FINAL
DRAFT

TECHNICAL
REPORT

ISO/DTR 17716

ISO/TC **22**/SC **32**

Secretariat: **JISC**

Voting begins on:
2023-10-30

Voting terminates on:
2023-12-25

Road vehicles — Electrical disturbances from narrowband radiated electromagnetic energy — Radiated immunity for V2X

Véhicules routiers - Perturbations électriques dues à l'énergie électromagnétique rayonnée en bande étroite - Immunité rayonnée pour V2X

Reference number
ISO/DTR 17716:2023(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

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Introduction

V2X (Vehicle-to-Everything), including DSRC (Dedicated Short-Range Communication) and C-V2X (Cellular Vehicle-to-Everything), is one of the most popular automated driving technologies applied in vehicles.

Immunity of components and vehicles equipped with V2X communication is very important, which can help to avoid unreasonable degradation of automated driving from electromagnetic interference. For the test purpose, it is very difficult to simulate V2X operation during the immunity test.

The purpose of this document is to describe the background of V2X operating conditions and information on the V2X simulation in the laboratory during the immunity test.

Road vehicles — Electrical disturbances from narrowband radiated electromagnetic energy — Radiated immunity for V2X

1 Scope

This document describes the introduction of radiated immunity testing for the components and vehicles equipped with V2X communications. The link communication connection and V2X scenario simulation are considered to make the V2X functions and their communications operate normally during the immunity testing. Examples of monitoring are also discussed to show the electromagnetic interference reactions of the device with V2X under test. In addition, test hints are described to provide information on radiated immunity for V2X. The technical specifications are not in the scope of this document.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 General

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.2 Abbreviated terms

For the purposes of the present document, the following abbreviations apply:

ALSE	Absorber Lined Shielded Enclosure
BSM	Basic Safety Message
BSS	Basic Service Set
CAL	Communication Adaptation Layer
CALM	Communications Access for Land Mobiles
CAM	Cooperative Awareness Message
C-V2X	Cellular Vehicle-to-Everything
C2C	Car-to-Car
C2I	Car-to-Infrastructure
C2P	Car-to-Pedestrian

C2N	Car-to-Network
DCC	Distributed Congestion Control
DUT	Device Under Test
DSRC	Dedicated Short-Range Communication
EEBL	Emergency Electronic Brake Lights
FCW	Forward Collision Warning
FEC	Forward Error Correction
GNSS	Global Navigation Satellite System
HV	Host Vehicle
IMA	Intersection Movement Assist
ITS	Intelligent Transport System
LCW	Lane Change Warning
LTA	Left Turn Assistance
LTE	Long Term Evolution
MAE	Management Adaptation Entity
MIIT	Ministry of Industry and Information Technology
NCAP	New Car Assessment Program
OBU	On-Board Unit
PC5	ProSe Communication reference point 5
PER	Packet Error Ratio
RAN	Radio Access Network
RSSI	Received Signal Strength Indicator
RSU	Road-Side Unit
RV	Remote Vehicle
RWW	Road Works Warning
WAVE	Wireless Access in Vehicular Environments
V2X	Vehicle-to-Everything
V2V	Vehicle-to-Vehicle
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2N	Vehicle-to-Network

4 Overview of V2X

4.1 V2X description

V2X can be considered a wireless environment sensing sensor, which allows vehicles to share information through communication channels. It can detect hidden threats and expand the sensing range of automated vehicle. There are many advanced applications such as vehicle platooning, remote driving and cooperative automated valet parking system where V2X communication is essential. V2X has the potential to inform the ego-vehicle about the status of a traffic light or other vehicles, weather conditions, crashes on the road and construction on the road, especially during severe weather conditions and in complex traffic scenarios. V2X contains V2V, V2I, V2P and V2N as shown in the following.

— vehicle to vehicle (V2V) communications (same as car-to-car (C2C));

— vehicle to infrastructure (V2I) communications (same as car-to-infrastructure (C2I));

— vehicle to pedestrian (V2P) communications (same as car-to-pedestrian (C2P));

— vehicle to network (V2N) communications (same as car-to-network (C2N)).

