



SURFACE VEHICLE STANDARD

J3315™

OCT2025

Issued

2025-10

LTE-V2X Requirements and Deployment Profile for Aftermarket V2X Devices

RATIONALE

SAE J3161/1 defines onboard requirements and profile for a V2V safety solution applicable to light-duty and emergency vehicles, and SAE J3161 defines a radio profile for V2V, V2I, and I2V communications in the 20-MHz channel between 5905 and 5925 MHz (LTE band 47 using EARFCN 55140). However, Aftermarket V2X Devices (AVDs) might not be compliant with the requirements defined in SAE J3161/1. AVDs as specified in this standard include different classes and capabilities, and they need to be differentiated from SAE J3161/1-compliant onboard devices with respect to data confidence, RF performance, and security services. This distinction is crucial because Basic Safety Messages (BSMs) from AVDs may have lower accuracy regarding the vehicle's state. By providing a framework for AVD deployment and enhancing interoperability, this standard plays a pivotal role in increasing the LTE-V2X penetration and furthering the adaptation of advanced safety technologies on our roads.

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	Purpose.....	3
2.	REFERENCES.....	3
2.1	Applicable Documents	3
2.1.1	SAE Publications.....	3
2.2	IEEE Publications.....	4
3.	DEFINITIONS	4
4.	ABBREVIATIONS	5
5.	CONCEPT OF OPERATIONS AND LTE-V2X SYSTEM ARCHITECTURE	6
5.1	LTE-V2X System Architecture	7
5.1.1	Common Design Elements for LTE-V2X Communication	7
5.1.2	LTE-V2X Functionality	7
5.2	Reference System Architecture	7
5.3	Security Credential Management System.....	8
5.4	Architecture Needs.....	8
5.4.1	Device to Device Communication Interface.....	8
5.4.2	Device to SCMS Communication Interface.....	9
5.4.3	Device to Positioning Subsystem Interface.....	9
5.5	Feature User Needs.....	9
5.6	Current Situation and Problem Statement	9

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2025 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 1-877-606-7323 (U.S. and Canada only)
Tel: 1-724-776-4970 (outside U.S. and Canada)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J3315_202510

For more information on this standard, visit https://www.sae.org/standards/content/J3315_202510/

Documents

Standard, visit Sharing Hub

5.7	Different Categories of AVDs	9
5.7.1	Ultralight AVD	9
5.7.2	Light AVD	10
5.7.3	Pro AVD	10
5.7.4	Applications	10
6.	REQUIREMENTS FOR AFTERMARKET V2X DEVICES	12
6.1	Requirements for Ultralight AVDs	13
6.1.1	Positioning Requirements	13
6.1.2	RF Requirements	13
6.1.3	Vehicle Data Access	14
6.2	Requirements for Light AVDs	14
6.2.1	Positioning Requirements	14
6.2.2	RF Requirements	15
6.2.3	Vehicle Data Access	15
6.3	Requirements for Pro AVDs	15
6.3.1	Positioning Requirements	16
6.3.2	RF Requirements	16
6.3.3	Vehicle Data Access	16
6.3.4	Trained Installation Requirements	16
6.4	Variable Vehicle Parameters	17
6.5	BSM Requirements	18
6.6	Radio Profile and Communication Interface	21
6.7	Summary of AVD Categories	21
6.8	Security and Privacy Guidance	22
6.8.1	Background	22
6.8.2	Example Security and Privacy Requirements	22
7.	NOTES	23
7.1	Revision Indicator	23
Annex A	REQUESTED CHANGE TO SAE J2735 FOR ASN.1 REPRESENTATION OF DATA ELEMENTS avdDoesNotMeetJ3161_1 and avdConfirmedInstallation	24
Figure 1	Reference physical architecture	8
Table 1	Example applications by different AVD classes	11
Table 2	List of modified SAE J3161/1 requirements for different class of AVDs	19
Table 3	Summary of AVD categories	21

1. SCOPE

This SAE Standard describes classes of Aftermarket V2X Devices (AVDs) intended to support particular services, provides their respective requirements (including RF performance requirements), and specifies their radio profiles. This document is targeted to enable near- and long-term deployments by supporting different classes of AVDs that could interact with other onboard units (OBUs) and roadside units (RSUs). Users of this document include manufacturers of vehicles and micro-mobility conveyances, developers of hardware and applications, as well as those interested in LTE-V2X system architecture, testing, and certification.

