



SURFACE VEHICLE RECOMMENDED PRACTICE

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Vulnerable Road User Safety Message Minimum Performance Requirements

RATIONALE

According to NHTSA, in 2012 traffic crashes in the United States claimed 4743 pedestrian fatalities and resulted in 76000 pedestrian injuries. NHTSA reports that 726 pedalcyclists were killed and 49000 were injured in traffic crashes. In addition, in 2012, 106 road workers were killed by traffic crashes in the United States. Vehicle-to-Vehicle (V2V) safety systems using Dedicated Short Range Communications (DSRC) have been researched and have been undergoing standardization for more than a decade. In the near future deployments are likely. Leveraging these developments and prospective deployment, research has been conducted using DSRC portable devices to extend the potential safety benefit to Vulnerable Road Users (VRU) such as pedestrians, bicyclists and road workers. In order to achieve interoperability between vehicle-based and portable DSRC safety devices for experimental use, there is a need to establish a VRU safety message minimum performance recommendations to support VRU safety applications.

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1. SCOPE

This document provides recommendations of safety message minimum performance requirements between a Vulnerable Road User (VRU) and a vehicle. It addresses the transmission of Personal Safety Messages (PSM) from road user devices carried by pedestrians, bicycle riders and public safety personnel, to provide driver and vehicle system awareness and potentially offer safety alerts to VRUs.

This document includes the recommendation of standards profiles, function descriptions and minimum performance requirements for transmitting the SAE J2735-defined PSM [1] over a Dedicated Short Range Communications (DSRC) Wireless communication link as defined in the Institute of Electrical and Electronics Engineers (IEEE) 1609 and the IEEE 802.11 Standards [[1]-[5]]. While other wireless media may be used to deliver the PSM, DSRC is explicitly assumed in this document, because of anticipated regulatory ruling in the United States and other countries requiring vehicles to be equipped with a DSRC-based safety system using V2V communication.

This recommended practice is limited at this time to communications between the VRU device carried by walking pedestrians and DSRC equipped vehicles. Later versions may incorporate improvements based on field experience with this recommended practice and may include other provisions for communicating with other DSRC equipped devices, and with other VRUs.

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] SAE J2945/1 On-Board System Requirements for V2V Safety Communications

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.

[3] IEEE Std 802.11™-2016 Standard for LAN/MAN - Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.
<https://standards.ieee.org/findstds/standard/802.11-2016.html>

[4] IEEE Std 1609.2™ 2016 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages.
<https://standards.ieee.org/findstds/standard/1609.2-2016.html>

[5] IEEE Std 1609.3™ 2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services. <http://standards.ieee.org/findstds/standard/1609.3-2016.html>

[6] IEEE Std 1609.4™ 2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-channel Operation. <https://standards.ieee.org/findstds/standard/1609.4-2016.html>

[7] IEEE Std 1609.12™ 2016 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Identifier Allocations. <https://standards.ieee.org/findstds/standard/1609.12-2016.html>

2.2 Related Publications

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

- [8] Federal Communications Commission (FCC) 47 Code of Federal Regulations (CFR) Parts 0, 1, 2, 90 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>, accessed February 16, 2016

Mitigation Strategies for Design

- [9] Objective Tests for Forward Looking Pedestrian Crash Avoidance/Mitigation Systems Final Report, June, 2014, <https://www.nhtsa.gov/DOT/NHTSA/NVS/Public%20Meetings/SAE/2015/2015SAE-Barickman-PCAMupdate.pdf>, accessed December, 2016
- [10] American Association of State Highway and Transportation Officials. A Policy on Geometric Design of Highways and Streets, AASHTO, 2011

3. TERMS AND DEFINITIONS

3.1 Definitions

3.1.1 ROAD USER

Any entity who uses a road, such as a pedestrian, cyclist, a passenger in a motorized vehicle, or a motorist.

3.1.2 VULNERABLE ROAD USER

A road user, who is not occupying a vehicle such as a passenger car, a motorcycle, a public transit vehicle, or a train. Pedestrians, cyclists, children, elderly, disabled people and road workers are particularly vulnerable to serious injury or death when involved in a motor-vehicle-related collision.

3.1.3 VRU DEVICE

A device that transmits Personal Safety Messages as defined in SAE J2735, and optionally is capable of receiving Basic Safety Messages (BSM). The device may be capable of receiving other message types, however it is outside the scope of this document.

