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TECHNICAL REPORT

**Intelligent Transport Systems (ITS);
Pre-standardization study on ITS architecture;
Part 2: Interoperability among heterogeneous
ITS systems and backward compatibility**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

The present document is part 2 of a multi-part deliverable covering the Intelligent Transport Systems (ITS); Pre-standardization study on ITS architecture, as identified below:

Part 1:   "Architecture for communications among ITS stations with multiple access layer technologies";

Part 2:   "Interoperability among heterogeneous ITS systems and backward compatibility".

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

There are a number of candidate wireless communications technologies to address ITS requirements, including ITS-G5, IEEE 802.11bd™ [i.24], LTE-V2X PC5, NR-V2X, mmWave, mobile cellular systems (Uu-Interface), etc. The available band, such as the 5,9 GHz ITS band, could be occupied by several distinct ITS technologies, and those technologies are likely to operate simultaneous at the same time and location. It is thus needed to clarify the inherent challenges in this situation and discover possible solutions to overcome the challenges.

1 Scope

The present document presents the results of the investigation for achieving interoperability and backward compatibility, two principles of ITS Directive [i.2], when implementing the ITS architecture with multiple communication interfaces according to the existing ETSI ITS specifications. The present document elaborates the definitions of interoperability and backward compatibility.

The requirements for functional safety according to ISO 26262 [i.12] and IEC 61508 [i.13], as well as privacy and security requirements are not addressed in detail in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] M/453 (6th October 2009) Standardication Mandate addressed to CEN, CENELEC and ETSI in the field of information and communication technologies to support the interoperability of co-operative systems for intelligent transport in the European Community.

[i.2] Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport.

[i.3] Commission Decision 2008/671/EC of 5 August 2008 on the harmonised use of radio spectrum in the 5875 - 5905 MHz frequency band for safety-related applications of Intelligent Transport Systems (ITS) (notified under document number C(2008) 4145).

[i.4] CEPT/ECC Decision (08)01: "The harmonised use of the 5875-5925 MHz frequency band for Intelligent Transport Systems (ITS)", approved 14 March 2008, Amended 3 July 2015.

[i.5] ETSI TS 136 300: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300)".

[i.6] ETSI EN 302 663: "Intelligent Transport Systems (ITS); ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.7] ETSI TR 102 962: "Intelligent Transport Systems (ITS); Framework for Public Mobile Networks in Cooperative ITS (C-ITS)".

[i.8] ETSI TS 103 613: "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems using LTE Vehicle to everything communication in the 5,9 GHz frequency band".

[i.9]   ETSI TS 123 401 (V10.5.0): "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401 version 10.5.0 Release 10)".

[i.10]   ETSI TS 125 300: "Universal Mobile Telecommunications System (UMTS); Universal Terrestrial Radio Access Network (UTRAN); General description; Stage 2 (3GPP TS 25.300)".

[i.11]   ETSI TS 138 300: "5G; NR; Overall description; Stage-2 (3GPP TS 38.300)".

[i.12]   ISO 26262: "Road vehicles -- Functional safety".

[i.13]   IEC 61508: "Functional safety of electrical/electronic/programmable electronic safety-related systems".

[i.14]   ETSI EN 302 665: "Intelligent Transport Systems (ITS); Communications Architecture".

[i.15]   EC COM(2016) 766 final (30th November 2016): "Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the committee of the regions -- A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility".

[i.16]   European Commission C-ITS Platform reports I, January 2016.

NOTE: Available at https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf.

[i.17]   European Commission C-ITS Platform reports II, September 2017.

NOTE: Available at https://ec.europa.eu/transport/sites/transport/files/2017-09-c-its-platform-final-report.pdf.

[i.18]   ETSI TS 101 539-1 (V1.1.1): "Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification".

[i.19]   ETSI TS 101 539-2 (V1.1.1): "Intelligent Transport Systems (ITS); V2X Applications; Part 2: Intersection Collision Risk Warning (ICRW) application requirements specification".

[i.20]   ETSI TS 101 539-3 (V1.1.1): "Intelligent Transport Systems (ITS); V2X Applications; Part 3: Longitudinal Collision Risk Warning (LCRW) application requirements specification".