V2X contains positioning technology and wireless communication technology. Two major wireless communication technologies can support V2X applications, namely DSRC and C-V2X. DSRC was published by the 802.11p group of IEEE in 2010. C-V2X was first introduced at World Telecommunication Day Conference in 2013 and published in 3GPP in 2017.

C-V2X communications contain three communication interfaces:

— PC5 communications interface;

— cellular communications interface (LTE, NR).

Examples of general structure description of V2X on-board unit are shown in Figure 1.

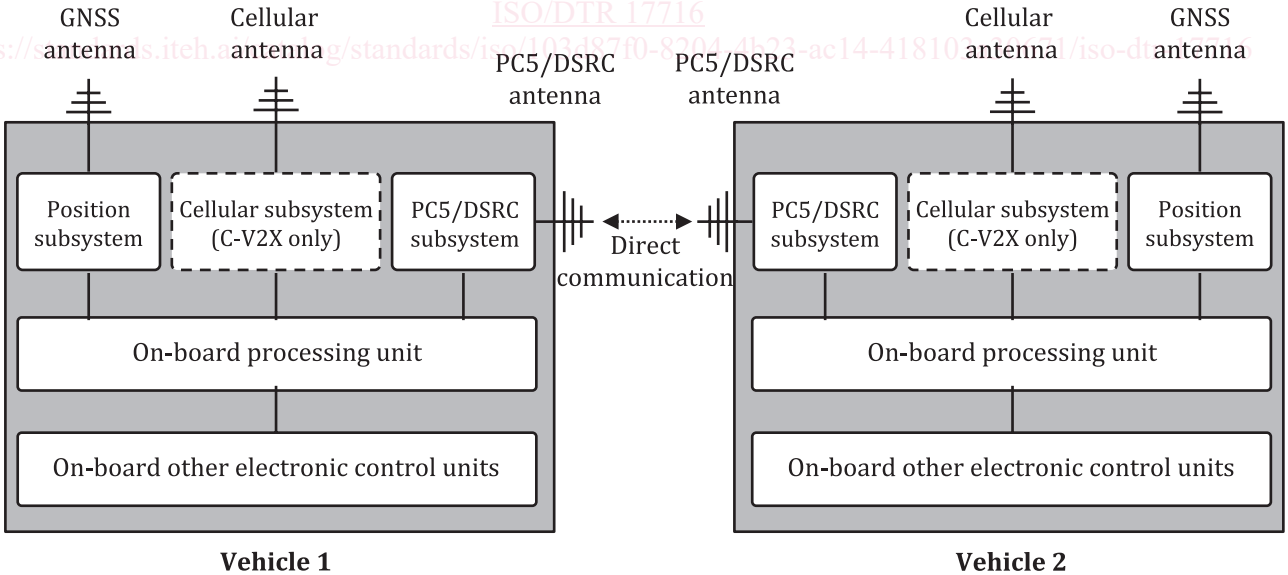

Figure 1 — General structure description of V2X on-board unit

List of reference documents:

— IEEE 802.11p (2010): IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments

— 3GPP TR 37.985 V16.0.0 (2020): Overall description of Radio Access Network (RAN) aspects for Vehicle-to-everything (V2X) based on LTE and NR

4.2 Industry trends

V2X has been equipped in lots of production cars (see Table 1).

Table 1 — V2X in production cars

NO.	Vehicle model	Ford	GAC GROUP	Buick	FAW	SAIC	Audi	GWM
		Edge Plus	AION V	GL8 Avenir	E-HS9	Marvel R	A7L	WEY
1	Forward collision warning				√			√
2	Intersection collision warning		√	√	√	√		√
3	Left turn assist					√		√
4	Blind spot warning/ lane change warning				√			√
5	Do not pass warning		√					√
6	Emergency brake warning			√	√			√
7	Abnormal vehicle warning			√				√
8	Hazardous location warning			√		√		√
9	Control loss warning			√				√
10	Speed limit warning			√	√	√		√
11	Red light violation warning	√		√		√	√	√
12	Vulnerable road user collision warning		√			√	√	√
13	Green light optimal speed advisory	√		√	√	√		√
14	In-vehicle signage					√		√
15	Traffic jam warning					√		√
16	Emergency vehicle warning						√	√

4.3 Legislation and standards

4.3.1 ISO/TR 4804 - Automated driving systems safety

Automated driving systems safety design is described in ISO/TR 4804. That document describes steps for developing and validating automated driving systems based on basic safety principles derived from worldwide applicable publications. It considers safety-by-design and cybersecurity-by-design, as well as verification and validation methods for automated driving systems, focused on vehicles with level 3 and level 4 features according to SAE J3016.