NOTE: This document does not cover product packaging or environmental criteria related to AVDs, as these topics are outside the scope of this standard.

1.1 Purpose

This SAE Standard defines the requirements for AVDs with various classes and capabilities. This standard differentiates AVDs from SAE J3161/1-compliant onboard devices by specifying their unique requirements, including RF performance and positioning accuracy, and provides security guidance. It also provides guidance on the deployment and interoperability of AVDs, such that they can effectively interact with factory-installed OBUs and RSUs. By establishing these requirements, the standard promotes deployment of AVDs, enhances vehicle safety communication systems, and supports the broader adoption of LTE-V2X technology.

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 (U.S. and Canada only) or +1 724-776-4970 (outside U.S. and Canada), www.sae.org.

SAE J2735	V2X Communications Message Set Dictionary
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 J2945/1C	On-Board System Requirements for V2V Safety Communications by School Buses
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
SAE J3217	V2X-Based Fee Collection

2.2 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 Environments - Security Services for Application and Management Messages
- IEEE 1609.2.1 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Certificate Management Interface for End Entities
- IEEE 1609.3 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

3. DEFINITIONS

Definitions unique to this document are included in Section 3. Refer also to 3.1 of SAE J3161/1.

3.1 AFTERMARKET V2X DEVICE (AVD)

An AVD is an LTE-V2X device that is installed in a vehicle post-production to enable Vehicle-to-Everything (V2X) communication. AVDs can vary in their capabilities and installation complexity, ranging from simple plug-and-play units to more sophisticated systems requiring trained installation. The categorization depends on both the inherent capabilities of the AVD and the capabilities provided by the installation process.

3.2 COMMUNICATION RANGE

Communication range is the maximum distance over which an LTE-V2X device can achieve packet error rates less than 10%. This range can be influenced by the device's transmission power, antenna characteristics, and environmental factors such as obstacles and interference.

3.3 HOST VEHICLE

The primary equipped vehicle of concern that is running a specific application about which a given use case may be constructed. The Host Vehicle (HV) can be a transmitting vehicle, a receiving vehicle, or both. This distinction is made clear in the use case description. There is typically only one HV in any use case.

3.4 LTE-V2X

LTE-V2X (long-term evolution vehicle-to-everything) is a communication technology defined by the 3GPP Release 14 specification. It includes both the PC5 interface for direct communication (V2V, V2I, V2P) and the Uu interface for network-based communication (V2N).

NOTE: The focus of this standard is the direct communication using the PC5 interface.

3.5 ONBOARD UNIT (OBU)

An LTE-V2X device installed in a vehicle that is used to transmit and receive message traffic to and from other LTE-V2X devices. This includes factory-installed OBUs and aftermarket-installed OBUs.

NOTE 1: In this document, aftermarket-installed OBUs are referred to as AVDs.

NOTE 2: In this document it is assumed that factory-installed OBUs are installed by trained personnel and compliant with SAE J3161/1, SAE J2945/1B, or SAE J2945/1C depending on vehicle class.

3.6 POSITIONING ACCURACY

Positioning accuracy refers to the degree of closeness of the measured position of a vehicle to its true position. As defined in SAE J3161/1, it is expressed as the radius of a circle within which a certain percentage (e.g., 50% of the position readings fall).

3.7 REMOTE VEHICLE (RV)

The equipped vehicle (or vehicles) that plays supporting roles in the use case by interacting with the HV in some way. Each RV can be a transmitting vehicle, receiving vehicle, or both. This distinction is made clear in the use case description. There is typically more than one RV in any use case.