[i.21]   Bijlsma, Tjerk & Hendriks, T & Vissers, J & Elshof, L & Jansen, T & Krosse, B. (2016): "In-Vehicle Architectures for Truck Platooning: The Challenges to reach SAE Automation Level 3".

[i.22]   Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.23]   Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code.

[i.24]   Description of IEEE 802.11bd[TM], C2C Journal page 21ff.

NOTE: Available at https://www.car-2-car.org/fileadmin/downloads/PDFs/car-2-car-journal/Journal_23_C2C-CC_Oct_2019_web.pdf.

[i.25]   IEEE 802.11[TM]-2016: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks-Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

3   Definition of terms, symbols and abbreviations

3.1   Terms

For the purposes of the present document, the terms given in ETSI EN 302 665 [i.14], ETSI EN 302 663 [i.6] and ETSI TS 103 613 [i.8] apply.

3.2   Symbols

Void.

3.3   Abbreviations

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

3GPP	3rd Generation Partnership Project
5G	5th generation of cellular mobile communications
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CENELEC	Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardization)
DTC	Duplicated transmission via cellular interface
GW	GateWay
IBC	Infrastructure Based Conversion
ITS	Intelligent Transportation System
ITS-G5	Access layer technology

NOTE: As defined in ETSI EN 302 663 [i.6].

ITS-S	ITS Station
LTE	Long Term Evolution
LTE-V2X	Long Term Evolution based Vehicle-to-Everything

NOTE: As defined in ETSI TS 103 613 [i.8].

MAC	Media Access Control
MEC	Multi-access Edge Computing
MTA	Multiple technologies for all ITS-Ss
MTL	Multiple technologies for later deployed ITS-Ss
MTL-DT	Multiple technologies and duplicated transmission for later deployed ITS-Ss
NGV	Next Generation V2X
NR	New Radio
PC5	Proximity-based Communication (Interface) 5
V2N	Vehicle-to-Network
V2X	Vehicle-to-Everything

4   Challenges in a heterogeneous ITS environment

There are a number of candidate wireless communications technologies to address ITS requirements, including in particular 3GPP LTE-V2X (Releases 14 and 15) specified in ETSI TS 103 613 [i.8], ITS-G5 specified in ETSI EN 302 663 [i.6], and 3GPP cellular technologies specified in ETSI TS 125 300 [i.10], ETSI TS 136 300 [i.5], ETSI TS 138 300 [i.11] and ETSI TR 102 962 [i.7] for short and long-range communications. Furthermore, it is expected that communication standards evolve; for example, 3GPP has a work item on an evolution of the existing LTE-V2X solution towards 5G New Radio (NR) technology, which aims to comprise a new system design, including a new access layer and aims to support interoperability and backward compatibility on system level with the existing LTE-V2X systems. Also, IEEE is developing IEEE 802.11bd [i.24] which aims to provide a next generation V2X access layer that aims to be interoperable and backward compatible with the existing ITS-G5 (IEEE 802.11p [i.25] - based access layer) on system level and radio access technology level.

Since it is possible that distinct short-range access layer technologies may be operated in the 5,9 GHz ITS band at the same time and location, interoperability and backward compatibility are addressed in the present document.

Other challenges, e.g. coexistence of different short-range communication technologies and potential architecture enhancement for ITS-Ss with multiple access layer technologies, are addressed by other work within ETSI.

5 Regulatory environment

To guide the investigation of interoperability and backward compatibility on utilizing multiple access layer technologies for Cooperative ITS, the related regulatory environments are summarized in this clause. The ITS Directive 2010/40/EU [i.2] is the umbrella legislation for ITS services. M/453 [i.1] was subsequently adopted to ensure that the addressed standardization bodies are taking their role in developing the standards. Those standards provide a basis for the effective provision of Cooperative ITS priority services.

The interoperability and backward compatibility aspects for heterogeneous communication systems are considered based on the definitions of interoperability and backward compatibility in the ITS Directive 2010/40/EU [i.2]. With regards to the regulatory framework, at least the following additional regulations and reports exist:

- COM(2016) 766 [i.15].

