



SURFACE VEHICLE INFORMATION REPORT

J2945™/8

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Surrogate Basic Safety Messages for Testing and Evaluation Purposes Only

RATIONALE

Evolving ADAS and ADS sensor capabilities can be combined with V2X data exchange capabilities to compensate for penetration rates and coexistence with legacy vehicles initial V2V deployments. This surface vehicle information report provides recommendations for evaluating the capability to send basic safety messages on behalf of unequipped vehicles. The corresponding functional requirements in this document are proposed only for testing purposes.

TABLE OF CONTENTS

1.	SCOPE.....	3
2.	REFERENCES.....	3
2.1	Applicable Documents	3
2.1.1	SAE Publications.....	3
2.1.2	IEEE Publications.....	3
2.1.3	NTCIP Publications	4
3.	DEFINITIONS	4
4.	ABBREVIATIONS	4
5.	CONCEPT OF OPERATIONS	6
5.1	Tutorial [Informative]	6
5.2	Current Situation and Problem Statement [Informative]	7
5.3	Reference Architecture	7
5.4	Architectural Needs.....	9
5.4.1	Communications Interface	9
5.4.2	Positioning.....	9
5.5	Features	9
5.5.1	Nearby Vehicle Detection and Characterization	10
5.5.2	SBSM Transmission Constraints	10
5.6	Security and Privacy	10
5.7	Operational Policies and Constraints	10
5.8	Relationship to ARC-IT [Informative]	10
5.9	Operational Scenarios [Informative].....	10
6.	PROPOSED FUNCTIONAL REQUIREMENTS	11
6.1	Tutorial [Informative]	11
6.2	Scope of the Interface [Informative].....	11
6.3	Needs to Requirements Traceability Matrix (NRTM)	11
6.3.1	Notation [Informative]	11
6.3.2	Instructions for Completing the NRTM [Informative].....	12
6.3.3	Proposed Needs to Requirements Traceability Matrix (NRTM) Table	12

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Documents

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6.4	Proposed Architectural Requirements	14
6.4.1	Communications Requirements	14
6.4.2	Proposed Positioning Requirements	14
6.5	Features	15
6.5.1	SBSM Contents	15
6.5.2	Minimum Transmission Criteria (MINTX) for SBSM	15
6.5.3	Proposed Data Element Accuracy Requirements	17
6.5.4	Limiting SBSM Transmission	20
6.6	Proposed Security and Privacy Requirements	20
6.6.1	Signing and Verification Algorithm	20
6.6.2	SBSM Signature and Certificate Transmission	20
6.6.3	SBSM Verification	20
6.6.4	SCMS	20
6.6.5	Privacy	20
7.	SYSTEM DESIGN	20
7.1	Tutorial	20
7.2	Specified Dialogs	20
8.	ASN.1 ENTITIES	21
9.	NOTES	21
9.1	Revision Indicator	21
APPENDIX A	REQUIREMENTS TRACEABILITY MATRIX (RTM) TABLE	22
APPENDIX B	RECOMMENDATIONS FOR PSIDS AND SECURITY	23
APPENDIX C	APPROACHES TO LIMIT SBSM DUPLICATIONS	24
Figure 1	Reference V2V architecture	8
Figure 2	Alternate architecture for RSE-based SBSM generation	9
Figure 3	SBSM transmission by eHV or RSE	11
Table 1	Conformance symbols	11
Table 2	Support column symbols	12
Table 3	NRTM table	13
Table 4	SBSM part I: Proposed minimum criteria for SBSM transmission	16
Table 5	SBSM part II: Proposed minimum criteria for SBSM transmission	17
Table 6	Preliminary parameter settings for this document	19

1. SCOPE

This document includes the initial recommendations for a V2X-equipped host vehicle (eHV) or Roadside Equipment (RSE) that can broadcast a surrogate basic safety message (SBSM) on behalf of an unequipped remote vehicle (uRV). This document is published for testing only, using a Test PSID (e.g., 0x7f) and not the PSID used by SAE J2945/1 and SAE J3161/1 for standard basic safety message (BSM) transmission (0x20).

