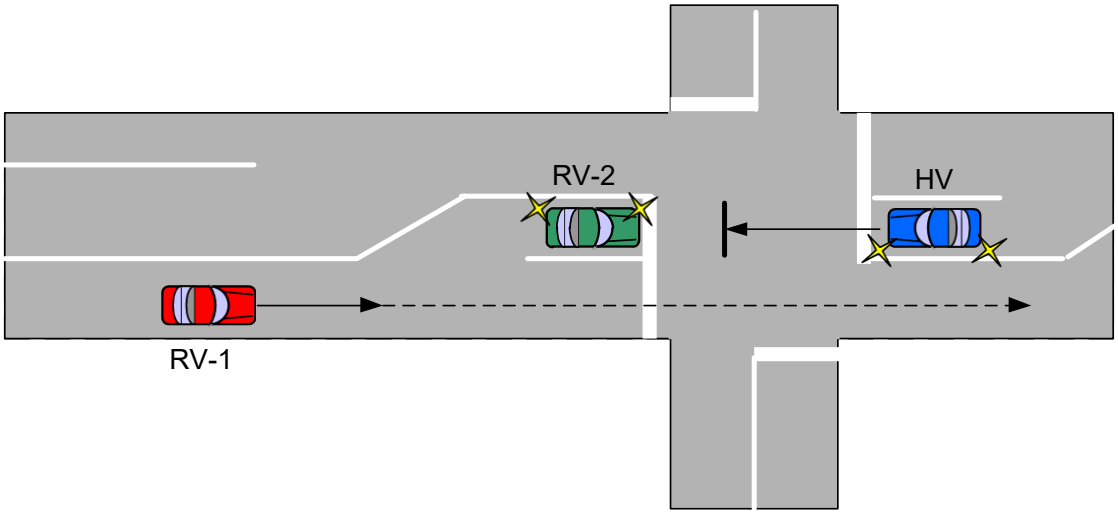


Figure 15 - LTA - left turn across path

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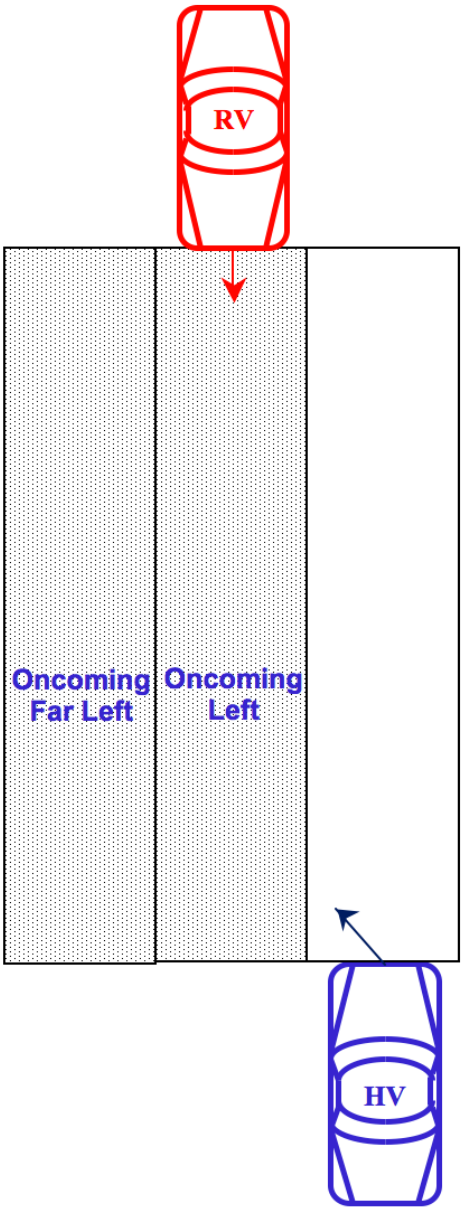


Figure 16 - Relevant RV zones for LTA feature

4.2.7.3 LTA Feature Systems Description

LTA should warn a driver intending to make a left turn across an intersection path when there is imminent danger of a crash with an RV in an oncoming opposite lane of travel. The relevant RV zones for the LTA feature are illustrated in Figure 16.