3.8 RF PERFORMANCE

RF performance encompasses the overall effectiveness of a V2X device's radio configuration and frequency components, including its ability to transmit and receive signals. In this document, key aspects of RF performance include TX signal strength and receiver sensitivity.

NOTE: V2X integrated or external antenna coverage requirements are not in the scope of this document.

3.9 ROADSIDE UNIT (RSU)

A device designed to communicate with LTE-V2X-equipped vehicles' OBUs and Vulnerable Road Users (VRUs). The RSU transmits from a fixed position on the roadside. Some RSUs have the ability to transmit signals with greater power than OBUs transmit, and some may have connectivity to other RSUs or to the Internet and to other network nodes such as traffic management centers, data servers, or cloud services.

3.10 TRAINED PERSONNEL

A trained personnel is an individual with expertise in vehicle electronics and V2X communication systems. Trained personnel have the expertise to connect the AVD to the vehicle's internal power system and possibly vehicle data interface (such as CAN or automotive Ethernet) and to configure the AVD according to the vehicle width and length, antenna offsets, and other device-specific settings. In the case of Pro AVD installations, trained personnel are responsible for compliance with all the requirements specified in SAE J3161/1.

3.11 USER EQUIPMENT (UE)

UE refers to any device used by an end user for LTE-V2X communication with other devices.

3.12 V2X

In the context of this document, V2X refers to vehicular communication using LTE-V2X PC5 sidelink technology.

3.13 VEHICLE DATA INTERFACE

An interface that enables the data exchange between OBU/AVD and vehicle data.

4. ABBREVIATIONS

AVD	Aftermarket V2X Device
BSM	Basic Safety Message
CRL	Certificate Revocation List
DVI	Driver-Vehicle Interface
DAI	Driver-AVD Interface
ECU	Electronic Control Unit
GNSS	Global Navigation Satellite System
HV	Host Vehicle

LTE	Long-Term Evolution
OBUE	Onboard Unit
PC5	ProSe Communications 5
RF	Radio Frequency
RSU	Roadside Unit
RTCM	Radio Technical Commission for Maritime Services
RV	Remote Vehicle
SCMS	Security Credential Management System
UE	User Equipment
V2I	Vehicle-to-Infrastructure
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VDI	Vehicle Data Interface
WAVE	Wireless Access in Vehicular Environments
WSA	WAVE Service Advertisement
WSM	WAVE Short Message
WSMP	WAVE Short Message Protocol

5. CONCEPT OF OPERATIONS AND LTE-V2X SYSTEM ARCHITECTURE

The concept of operations for direct LTE-V2X revolves around the use of PC5 sidelink communication mode, which allows direct V2X communication between devices without the need for a cellular network. V2X communication can enable information exchange between vehicles and other devices and includes Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Network (V2N), and Vehicle-to-Pedestrian (V2P). To enable V2V, V2I, and V2N communication, vehicles must be equipped with an LTE-V2X radio. This integration can occur either during vehicle production by the manufacturer or by installing an LTE-V2X device after the vehicle has been manufactured.

An AVD is a device that is not integrated at the factory but is typically installed after the vehicle has been manufactured in order to enable direct V2X communication. AVDs can be categorized by different classes based on their capabilities and the quality of their installation. The categorization depends on both the inherent capabilities of the AVD and the capabilities provided by the installation process. These devices play a crucial role in enhancing the uptake of the direct V2X communication system (PC5 sidelink) and contribute significantly to the deployment of safety applications on our roads. The PC5 sidelink communication mode can be used with several variants of AVDs, from non-integrated devices that might not have "lane-level positioning accuracy" to devices installed by trained personnel with extensive integration that meet the same SAE J3161/1 requirements as factory-installed OBUs.

NOTE 1: In this document it is assumed that factory-installed OBUs are installed by trained personnel and compliant with SAE J3161/1, SAE J2945/1B, or SAE J2945/1C depending on the vehicle class.

NOTE 2: Throughout this document, the term “lane-level positioning accuracy” refers to the positioning accuracy as defined in SAE J3161/1, which provides lane-level accuracy in open sky conditions. No accuracy requirements are specified for non-open sky conditions.