The basic principle is that the host system of the V2X capable device, whether on a host vehicle or an RSE, can determine whether detected vehicles are V2X enabled or not, and if not, formulate and broadcast messages on their behalf that describe their status to other V2X enabled devices. This document is based extensively on the V2V safety communication requirements in SAE J2945/1 and SAE J3161/1 and the supporting message set details in SAE J2735.

The initial version of this document is an information report. If feedback from implementations, testing, and simulation becomes available, this report may be updated to a recommended practice or standard. The performance, data quality, and corresponding population of message data fields need more consideration.

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 should 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 J2945/1	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 J2945/9	Vulnerable Road User Safety Message Minimum Performance Requirements
SAE J3067	Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods
SAE J3161/1	Onboard System Requirements for LTE-V2X V2V Safety Communications
SAE J3224	V2X Sensor-Sharing for Cooperative and Automated Driving

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 1609.2	IEEE Standard for Wireless Access in Vehicular Environment - Security Services for Application and Management Messages
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2.1.3 NTCIP Publications

Copies of these documents are available online at <https://www.ntcip.org/>.

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

3. DEFINITIONS

For the purposes of this document, the definitions, abbreviations, and acronyms found in SAE J2735 and SAE J2945/1 apply. Additionally, the following definitions apply.

3.1 EQUIPPED HV (eHV)

A host vehicle capable of detecting unequipped RVs and sending SBSMs on the unequipped vehicle's behalf.

3.2 SURROGATE

One that takes the place of another; a substitute.

3.3 SURROGATE BASIC SAFETY MESSAGE (SBSM)

This information report focuses only on a surrogate BSM service. It is a method for including a BSM message on behalf of an unequipped vehicle.

The SBSM is transmitted by an eHV or RSE on behalf of a uRV. The SBSM has the same format as the BSM defined in SAE J2945/1 and SAE J2735, but with contents that pertain to the uRV as measured by the eHV or RSE.

3.4 UNEQUIPPED RV (uRV)

A remote vehicle that is not capable of sending BSMs.

4. ABBREVIATIONS

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

ACC	automatic cruise control
ADAS	advanced driver assistance systems
AEB	automatic emergency braking
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ASN.1	Abstract Syntax Notation One
BSM	basic safety message
CAN	controller area network
DE	data element
DF	data frame
DSRC	dedicated short range communications
ECU	electronic control unit

eHV	V2X-equipped host vehicle
FHWA	Federal Highway Administration
FYL	functional years lost
GNSS	global navigation satellite system
IEEE	Institute of Electrical and Electronics Engineers
IMA	intersection movement assist
kph	kilometers per hour
LTAP/OD	left turn across path/opposite direction
LTE	long term evolution 4G communications standard
MAC	medium access control
NRTM	needs to requirements traceability matrix
OBE	on-board equipment
PA	parking assist
PH	path history
PHY	physical layer
POSTIM	positioning and timing
PP	path prediction
SBSM	surrogate basic safety message
RF	radio frequency
RSE	roadside equipment
RTM	Requirements Traceability Matrix
SBSM	surrogate BSM
SCMS	security credential management system
SDSM	sensor data sharing message
TPL	transmission persistence level
Tx	transmit
uRV	unequipped remote vehicle
V2V	vehicle to vehicle
V2X	vehicle-to-everything

WAVE	wireless access in vehicular environments
WGS	World Geodetic System
WSMP	WAVE short message protocol

5. CONCEPT OF OPERATIONS

5.1 Tutorial [Informative]

A concept of operations describes a proposed system from the user's perspective. Typically, a concept of operations is used on a project to ensure that the system developers understand the users' needs. 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 document and to the development of the document 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 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 documents. 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 [6.3.3](#).

Architectural needs and features are collectively called user needs. These user needs lead to the definition of the various proposed requirements in [6.4](#) through [6.6](#). Basic systems engineering requires that:

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

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

SAE J2945/8 is intended to be used across vehicles classes defined by the Federal Highway Administration (FHWA) to ensure that the exchange of BSMs (or Surrogate BSMs) in V2V safety communications provides the desired interoperability and data integrity to support the performance of the envisioned safety applications. 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 J2945/8, 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 proposed requirement is presented in the Requirements Traceability Matrix (RTM) in [Appendix A](#), which defines how the requirement is fulfilled through the dialogs and data entities defined in the various sections.