- European Commission C-ITS Platform reports I [i.16] and II [i.17].

- European spectrum regulation, EC Decision 2008/671/EC [i.3], Directive 2014/53/EU [i.22] and Directive (EU) 2018/1972 [i.23].

6 Interoperability

6.1 Context

Multiple ITS access layer technologies have been developed independently of each other or are currently in development, e.g. ITS-G5 specified in ETSI EN 302 663 [i.6], LTE-V2X specified in ETSI TS 103 613 [i.8], and cellular technologies specified in ETSI TS 125 300 [i.10] for 3G, ETSI TS 136 300 [i.5] for 4G and ETSI TS 138 300 [i.11] for 5G. Some access layer technologies for ITS services are fundamentally different and thus not interoperable at the physical and MAC layers. For example, an LTE-V2X PC5 radio is not able to process ITS-G5 signals nor vice versa. However, interoperability of C-ITS services between devices using different access layer technologies might be supported via other means such as those described in subsequent clauses of the present document.

NOTE: Some other access layer technologies in development aim to be interoperable and backward compatible with each other, for example IEEE 802.11p [i.25] access technology and its evolvement IEEE 802.11bd [i.24].

6.2 Definition

The Article 4 in the Directive 2010/40/EU [i.2] defines interoperability as follows:

- **interoperability:** capacity of systems and the underlying business processes to exchange data and to share information and knowledge.

The Annex II in the Directive 2010/40/EU [i.2] provides a related principle and definition as follows:

- **deliver interoperability:** ensure that systems and the underlying business processes have the capacity to exchange data and to share information and knowledge to enable effective ITS service delivery.

7 Backward Compatibility

7.1 Context

As various short-range ITS access technologies designed to operate in the 5,9 GHz ITS band as well as long-range cellular technologies supporting ITS applications have been developed and are continuing to evolve, it is important to consider how a new iteration of a technology can operate with previous iterations of that technology. In practice, this often leads to the following approach that earlier generation features are maintained by later generation equipment; however, later generation equipment include additional innovations, services and features.

NOTE: Where updates of existing equipment are needed to obtain backward compatibility it should be noted that updates in the field, when possible, might imply recalls for ITS equipment where a 100 % update rate would be unrealistic to guarantee.

7.2 Definition

The article 4 in the Directive 2010/40/EU [i.2] defines compatibility as follows:

- **compatibility:** general ability of a device or system to work with another device or system without modification.

The Annex II in the Directive 2010/40/EU [i.2] defines the support of backward compatibility as follows:

- **support backward compatibility:** ensure, where appropriate, the capability for ITS systems to work with existing systems that share a common purpose, without hindering the development of new technologies.

NOTE: Incumbent technologies are not considered here and are treated according to frequency regulation.

8 Implementation options

8.1 Context

The context and terminology explanation for the interoperability and backward compatibility have been introduced in previous clauses. The objective of clause 8 is to introduce candidate solutions, which allow vehicular wireless communications equipment of distinct short-range communication technologies interact with each other.

The background of 5,9 GHz ITS band is described in clause 8.2, the evaluation criteria used to evaluate implementation options are listed in clause 8.3, and the baseline implementation options which do not take into account the interoperability and backward compatibility are described in clause 8.4 for the purpose of comparison. The implementation options supporting interoperability are described in clause 8.5, and those supporting interoperability and backward compatibility are described in clause 8.6.

NOTE 1: For technologies which support interoperability and backward compatibility via their access layer design, the implementation options providing interoperability and backward compatibility via higher layer design described in clauses 8.5 and 8.6 are not needed.

Coexistence of access layer technologies is out of scope of the present document. Co-channel and adjacent channel coexistence between the two existing C-ITS technologies are covered by other work in ETSI. For the scope of the present document, it is assumed that different technologies use separate channels, but coexistence studies may overcome this assumption.

NOTE 2: It is essential to know how long products equipped with ITS-Ss will be supported. For vehicles it is typical for 10 years after end of production. For a typical vehicle model, typical development time is 3-5 years, production time is 5-8 years and lifetime is more than 10 years with guaranteed support. In contrast, the typical lifetime of consumer communication equipment is 2-3 years.