SAE J3161/1 outlines the onboard system requirements and radio and security profiles for a V2V safety solution. Additionally, SAE J3161 defines a radio profile for V2V, V2I, and I2V communication in the 5905 and 5925 MHz band, corresponding to LTE band 47 using EARFCN 55140. To complement these LTE-V2X standards and boost the network effect with higher market penetration, this document standardizes requirements for three classes of AVDs and their minimum performance capabilities.

5.1 LTE-V2X System Architecture

Refer to 5.3 of SAE J3161.

5.1.1 Common Design Elements for LTE-V2X Communication

Refer to Section 6 of SAE J3161 for common design elements and definition of LTE-V2X protocol stack.

5.1.2 LTE-V2X Functionality

Refer to Section 7 of SAE J3161 for functional descriptions of the physical layer, channel access procedure, sidelink synchronization, and unicast addressing.

5.2 Reference System Architecture

This section provides a comprehensive overview of the LTE-V2X communication ecosystem, which includes AVDs, factory-installed OBUs, and RSUs. While the primary focus of this report is on AVDs, it is essential to understand their interaction with factory-installed OBUs and RSUs to enable seamless communication and interoperability within the LTE-V2X system. These details are crucial for understanding how AVDs fit into the broader V2X communication framework and how they interact with other components to support various applications and services.

[Figure 1](#) depicts the elements of V2V, V2I, and I2V communication using the AVD. An AVD can establish communication with other AVDs, factory-installed OBUs, and RSUs. The factory-installed OBU, AVD, and RSU specified in this standard typically comprise various subsystem components, which can be either separate or integrated based on the specific implementation:

- PC5 radio subsystem: Transmits and receives V2X messages.¹ The factory-installed OBU, RSU, and AVD can include one or more LTE-V2X radio subsystems.
- Timing and 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 that are not shown in [Figure 1](#). Examples of these are speed data from the CAN bus, dead-reckoning sensors, and optical/camera-based systems.

NOTE 1: The time information in the GNSS signal is used for synchronization in the PC5 radio subsystem.

NOTE 2: In places where GNSS signal is not available, the Sidelink Synchronization Signal (SLSS) can be used for synchronization in the PC5 radio subsystem. AVDs are required to be SLSS-compatible² or SLSS-aware³ to enable communication with other OBUs and RSUs. It is important to note that an RSU needs to be available to transmit the SLSS for synchronization.

¹ The term “V2X messages” is used in a general sense to refer to messages exchanged over PC5 interface. It is not intended to specify a particular message type (e.g., WSM, WSA, or IP-based messages) or to indicate whether the messages are signed or unsigned.

² SLSS-compatible means that the LTE-V2X radio is not only configured with SLSS parameters but is also capable of detecting, decoding, and using the SLSS for time synchronization.

³ SLSS-aware means that the LTE-V2X radio is configured with SLSS parameters but may not be capable of detecting or decoding the SLSS signal. It is logically aligned with the SLSS configuration (e.g., subframe indexing) but does not rely on SLSS for synchronization.