A conformant system may support additional features beyond the proposed requirements of SAE J2945/8.

5.2 Current Situation and Problem Statement [Informative]

Advanced driver assistance systems (ADAS) and driving automation system technologies have developed to the point where many vehicles are now equipped with on-board sensing using visible or infrared cameras, radars, ultrasonic transducers, and lidars to allow for features like Parking Assist (PA), Lane Keeping Assist (LKA), Adaptive Cruise Control (ACC), and Automatic Emergency Braking (AEB). Similarly, the same type of sensors is increasingly being used on the infrastructure side at intersections to detect the presence of vehicles approaching or stopped, as well as other road users within the field-of-view of the sensing systems (for this document, the focus is on surrogate BSMs generated from equipped vehicles and RSE on behalf of unequipped vehicles only). At the same time, transportation and communication engineers have for years been developing V2X technologies to exchange vehicle and system status information among the fleet, generally for safety and/or mobility improvement. This document provides a method to utilize a combination of on-board sensing and cooperative information exchange for enhanced mobility and crash avoidance capability. The fundamental feature and objective of the system and service specified in this document is to describe the use of on-board and roadside sensing to detect vehicles not equipped with a V2X Device Processor equipment, and broadcast what is termed a “surrogate BSM” (hereafter SBSM – Surrogate Basic Safety Message) to inform neighboring V2X equipped vehicles of the presence of such other vehicles that may present collision hazards. This capability can be used to help improve the collective perception of the network of devices and potentially reduce the number and severity of vehicle crashes to improve overall transportation safety.

The basic thesis in this concept, which can be viewed as a form of cooperative perception, is that a new type of message construct is not necessary in supporting the additional situational awareness afforded by including the SBSMs. The SBSMs are very similar to BSMs in their structure but with appropriately modified contents.

5.3 Reference Architecture

[Figure 1](#) illustrates the components of the V2V system and its interfaces, which is based on the reference physical architecture of SAE J3161/1 and SAE J2945/1.

- V2X Radio Subsystem: Supports the transmission and reception of BSMs and SBSMs.
- Positioning Subsystem: Provides position, heading, speed, and time information for the equipped Host Vehicle (eHV). The positioning subsystem may be augmented with additional components, for example, dead reckoning sensors, optical/camera-based systems, etc.
- On-Board Equipment (OBE) Control Processor Subsystem: Executes software to support functionality including the transmission and reception of BSMs and SBSMs; it interfaces with the Safety Application Processor Subsystem.
- Safety Application Processor Subsystem: Estimates the dynamic parameters of the unequipped vehicle detected by the Perception Sensor Data Module within the Safety Application electronic control unit (ECU) and determines the need to transmit SBSMs.
- Global Navigation Satellite System (GNSS) Radio Antenna Subsystem: Supports radio frequency (RF) link for the GNSS receiver.
- V2X Radio Antenna Subsystem: Supports RF links for the V2X radio.
- On-Board Sensor Subsystem: Collects sensor device generated data such as that input from one or more environmental perception sensors, e.g., on-board camera, radar, ultrasonic transducer, and lidar elements that define the dynamic description of detected non-V2X vehicles.
- An Infrastructure-Based Security Credential Management System (SCMS): 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.