LTA performs the following operations:

- Analyzes received BSMs from the RVs approaching the intersection and determines which of the RVs are classified as “oncoming left” or “oncoming far left” to determine if the HV is at risk of being involved in an intersecting crash with an RV approaching in an oncoming lane of travel.
- Determines which, if any, RVs classified as “oncoming left” or “oncoming far left” are within a range threshold.
- Calculates the clearance gap for each “oncoming left” or “oncoming far left” RV to determine potential intersecting crash threats.

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- Identifies the principal threat, if at least one RV is determined to be a threat.
- Provides a warning to the driver via a DVI.

4.2.8 Control Loss Warning (CLW)

4.2.8.1 Definition

The CLW safety application warns the driver of the HV in the case of an emergency control loss event (defined as activation of the antilock brake system, traction control system, or stability control system) by an RV traveling in the same or opposite direction. The RV broadcasts control loss event information within the BSM. Upon receiving such event information, the HV determines the relevance of the event and provides a warning to the driver of the HV.

4.2.8.2 CLW Use Case Scenarios

a. CLW: RV Same Direction of Travel (Figure 17)

- The HV follows the RV in the same direction.
- The HV receives BSMs from the RV indicating a control loss event (antilock brake system, traction control system or stability control system active).
- The timing of the corresponding warning to the driver is expected to be such that the driver of the HV can avoid a crash with the RV.

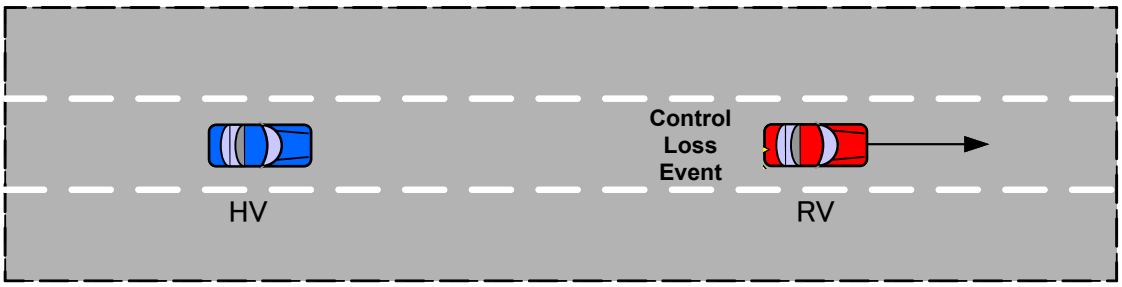


Figure 17 - CLW - RV same direction of travel

b. CLW: RV Traveling in Opposite Direction (Figure 18)

- The RV approaches the HV from the opposite direction.
- The HV receives BSMs from the oncoming RV indicating a control loss event (antilock brake system, traction control system or stability control system activated).
- The timing of the corresponding warning to the driver is expected to be such that the driver of the HV can avoid a crash with the RV.

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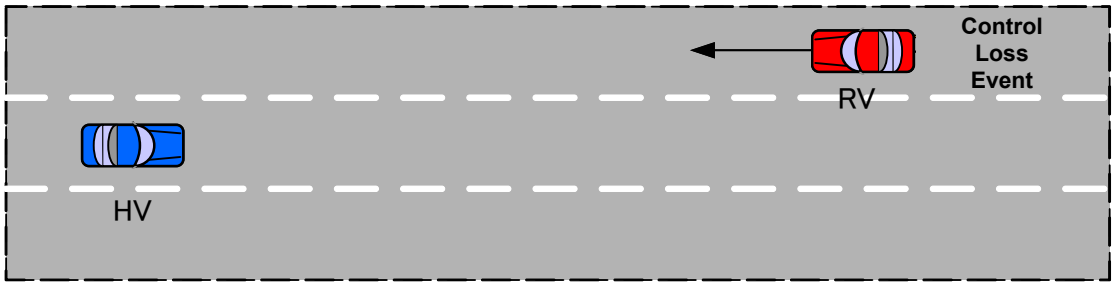


Figure 18 - CLW - RV traveling in opposite direction

4.2.8.3 CLW Feature Systems Description

The CLW safety application warns the driver of the HV in the case of an emergency control loss event by an RV traveling in the same or opposite direction. The relevant zones for the CLW features are illustrated in Figure 19.

