



SURFACE VEHICLE STANDARD

J2945™/1C

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On-Board System Requirements for V2V Safety Communications by School Buses

RATIONALE

The National Transportation Safety Board (NTSB) believes that it remains a safety priority that school buses be included in performance standards for connected vehicle technologies. Given their special operating features, school buses must be uniquely treated.

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1. SCOPE

This document specifies the on-board system requirements for vehicle-to-vehicle (V2V) safety system for school buses, including functional requirements and performance requirements. The system can send the SAE J2735-defined basic safety message (BSM) over a wireless communications interface; the communications interface itself is outside the scope of this document. This document provides the specifications necessary to build interoperable systems that support V2V applications that rely on receiving BSMs from school buses.

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.

SAE J2735® V2X Communications Message Set Dictionary

SAE J2945® Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts™

SAE J2945/C Requirements for Probe Data Collection Applications

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

SAE J2945/1B On-Board System Requirements for V2V Safety Communications by Non-Light-Duty Vehicles and Motorcycles

SAE J3161 LTE Vehicle-to-Everything (LTE-V2X) Deployment Profiles and Radio Parameters for Single Radio Channel Multi-Service Coexistence

SAE J3161/1 On-Board System Requirements for LTE-V2X 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.

IEEE Std 1609.2 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Application and Management Messages

2.1.3 NTCIP Publications

Copies of these documents are available online at <https://www.ntcip.org/document-numbers-and-status/>.

NTCIP 8002 Annex B1 Content Outline for NTCIP 1200-Series Documents (for Standards Engineering Process (SEP) Content)

2.2 Related Publications

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

2.2.1 NHTSA Publications

Available from National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 888-327-4236, www.nhtsa.gov.

NHTSA. (n.d.). *School Bus Safety*. U.S. Department of Transportation. Retrieved February 15, 2024, from www.nhtsa.gov/road-safety/school-bus-safety.

3. DEFINITIONS

For the purposes of this document, the definitions, abbreviations, and acronyms found in SAE J2735 and SAE J2945/1 also apply. In the case of conflict, the following additional definitions, abbreviations, and acronyms supersede those found in SAE J2735. The definitions in SAE J2945 are incorporated by reference.

4. ABBREVIATIONS

The additional abbreviations and acronyms cited below are terms related to this document (and of the other companion volumes and guides), unless specifically cited otherwise.

ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ASN.1	Abstract Syntax Notation One
BSM	Basic Safety Message
CAN	Controller Area Network
CRL	Certificate Revocation List
CVRIA	Connected Vehicle Reference Implementation Architecture
DE	Data Element
DF	Data Frame
DVI	Driver Vehicle Interface
ECU	Electronic Control Unit
FHWA	Federal Highway Administration
FR	Functional Requirement
GNSS	Global Navigation Satellite System
HV	Host Vehicle
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IT	Intelligent Transportation

LTE-V2X	LTE Vehicle-to-Everything
MSG	Message
NRTM	Needs to Requirements Traceability Matrix
NTSB	National Transportation Safety Board
OBE	Onboard Equipment
RF	Radio Frequency
RTM	Requirements Traceability Matrix
RV	Remote Vehicle
SCMS	Security Credential Management System
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything

5. CONCEPT OF OPERATIONS

5.1 Tutorial [Informative]

A concept of operations describes a proposed system from the users' perspective. Typically, a concept of operations is used on a project to ensure that the system developers understand the users' needs. Within the application standards, the concept of operations documents the purpose of each feature for which an application standard supports an application. The concept of operations also serves as the starting point for users to select those features that may be appropriate for a specific application.

The concept of operations starts with a discussion of the current situation and issues that have led to the need to deploy systems within the scope of a standard and to the development of the standard itself. This discussion permits both potential users and system developers to understand the situation.

The concept of operations then documents key aspects of the proposed system, including:

- a. Reference Physical Architecture – The reference physical architecture defines the overall context of the proposed system and defines which specific interfaces are addressed.
- b. Architectural Needs – The architectural needs discuss issues and needs relative to the system architecture.
- c. Features – The features identify and describe the various capabilities the users may want that are not currently covered in other standards. These features are derived from the high-level user needs identified in the problem statement but are refined and organized into a more manageable structure that forms the basis of the traceability tables contained in 6.3.

Architectural needs and features are collectively called user needs. In 6.4 and 6.5, these user needs lead to the definition of the various requirements. Basic systems engineering requires that:

- a. Each user need traces to one or more functional requirement(s), and
- b. Each functional requirement derives from at least one user need.

This traceability is shown in the Needs to Requirements Traceability Matrix (NRTM) in 6.3.3.

SAE J2945/1C is intended to be used for school buses to ensure 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. SAE J2945/1C is a complementary standard document to SAE J2945/1 and SAE J3161/1 and provides additional requirements for school buses transmitting BSMs.

Within the NRTM, each user need and requirement is identified as mandatory, optional, or conditional, and users may complete the NRTM to clearly define unique aspects of their implementation. Within SAE J2945/1C, items marked mandatory are those that relate to the most basic functionality required in meeting the identified user needs. For specific implementations, the user identifies those optional or conditional needs appropriate for a specific implementation.

Each requirement is presented in the Requirements Traceability Matrix (RTM) in Appendix A, which defines how the requirement is fulfilled through the standardized dialogs and data structures described in Sections 7 and 8.

A conformant system may support additional features, as long as it is conformant with the requirements of SAE J2945/1C.