ISO/TR 4804 automated driving systems description is shown in Figure 2.

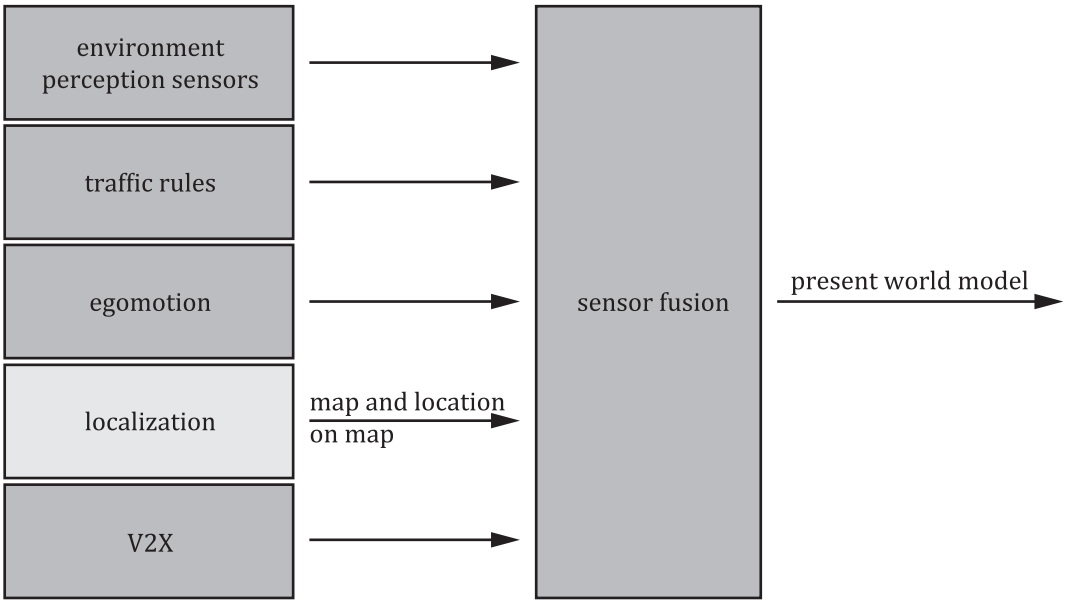

Figure 2 — ISO/TR 4804 automated driving systems description

All entities that an automated driving system requires to account for its functional behaviour are perceived, pre-processed and provided safely. The highest priority is placed on entities with the highest associated risk of collision. Example entities include dynamic instances (e.g. other road users and characteristics of the respective movement), static instances (e.g. road boundaries, traffic guidance signals) and obstacles exceeding a critical size. Localization and V2X information are two of the main elements used to generate the present world model.

4.3.2 ISO 22737 – Low-speed automated driving (LSAD) systems

The safe operation of low-speed automated driving (LSAD) systems is described in ISO 22737, where V2N technique is applied. The LSAD system periodically provides its status (e.g. system health, trip status) to the user and the dispatcher/control server. The selected predefined route and emergency stop can be provided by the dispatcher/control centre with communication.

ISO 22737 LSAD system description is shown in Figure 3.