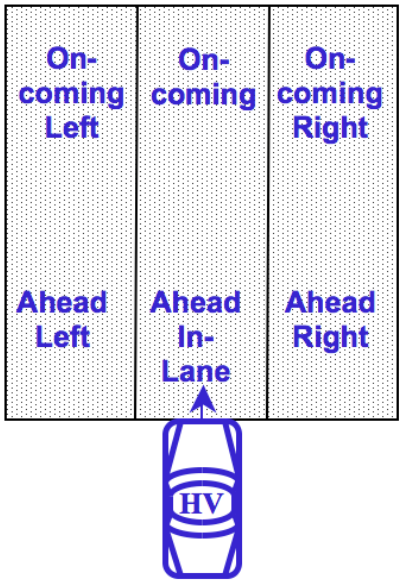


Figure 19 - Relevant RV zones for CLW feature

CLW performs the following operations:

- The RV broadcasts a control loss event in the BSM upon activation of the antilock brake system, traction control system, or stability control system.

Upon receiving such event information, the HV performs the following operations:

- Determines which, if any, RVs have reported a control loss event.
- For each RV that has reported an event and is classified as “ahead in-lane,” “ahead left,” “ahead right,” “oncoming,” “oncoming left,” or “oncoming right,” determines if the range or TTC is less than a threshold value.
- Calculates the CLW threat levels among all RVs identified above, determines the principal threat, and sets the appropriate threat status.
- Provides a warning to the driver via a DVI.

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5. INTERFACE DESCRIPTION

5.1 V2V Over-the-Air Data Description

5.1.1 Basic Safety Message Exchange

The BSM, which is defined in SAE J2735 [1], is the message used for V2V safety communications in this standard. Each vehicle broadcasts (refer to [11]) BSMs to provide neighboring vehicles with trajectory and status information. With a sufficiently high population of V2V-equipped vehicles, the number of BSMs being transmitted can congest the channel, necessitating congestion control procedures.[4] The BSM consists of all data elements listed in Part I and selected data elements and data frames listed in Part II of the SAE J2735 standard. Part I contains the vehicle position, speed, heading, acceleration, transmission, steering-wheel angle, brake, and vehicle-size information.

For the system defined in this standard, the following additional information is transmitted as part of the Part II vehicle safety extension:

- Event flags, which convey the sender's status with respect to safety-related events such as antilock brake system (ABS) activation, stability control activation, and hard braking.
- Path history, which provides a concise representation of the vehicle's recent movement. It consists of a sequence of positions selected to represent the vehicle's path within an allowable error.
- Path prediction, which provides an estimate of the vehicle's future trajectory. The trajectory is represented as a radius of curvature.
- Exterior lights, which provides the vehicle light status, including turn signals.

5.1.2 Positioning

Many V2V safety applications need relative positioning of the HV and RVs with lane-level granularity. For example, a safety application can determine if the HV and an RV are in the same or adjacent lanes. The system includes a GNSS receiver to enable the system to determine its own position and accurate time. The system also maintains its own path history and calculates its path prediction. Each vehicle broadcasts its time-tagged position, heading, speed, and acceleration, plus its path history and path prediction in the BSM. Based on the HV and RV information, the system can calculate the range, range-rate, difference in headings, and relative position between vehicles. The path history and path prediction information are used to estimate the relative lane positioning between the HV and RV.