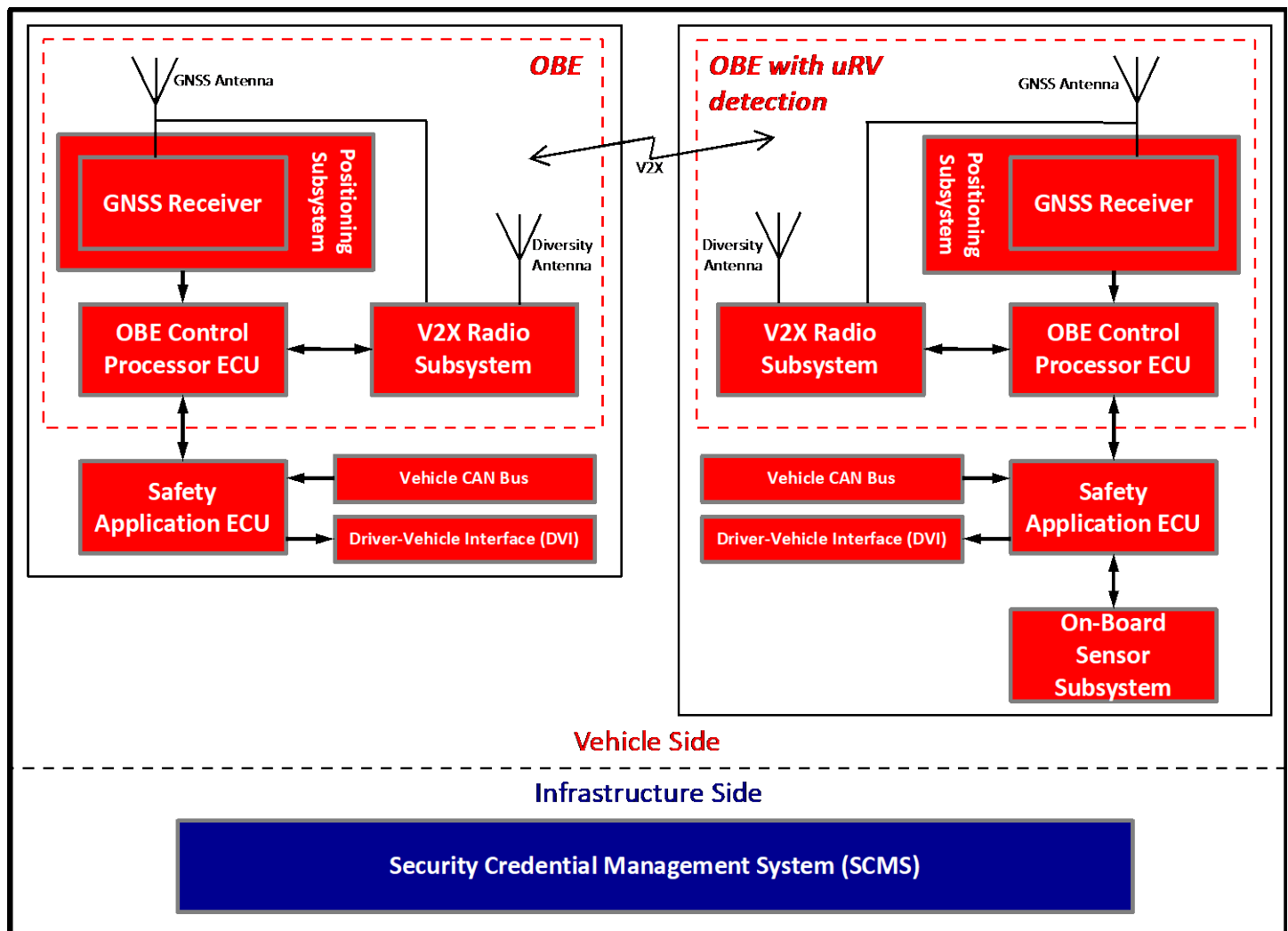


Figure 1 - Reference V2V architecture

The SBSM service specified in this document is proposed to perform the same functions that define BSM use cases in SAE J2945/1, 4.2. SBSMs are BSMs that are generated by a combination of the Host OBE Control Processor Subsystem, Positioning Subsystem, and the Safety Application Processor Subsystem, which determines the need and feasibility of transmitting an SBSM. The SBSM contains an array of information including positioning reference, relative range, azimuth and elevation, or relative x, y measurements from on-board perception sensors, detected vehicle type, and description of its dynamics, along with indications of confidence in those measurements.

Figure 2 illustrates the corresponding reference architecture when the RSE performs the functions of the host vehicle for the detection of the unequipped vehicle, and the formulation and transmission of the SBSM. If an RSE is capable of generating SBSMs, the same proposed requirements that apply to SBSM-capable vehicles can be applied by to RSE. The RSE has similar components as the OBE, without the vehicle-specific subsystem interfaces.