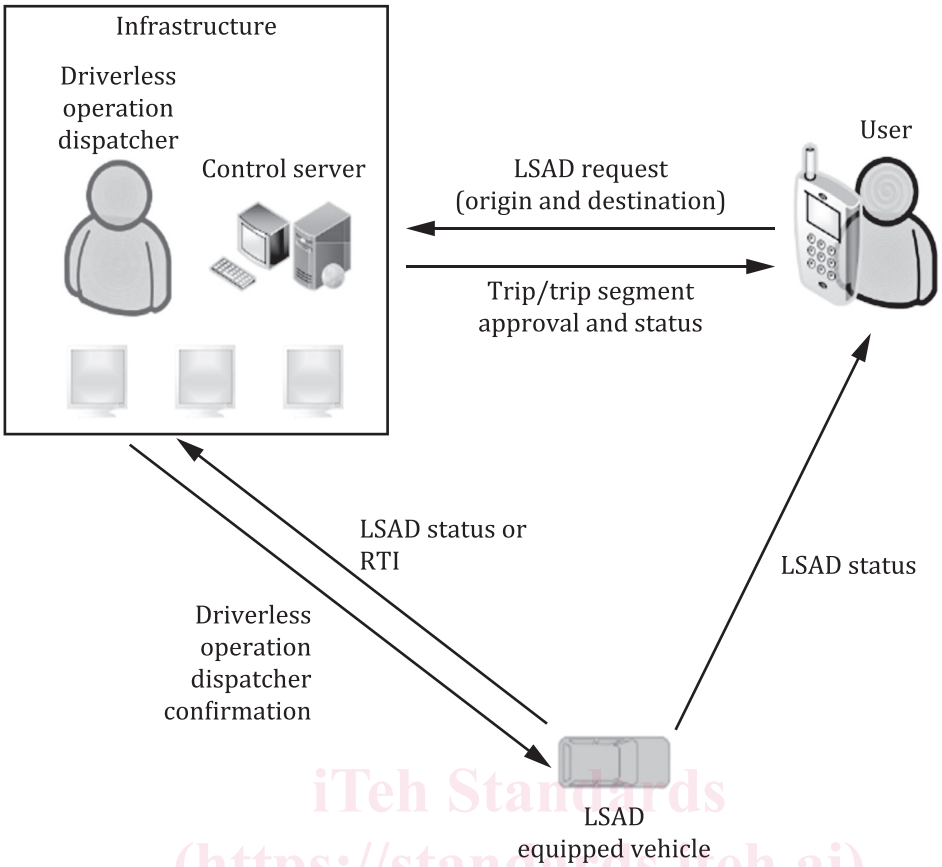

Figure 3 — ISO 22737 LSAD system description

Examples of LSAD communication messages are shown in Table 2.

Table 2 — Examples for LSAD communication messages

Data	Description	Transmit (T) / Receive (R)		Minimum frequency
		Vehicle driven by the LSAD system	Dispatcher	
Vehicle ID	Vehicle unique identifier (at any point in time)	T	R	1 Hz
LSAD system state	LSAD off/standby/ active (DDT, MRC, e-stop, MRM)	T	R	1 Hz
Dispatcher authentication	Trip/rip segment approval by dispatcher to confirm status of the LSAD system	R	T	At start of trip/trip segment or when the LSAD system has applied e-stop
LSAD system maximum operating speed	Selection of top speed ODD parameter based on the dispatcher's or system's evaluation of the LSAD system's ODD and other external factors (e.g. weather, scheduled construction, …)	R	T	At start of trip/trip segment or when the LSAD system has applied e-stop
LSAD system speed		T	R	1 Hz

Table 2 *(continued)*

Data	Description	Transmit (T) / Receive (R)		Minimum frequency
		Vehicle driven by the LSAD system	Dispatcher	
Vehicle driven by the LSAD system heading		T	R	1 Hz
LSAD system position		T	R	1 Hz

4.3.3 ISO 17515-3 – Intelligent transport systems – LTE-V2X

ISO 17515-3 LTE-V2X layer is shown in Figure 4.