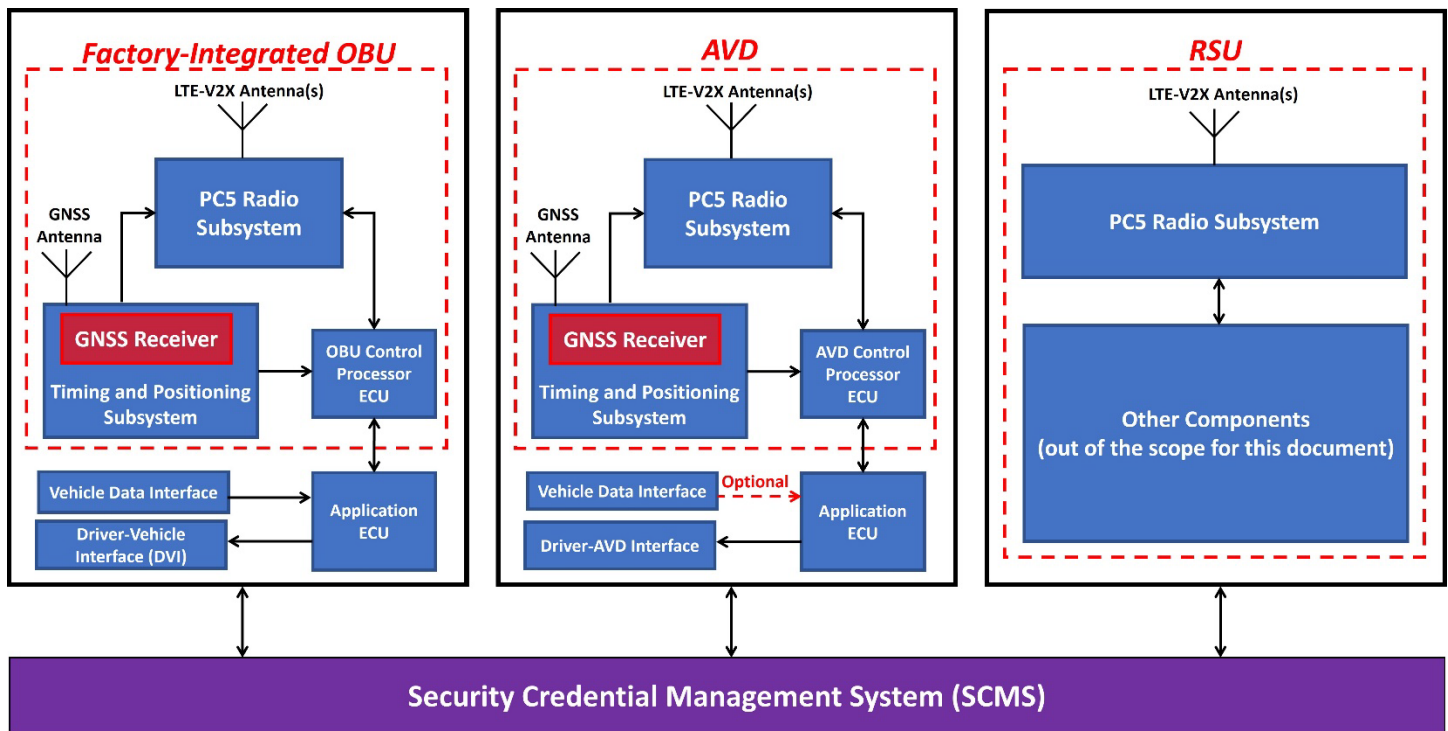


Figure 1 - Reference physical architecture

- Control processor electronic control unit (ECU): A hardware component that executes software which generates V2X messages for transmission or interprets the V2X messages from other UEs.
- Antennas: It supports Radio Frequency (RF) links for the PC5 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 into the module as long as the necessary isolation is maintained.

The factory-installed OBU, RSU, and AVD systems communicate amongst themselves using the PC5 radio subsystem as an interface. Each system can interface to an application ECU that interprets the received V2X messages. The application ECU can interface with the driver through a Driver-Vehicle Interface (DVI) or Driver-AVD Interface (DAI). The DVI or DAI can provide visual, audio, and/or haptic alerts. The factory-installed OBU or AVD can also interface with the Vehicle Data Interface (VDI) bus to obtain the vehicle's state information. The application ECU, DVI, DAI, and VDI are outside the scope of this standard.

5.3 Security Credential Management System

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 supporting or participating systems.

5.4 Architecture Needs

This section provides detailed architecture needs.

5.4.1 Device to Device Communication Interface

Each device interfaces with other devices by transmitting and receiving V2X messages. Non-IP V2X messages are typically transmitted over the LTE-V2X interface as a Wireless Access in Vehicular Environments (WAVE) Short Message (WSM) using the WAVE short message protocol (WSMP) specified in IEEE 1609.3 without the IEEE 802.3 ethernet.