5.1.3 Security and Privacy

5.1.3.1 Signing and Verification Algorithm

To support trust in message exchange between vehicles, BSM signing and verification are performed using a public key digital signature algorithm. The transmitter computes a signature using an elliptic curve digital signature algorithm (ECDSA) with a private key, and the receiver verifies the signature using the associated certificate.

5.1.3.2 BSM Signature and Certificate Transmission

Each BSM is transmitted with a signature and either a security certificate containing the public key or a certificate digest (hash of the current security certificate). The BSM with a certificate is transmitted approximately every 500 ms (see 6.5.2), and other BSMs are transmitted with a certificate digest to reduce the overall message length. The receiver buffers recently received certificates and is able to identify the certificate corresponding to a received digest.

[4] Non-BSM transmissions from V2X devices, e.g., from roadside units, may also contribute to congestion on the channel.

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5.1.3.3 BSM Verification

The receiver can verify every message or use a verify on demand (VOD) approach [17] whereby only a subset of BSMs is verified. For example, the receiver may verify only BSMs containing information that would trigger an alert to the driver, or the receiver may verify a subset of messages received to support other functional requirements. Upon selecting a BSM for verification, if the BSM contains a security certificate, the receiver uses the public key in the certificate to perform the verification. If the BSM contains a digest, the receiver can use the digest to identify the corresponding buffered certificate for use in the verification. In certain cases, a system may obtain (learn) certificate information from peer systems over the same interface.

5.1.3.4 SCMS

The SCMS is responsible for generating and distributing security certificates. The SCMS is also responsible for generating and distributing a certificate revocation list (CRL), which contains a list of linkage information that all receiving devices can use to identify non-trustworthy certificates. Certificates and the CRL are stored within the OBE system, and are updated by the SCMS. A well-behaved system does not send a BSM if its linkage information is on the CRL. If a receiver receives a BSM with linkage information on the CRL, the BSM is considered invalid. More information about the CRL is available in 1609.2 [3]. For the initial equipping of a system, it interfaces to a device configuration manager (DCM) to acquire the root certificate authority (CA) certificate (see 6.6.1).

5.1.3.5 Privacy

To protect privacy, the signing security certificate is changed after a variable length of time (for example, every 5 minutes), and fields within the broadcast message (DE_MsgCount, DE_TemporaryID, and the layer 2 address) are randomized whenever the certificate is changed. The SCMS is structured as a set of components, so the component generating the certificates has no knowledge of which certificates are used by a particular device. For a more detailed description of the SCMS and associated security system design and operation, refer to [9] and [10].

5.1.4 Startup and Shutdown

To ensure performance, systems include additional capabilities related to device startup and shutdown. Systems store the last known heading and path history information on shutdown so they can be retrieved for use in BSMs upon the next system device startup. Systems also randomize their message generation schedule upon startup to avoid repeated packet collisions of transmitted BSMs with those transmitted by other systems.

5.1.5 Mapping to the V2V Over-the-Air Data

A generic logic design of the safety features is shown by the flowchart in Figure 20. Table 4 provides a mapping to the V2V over-the-air data.

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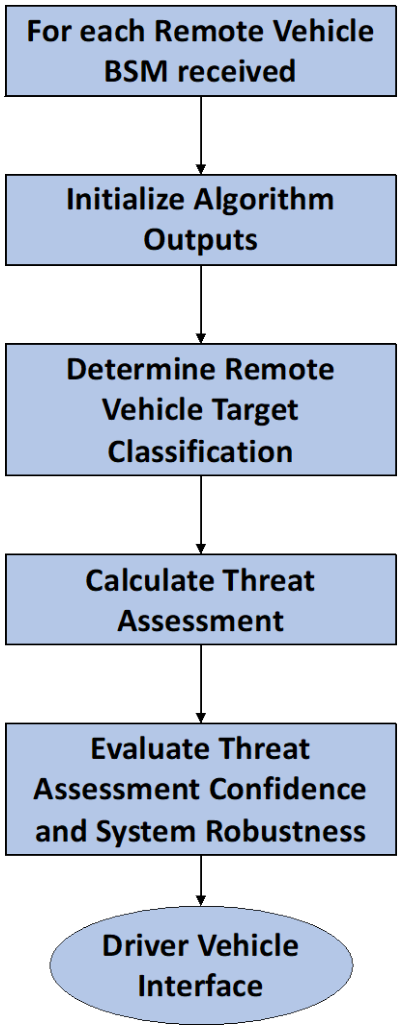