5.2 Current Situation and Problem Statement [Informative]

SAE J2945/1 and SAE J3161/1 address vehicle-safety communications for FHWA classes 2 and 3, while the safety communications needs for FHWA classes 1, and 6 through 13 are covered in SAE J2945/1B. The unique needs of school buses are not covered in any of the current SAE standards. The need to focus on safety of students during the portion of their journey to and from school, and during school activities, necessitates the development of the unique requirements for this category of vehicles. School buses are typically a subset of class 4 vehicles; however, minibuses and some handicap-equipped school buses may use vehicles that are part of class 5 vehicles. Some class 3 vans may also be used as school buses.

SAE J2945/1C is a complementary standard to SAE J3161/1 providing the extra requirements for school buses to transmit BSMs. A school bus transmitting BSMs must comply with both SAE J3161/1 and SAE J2945/1C.

This document specifies the functional and performance requirements for V2V safety communications for school buses. These specifications provide the requirements necessary to build interoperable systems that support V2V safety applications that rely on receiving BSMs from school buses. The system specified in this document can send SAE J2735-defined BSMs over a wireless communications interface; the communications interface itself is outside the scope of this document.

5.3 Reference Architecture

Hereafter in this document, the school bus/Remote Vehicle (RV) sending the required data using BSMs is referred to as “the System,” and a vehicle receiving and acting on BSMs from school buses is referred to as a Host Vehicle (HV), which is consistent with the architecture and terminology adopted by SAE J2945/1 and SAE J3161/1. School buses can also receive BSMs to implement the applications identified in SAE J2945/1 and SAE J3161/1.

NOTE: SAE J2945/1 was originally developed for DSRC, and V2V safety communications was extended to LTE-V2X in SAE J3161/1. While SAE J3161/1 may eventually also contain all requirements originally in SAE J2945/1, both documents are referred herein to for completeness.

Figure 1 illustrates the components of the System and its interfaces, which is based on the reference physical architecture of SAE J3161/1 and SAE J2945/1.

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.

The V2V onboard equipment (OBE), which is the on-board vehicle-to-vehicle safety communications system defined in this document, typically consists of multiple subsystem components which may be discrete or integrated depending on the implementation. The following subsystems components are included:

- V2X Radio Subsystem – Transmits and receives BSMs. The OBE can include one or more radio subsystems.
- 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 positioning using additional information and components, which are not shown in Figure 1. Examples of these are speed data from the Controller Area Network (CAN) bus, dead reckoning sensors, optical camera-based systems, and pivot data.
- OBE Control Processor Electronic Control Unit (ECU) – Executes software that generates BSMs for transmission according to the requirements in this document.
- Antennas – Support radio frequency (RF) links for the V2X radio and GNSS receiver. A second diversity antenna for the V2X Radio Subsystem is recommended to improve performance. GNSS and radio subsystem antennas may be integrated (dual band).

Systems communicate amongst themselves using the V2X 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 haptic alerts. The OBE can also interface with the vehicle CAN bus to obtain vehicle status information. The safety application ECU, CAN bus, and DVI specifications are outside the scope of this document.

NOTE: The Safety Application ECU is anticipated to support interfacing to other sensing systems and use data fusion techniques to implement related applications. Those sensors and the interfaces to them are outside the scope of this document.

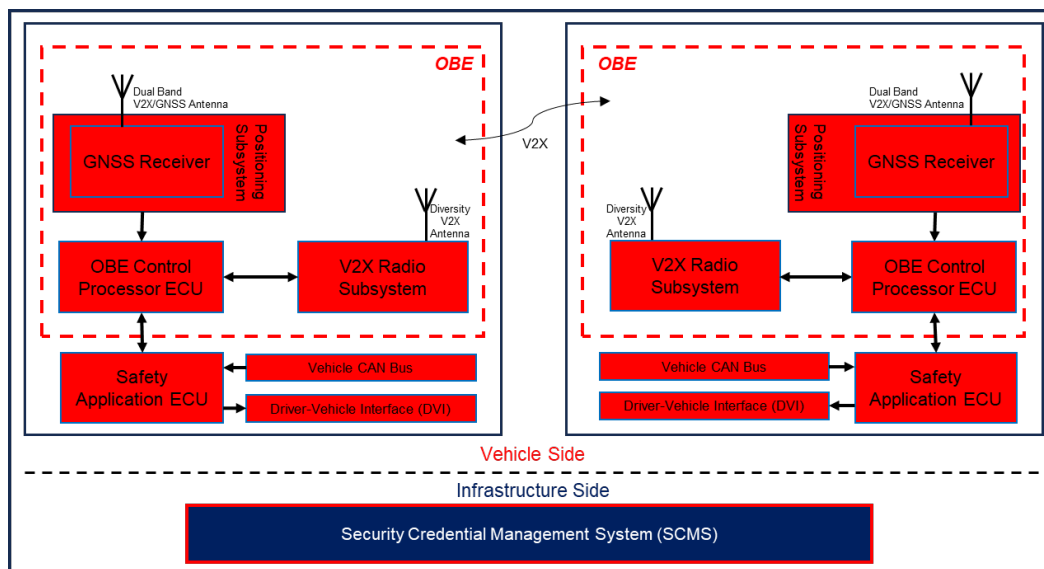


Figure 1 - Reference physical architecture

5.4 Architectural Needs

5.4.1 V2V Communications Interface

Refer to 5.2.1 of SAE J2945/1 for DSRC and SAE J3161/1 for LTE-V2X.

5.4.2 Positioning

Refer to 5.2.3 of SAE J2945/1 and SAE J3161/1.