3.2 Abbreviations and Acronyms

ASN.1	Abstract Syntax Notation One
BSM	Basic Safety Message
CAMP	Crash Avoidance Metrics Partnership
CAN	Controller Area Network
CFR	Code of Federal Regulations
CRL	Certificate Revocation List
DE	Data Element
DF	Data Frame
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
ECU	Electronic Control Unit
FCC	Federal Communications Commission
FYL	Functional Years Lost
GHz	Gigahertz
GNSS	Global Navigation Satellite System
HSM	Hardware Security Module
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers

kph	Kilometers per hour
MAC	Medium Access Control
MHz	Megahertz
mph	Miles per hour
MPR	Minimum Performance Requirements
NHTSA	National Highway Traffic Safety Administration
NMEA	National Marine Electronics Association
OBE	On Board Equipment
OFDM	Orthogonal Frequency Division Multiplexing
OTA	Over The Air
PCAM	Pedestrian Crash Avoidance/Mitigation
PH	Path History
PHY	Physical Layer
POSTIM	Positioning and Timing
PP	Path Prediction
PSID	Provider Service Identifier
PSM	Personal Safety Message
PSMTX	Personal Safety Message Transmission
RF	Radio Frequency
RFPERF	Radio Frequency Performance Requirements Recommendation
RSE	Roadside Equipment
RV	Remote Vehicle
SCMS	Security Credential Management System
SCMGMT	Security Management
SCPRIV	Security and Privacy
STD	Standards Compliance
3D	Three-Dimensional
T _i	Transmission Interval
Tx	Transmit
V2P	Vehicle to Pedestrian
V2VV _p	Vehicle to Vehicle
VRU	Velocity of VRU
	Vulnerable Road User
V2V	Vehicle-to-Vehicle
WAAS	Wide Area Augmentation System
WAVE	Wireless Access in Vehicular Environments
WGS	World Geodetic System

3.3 Requirement Numbering Convention

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

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

For example, if the requirement number is 6.3.1 VRU-PSMTX-PSMCONT-005, the subsection is 6.3.1, the category is PSM Transmission, the subcategory is PSM Contents, and it is requirement number 5 in the subcategory. Table 1 identifies the sections in this recommended practice 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 Conformance	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			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	SYSTMCOORD
6.3	6.3.1	PSM Transmission	PSMTX	PSM Contents	PSMCONT
	6.3.2			Channel and Data Rate	CHDATARATE
	6.3.3			Transmit Timing	TXTIM
	6.3.4			Minimum Transmission Criterial	MINTX
	6.3.5			Data Element Accuracy	DATAACC
	6.3.6			Data Persistency	DATAPERSIST
6.4				RF Performance Requirements Recommendation	RFPERF
6.5				Security and Privacy Tx	SECPRIV
6.6				Security Management	SECMGMT

4. VRU SAFETY COMMUNICATION CONCEPT OF OPERATION AND SYSTEM DESCRIPTION

4.1 VRU Safety Communication System Overview

VRU safety communications are designed for a personal safety device to broadcast PSMs which can be received by approaching vehicles and other connected devices such as roadside equipment (RSE), to support detection of collision threats and alerting the driver and notifying relevant devices. The PSM includes the VRU's position, speed, heading, and other VRU-specific information. Upon receiving PSMs, vehicles would use the information to detect potential safety threats and take appropriate action, e.g., alert the driver.

VRU communications can enable improved safety system effectiveness by complementing or providing an alternative to the existing in-vehicle pedestrian detection systems. VRU communications can provide 360° awareness at a greater distance than other types of sensors, as well as detecting potential threats to some degree when the VRU is not in direct line of sight with the approaching vehicles. This enables an approaching vehicle and its driver to receive alerts earlier and have more time to take action and avoid conflicts with VRUs.

The VRU devices will need to be able to sign the PSMs before transmitting. The V2V security system requirements described in SAE J2945/1 Section 5.1.3, Section 5.2.2, and Section 6.5.5 are used in this document with supplemental description if different from SAE J2945/1. This document does not make an assumption on whether a hardware security module is required.