Figure 20 - Safety feature logic

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Table 4 - Mapping crash scenarios to the V2V over-the-air data

V2V Safety Message BSM Contents (refer to SAE J2735 [1])		FCW, BSW/LCW, IMA Stopped, LTA	EEBL, CLW, IMA Moving
DE_DSecond DE_Latitude DE_Longitude DE_Elevation DF_PositionalAccuracy DE_Heading	Relative Road Level Positioning		Required for: • Relative Road Level Target Classification • Threat Assessment • Threat Assessment Confidence and System Robustness
	Relative Lane Level Positioning	Required for: • Relative Lane Level Target Classification • Threat Assessment • Threat Assessment Confidence and System Robustness	
DE_VehicleWidth DF_PathHistory DF_PathPrediction		Required for: • Relative Lane Level Target Classification	Required for: • Relative Road Level Target Classification
DE_Speed DE_TransmissionState DE_Acceleration (Longitudinal) DF_BrakeSystemStatus DE_ExteriorLights DE_VehicleLength		Required for: • Threat Assessment • Threat Assessment Confidence and System Robustness	Required for: • Threat Assessment • Threat Assessment Confidence and System Robustness
DE_SteeringWheelAngle DE_Acceleration (Lateral) DE_Acceleration (Vertical) DE_YawRate		Required for: • Threat Assessment Confidence and System Robustness	Required for: • Threat Assessment Confidence and System Robustness
DE_VehicleEventFlags			Required for (EEBL and CLW only): • Hard-Braking Event Notification • Control-Loss Event Notification

NOTE: The positioning and other related data (e.g., speed, heading) accuracy requirements in this standard are designed to meet the relative lane level positioning needs of the crash scenarios described in the preceeding sections (see 6.3.6.5 through 6.3.6.12).

5.1.6 Objective Tests Conducted for V2V Safety Applications (Informative)

Details and results from testing for the crash scenarios described in this standard can be found in the VSC-A final report, Appendices C-2 and C-3 [13]. Refer to the report for details.

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5.2 System Interfaces

This section provides an overview of the system interfaces. Section 6 provides the detailed requirements for these interfaces.

5.2.1 Vehicle to Vehicle Communications Interface

The system interfaces to other vehicles (systems) by transmitting and receiving BSMs.

- The format and contents of the BSM are compliant with SAE J2735 [1].
- The BSM is transmitted as a wireless access in vehicular environments (WAVE) short message (WSM) using the WAVE short message protocol (WSMP) as defined in IEEE 1609.3 [4].
- BSM security is compliant with IEEE 1609.2 [3].
- The over-the-air medium access control (MAC) and physical layer (PHY) protocol are compliant with IEEE 1609.4 [5] and IEEE 802.11 [2].
- The WSM provider service ID (PSID) is set as specified in IEEE 1609.12 [6].

Section 6.1 of this standard profiles the applicable requirements from each of these standards.

5.2.2 System to SCMS Communications Interface

The system interfaces to the SCMS to request security credential generation, download security credentials, and receive CRLs. Learning security credentials from other systems that interface to the SCMS can also be used. The requirements listed in this standard are based on the following reports, which include dialogs and other SCMS interface details:

- CAMP Vehicle Safety Communications Security Studies: Study 1 - Security Credential Management System [10].
- CAMP Vehicle Safety Communications Security Studies: Study 3 Final Report: Protocols and Components of the SCMS [9].

Section 6.6 of this standard defines the applicable requirements for interfacing to the SCMS.