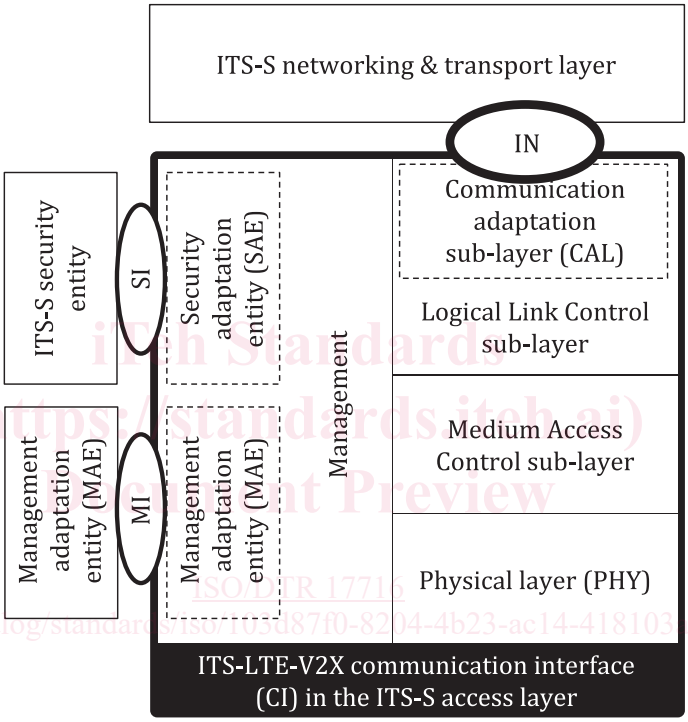

Figure 4 — ISO 17515-3 LTE-V2X Layer

ISO 17515-3 enables usage of the LTE-V2X technology as an ITS access technology in an ITS station by reference to respective specifications from 3GPP, and by specifying details of the communication adaptation layer (CAL) and the management adaptation entity (MAE) of communication interfaces specified in ISO 21218.

4.3.4 List of other ISO standards

ISO 26684:2015 Intelligent transport systems (ITS) — Cooperative intersection signal information and violation warning systems (CIWS) — Performance requirements and test procedures

ISO/TS 17425:2016 Intelligent transport systems — Cooperative systems — Data exchange specification for in-vehicle presentation of external road and traffic related data

ISO/TS 17429:2017 Intelligent transport systems — Cooperative ITS — ITS station facilities for the transfer of information between ITS stations

ISO/TS 19091:2019 Intelligent transport systems — Cooperative ITS — Using V2I and I2V communications for applications related to signalized intersections

ISO 20035:2019 Intelligent transport systems — Cooperative adaptive cruise control systems (CACC) — Performance requirements and test procedures

ISO 23376:2021Intelligent transport systems — Vehicle-to-vehicle intersection collision warning systems (VVICW) — Performance requirements and test procedures

4.3.5 ITU-R related standard

ITU-R released a recommendation M.2084 on the V2X topic in 2019, in which several radio interface standards of V2V and V2I communications for ITS applications are identified. M.2084 is radio interface standards of V2V and V2I two-way communications for ITS applications.

4.4 Technical characteristics of V2X

This information is provided in Annex A.

5 Introduction of radiated immunity testing for components with V2X

5.1 General

V2X immunity is essential, as it can help avoid the unreasonable degradation of automated driving due to electromagnetic interference. However, conventional standards lack the communication link to verify the immunity of components with V2X.

5.2 Introduction of link communication connection

Link antennas or transmit/receive (Tx/Rx) links with global navigation satellite system (GNSS), cellular (Uu link), and proximity communication at 5,9 GHz/dedicated short-range communication (PC5/DSRC) are considered to activate the V2X communication operation. In this link communication connection, test signals at the input of receivers can be set according to the ETSI EN 301 489 series.

For the DUT with distributed antenna, the conducted link with an optical fibre or coaxial cable can be used between the simulators and the DUT, where the conducted interface is applied only to one port of the DUT. Based on varied factors, there are two kinds of layouts for reference.

a) If the antenna is seen as the DUT's load simulator, the wiring harness between the antenna and DUT can be considered as the test harness parallel to the front edge of the ground plane.

b) If the antenna and its wiring harness are seen as another separate DUT, the wiring harness between the antenna and DUT cannot be tested perpendicular to the front edge of the ground plane.

For the DUT with an integrated antenna, the over-the-air interface with link antennas for GNSS, BSM (PC5 link), or cellular (Uu link, if necessary, in C-V2X) signal can be used.

For the DUT with distributed multiple input and multiple output (MIMO) antennas to increase the radio frequency (RF) performance, the over-the-air interface can also be used.

In the over-the-air layout, link antennas can be positioned at sufficient distances to avoid mutual coupling. This over-the-air interface can be similar to vehicle levels in a telecommunication environment.

5.3 Communication indicators for monitoring

Examples of monitoring indicators for the malfunction description are as follows.

Core data frame of BSM (part 1), as defined by technical standards (see A.4).

— Msg count, GNSS (latitude, longitude), speed, header, etc.