A VRU device (the device of interest for this document) typically consists of multiple subsystem components, behaving as an integrated system. Figure 1 illustrates the following subsystems within the VRU device:

- **DSRC Radio** – Supports the transmission of PSMs. Support of BSM receptions is optional. In this document a DSRC radio subsystem is assumed to be a single-channel-at-a-time with channel switching device. The OBE can include one or more DSRC radio subsystems and still comply with this recommended practice.
- **Global Navigation Satellite System (GNSS) receiver** – The positioning subsystem that provides position, heading, speed, and time information. The VRU device may be augmented with additional components, which are not shown in Figure 1.
- **VRU Device Processor** – Executes software to support VRU system requirements including the transmission and optional reception of BSMs; It interfaces with Application subsystem.
- **Application** – Determines the need to transmit PSMs; Optionally, supports the threat assessment based on information from VRU Device processor such as the received BSMs.
- **Antennas** – Supports radio frequency (RF) links for the DSRC radio and GNSS receiver.
- **VRU Data** – Supports collection of VRU device generated data such as input from accelerometers; It interfaces with the VRU Application
- **VRU Device User Interface** – Provides visual, audio and /or haptic alerts triggered by VRU Application; Can be used to configure VRU applications such as the VRU specific information (e.g., VRU user type – bike, pedestrian etc.), and/or VRU assistive types.

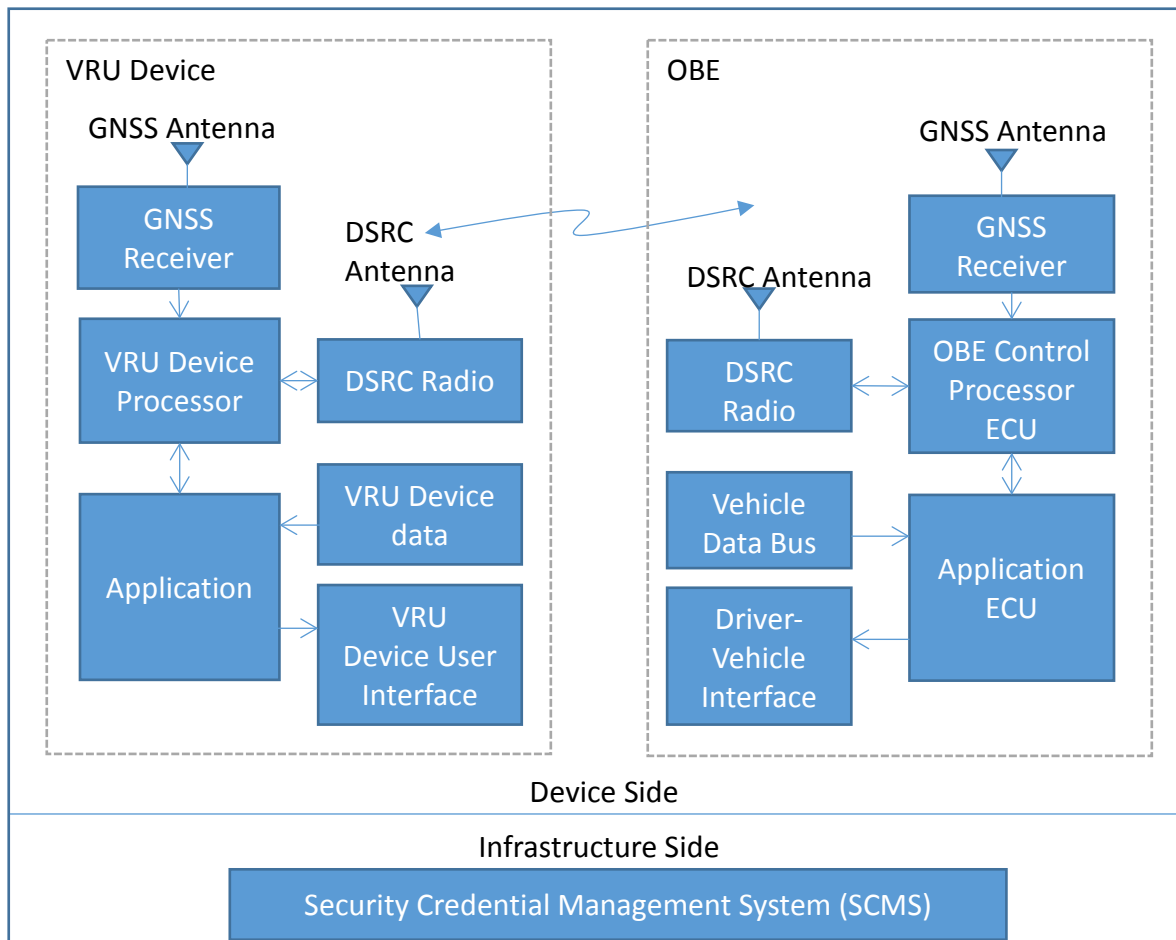


Figure 1 - V2P system