5.2.3 System to Positioning Subsystem Interface

The system has access to positioning subsystem information to meet the positioning and timing requirements of 6.2.

6. MINIMUM REQUIREMENTS

6.1 Standards Profiles (STD)

The standards compliance subsections below describe the requirements from the corresponding standards necessary to support V2V operation. Additional requirements apply if the system optionally supports the SCMS interface via DSRC-equipped roadside equipment (RSE). If a clause from the referenced standard is not explicitly referenced below, then it and its sub-clauses are considered informative or optional and not required for either V2V or SCMS operation, unless they are implicitly referenced from one of the mandatory clauses of that referenced standard.

6.1.1 IEEE 802.11 (802.11)

This section specifies the requirements from IEEE 802.11 [2] to support V2V and SCMS operation, as described in 6.1. In Table 5, items marked V2V in the “required for” column are always required, and items marked SCMS are required only if interfacing to an SCMS over DSRC is implemented.

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Table 5 - IEEE 802.11 requirements

802.11 Clause	Title (802.11 Clause)	Required For	Requirement
4.3.11	STA Transmission of Data Frames Outside the Context of a BSS	V2V	The DSRC radio subsystem shall operate within the procedures for STA transmission of data frames outside the context of a BSS (dot11OCBActivated=True), as specified. [6.1.1-V2V-STD-802.11-001]
5	MAC Service Definition		
5.1	Overview of MAC Services	V2V	The DSRC radio subsystem shall comply with MAC services with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-002]
5.2	MAC Data Service Specification	V2V	The DSRC radio subsystem shall comply with MAC data service specification features with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-003]
6	Layer Management		
6.3	MLME-SAP Interface		Note: MLME-SAP primitives provide guidance when determining actual requirements. The DSRC radio subsystem includes the specified functionality corresponding to each service primitive, but the method in which it is implemented is implementation specific.
6.3.10, 6.5.2	Reset	V2V	The DSRC radio subsystem shall be capable of changing the layer 2 address during operation. [6.1.1-V2V-STD-802.11-004]
6.3.42	Get TSF Timer	SCMS	If TSF timer capabilities are used for time synchronization, the DSRC radio subsystem shall use the TSF timer as specified. Other methods may also be utilized for enhanced time synchronization. [6.1.1-V2V-STD-802.11-005]
7	PHY Service Specification		
7.1	Scope	V2V	The DSRC radio subsystem shall be capable of PHY services with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-006]
7.2	PHY Functions	V2V	The DSRC radio subsystem shall be capable of PHY services with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-007]
7.3	Detailed PHY Service Specification	V2V	The DSRC radio subsystem shall be capable of PHY services with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-008]
8	Frame Formats		
8.1	General Requirements	V2V	The DSRC radio subsystem shall comply with the frame format general requirements with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-009]
8.2	MAC Frame Formats	V2V	The DSRC radio subsystem shall comply with the MAC frame formats with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-010]
8.3	Format of Individual Frame Types		
8.3.1	Control Frames		
8.3.1.1	Format of Control Frames	SCMS	If interfacing to an SMCS over DSRC is implemented by the system, the DSRC radio subsystem shall comply with the control frame format with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-011]
8.3.1.4	ACK Frame Format	SCMS	If interfacing to an SMCS over DSRC is implemented, the DSRC radio subsystem shall comply with the ACK frame format with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-012]

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802.11 Clause	Title (802.11 Clause)	Required For	Requirement
8.3.2	Data Frames	V2V, SCMS	The DSRC radio subsystem shall comply with the data frame with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-013]
8.3.2.1	Data Frame Format	V2V	The DSRC radio subsystem shall set the data frame fields to the following values for V2V operation: Frame Control (bits) • Protocol version = 00 • Type = 10 (Data) • Subtype = 1000 (QoS Data) • ToDS = 0 • FromDS = 0 • More Fragments = 0 • Retry = 0 • Power Mgmt = 0 • More Data = 0 • Protected Frame = 0 • Order = 0 Duration ID = 0 Address 1 (destination) = ff ff ff ff ff ff Address 2 (source) = <random 6 octets, changed per rules defined in 6.5.1> Address 3 (BSS ID) = ff ff ff ff ff ff Sequence Control • Fragment Number = 0 • Sequence Number = <incrementing value for each transmitted frame> Address 4 field is omitted. QoS Control • TID (bits 0-3) = <User Priority (0-7)> • EOSP (bit 4) = 0 • Ack Policy: bit 5=1, bit 6=0 (No ACK) • A-MSDU Present (bit 7) = 0 • Tx Op Duration Req (bits 8-15) = 0 HT Control field is omitted. Frame body content is defined by the higher layers and shall not exceed 1500 octets. FCS contains the 32-bit CRC of the MAC header and frame body field. [6.1.1-V2V-STD-802.11-014]

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802.11 Clause	Title (802.11 Clause)	Required For	Requirement
8.4.2.31	EDCA Parameter Set Element	V2V	The DSRC Radio Subsystem shall comply with the EDCA parameter set element, with the default EDCA values set as specified in 6.3.4 of this standard. [6.1.1-V2V-STD-802.11-015]
9	MAC Sublayer Functional Description		
9.2	MAC Architecture		
9.2.4	Hybrid Coordination Function	V2V	The DSRC radio subsystem shall comply with the enhanced distributed channel access (EDCA) mechanism of the hybrid coordination function (HCF) with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-016]
9.7	Multirate Support	V2V	The DSRC radio subsystem shall comply with the multirate support feature with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-017]
9.19	HCF		
9.19.1	General	V2V	The DSRC radio subsystem shall comply with the HCF general features with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-018]
9.19.2	HCF Contention-Based Channel Access (EDCA)	V2V	The DSRC radio subsystem shall comply with the HCF contention-based channel access (EDCA) features with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-019]
10	MLME		
10.1	Synchronization	V2V	The DSRC radio subsystem shall comply with the MLME synchronization feature with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-020]
10.20	STAs Communicating Data Frames Outside the Context of a BSS	V2V	The DSRC radio subsystem shall comply with the protocol of STAs communicating data frames outside the context of a BSS, with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-021]
18	Orthogonal Frequency Division Multiplexing (OFDM) PHY Specification	V2V	The DSRC radio subsystem shall comply with the orthogonal frequency division multiplexing (OFDM) PHY specification with dot11OCBActivated equal to true, with 10 MHz channel spacing, as specified. [6.1.1-V2V-STD-802.11-022]
Annex C	ASN.1 Encoding of the MAC and PHY MIB	V2V	The DSRC radio subsystem shall include the MIB items used to support OFDM and the features with dot11OCBActivated equal to true, as specified. [6.1.1-V2V-STD-802.11-023]
Annex D	Regulatory References		
Annex D.1	External Regulatory References	V2V	The DSRC radio subsystem shall comply with the United States Federal Communications Commission (FCC) specifications, as specified. [6.1.1-V2V-STD-802.11-024]
Annex D.1	External Regulatory References	V2V	The DSRC radio subsystem shall comply with the behavior limits set for ITS_mobile_operations, as specified. [6.1.1-V2V-STD-802.11-025]
Annex D2.1	Transmit and Receive In-Band and Out-of-Band Spurious Emissions	V2V	The DSRC radio subsystem shall comply with transmit and receive in-band and out-of-band spurious emissions, as specified. [6.1.1-V2V-STD-802.11-026]
Annex D2.2	Transmit Power Levels	V2V	The DSRC radio subsystem shall comply with the transmit power level requirements for STA transmit power classification C, as specified. [6.1.1-V2V-STD-802.11-027]
Annex D2.3	Transmit Spectrum Mask	V2V	The DSRC radio subsystem shall comply with the transmit spectrum mask requirements for 10 MHz channel spacing for STA transmit power classification C, as specified. [6.1.1-V2V-STD-802.11-028]
Annex E	Country Elements and Operating Classes		

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