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Urban Rail ITS and Road ITS applications in the 5,9 GHz band; Investigations for the shared use of spectrum

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Railway Telecommunications (RT).

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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Executive summary

The present document is in response to CEPT's invitation to ETSI to develop sharing and interference mitigation techniques within three years, to ensure co-channel coexistence in the frequency range 5875 MHz to 5925 MHz between Road ITS and Urban Rail radio technologies. It was initiated through the RSC (RSCOM17-26 rev.3 (Final) [i.41]) with the wherein the following recommendation was made:

- *"Mitigation techniques developed through ETSI standardization should be accompanied by technical conditions for spectrum access and relevant harmonised standards, in a technology neutral approach."*

CEPT Report 71 [i.12] proposed that technical solutions already deployed should remain available for maintenance and evolution and the continued rollout of these systems should not be unduly hindered by a change of the spectrum regulatory environment.

The present document proposes methods to allow sharing of Road ITS and Urban Rail in the frequency range 5 915 MHz to 5925 MHz where Urban Rail's priority is respected. Urban Rail intents to use the spectrum from 5875 MHz to 5 915 MHz within closed tunnels where interference with Road ITS services is not expected to be an issue. The regulatory basis for this usage needs to be defined but is outside the scope of the present document. Usage of this spectrum outside of tunnels is not considered in the present document. However, it may be addressed in the future.

The sharing techniques described in the present document should be extendable to other "aggressor" or "victim" channels and bandwidths, if needed, to protect CBTC systems.

The present document proposes:

- Methods to compute the zones where Urban Rail and Road Intelligent Transportation Systems are likely to interfere, based on the outcome of the measurement campaign.
- Principles governing the sharing solution and outline the design of the technical infrastructure allowing Road ITS equipped vehicles to have access to up to date sharing information.
- Appropriate mitigation features to be implemented. These are Restricted Modes of Operations (RMOs) that Road ITS equipped vehicles would activate to avoid interfering with Urban Rail ITS.

It is recommended that:

- a new Technical Specification (ETSI TS 103 745 [i.47]) be developed to address detection and mitigation techniques outlined in the present document; and
- the regulatory and normative frameworks be subsequently updated to enable the use of the 5 915 MHz to 5 925 MHz by Road ITS subject to the implementation of the selected sharing solution.

Introduction

Modern mass-transit Urban Rail systems run trains at short intervals - often 90 seconds apart, sometimes even less. To enable this in complete safety, automatic train control systems are employed, which drive the train, continuously supervise train speed and enforce safe separation between trains.

These systems require continuous, bidirectional data transmission from track to trains, for which radio has been increasingly used over the past fifteen years. Frequencies above 5 905 MHz are used based on national authorizations in several countries (see Annex 1, Table 2b in CEPT Report 71 [i.12]) with proprietary radio technologies and protocols. These radio-based systems are known as Communications Based Train Control (CBTC) systems.

In the context of extensive use of the spectrum, and to enable Public Transport Operators to modernize existing systems and to plan new lines with CBTC, the need for a designated harmonised bandwidth for CBTC, with suitable quality of service, has been expressed in the ETSI TR 103 111 [i.17].

Later, ETSI TR 103 442 [i.10] was developed to present to the ECC a common point of view between TC ITS and TC RT, regarding sharing possibilities between CBTC and Road ITS applications in the 5 875 MHz to 5 925 MHz frequency band. CEPT WGFM invited ETSI to provide a detailed and agreed technical standard allowing practical implementation of both Urban Rail and Road ITS applications in the 5 875 MHz to 5 925 MHz band.

At EU level, the RSCOM mandated an ITS study [i.41] for the extension of the upper edge of the EC harmonised safety-related ITS band (5 875 MHz to 5 905 MHz) by 20 MHz up to 5 925 MHz and allowing Urban Rail (using Communication Based Train Control, (CBTC)) to use the EC harmonised safety-related ITS band. Its outcome is CEPT Report 71 [i.12]. The RSCOM states, that it is important to note that the potential spectrum expansion is not intended to support segmentation and segregation between technologies and applications within the same band and thus to compensate for any cases of inefficient spectrum use.

CEPT Report 71 [i.12] also mentioned the fact that technical solutions already deployed should remain available for maintenance and evolution and the continued rollout of these systems should not be unduly hindered by a change of the spectrum regulatory environment.

CEPT Report 71 [i.12] responds to that mandate, inviting the European Commission to take into consideration the following improvements in the regulatory framework for ITS: "*The restriction to road transportation system should be withdrawn and should encompass all ground-based land transportation systems including Urban Rail*".

CEPT invited ETSI to develop sharing and interference mitigation techniques with a reasonable timeframe (no more than 3 years), to ensure co-channel coexistence in the frequency range 5 875 MHz to 5 925 MHz between Road ITS and Urban Rail applications, and between Road ITS radio technologies, considering the following from CEPT 71 report:

- *"the frequency band 5875-5925 MHz is designated for all safety-related ITS applications (Road ITS and Urban Rail ITS);*
- *the frequency band 5925-5935 MHz is designated for safety-related Urban Rail ITS applications.*
- *define priority to Road ITS applications below 5915 MHz and to Urban Rail ITS applications above 5915 MHz, so that protection is afforded to the application having priority;".*

CEPT Report 71 [i.12] also mentioned the fact that technical solutions already deployed should stay available for maintenance and evolution and the continued rollout of these systems should not be unduly hindered by a change of the spectrum regulatory environment.

The current frequency allocation is summarized in Figure 1.

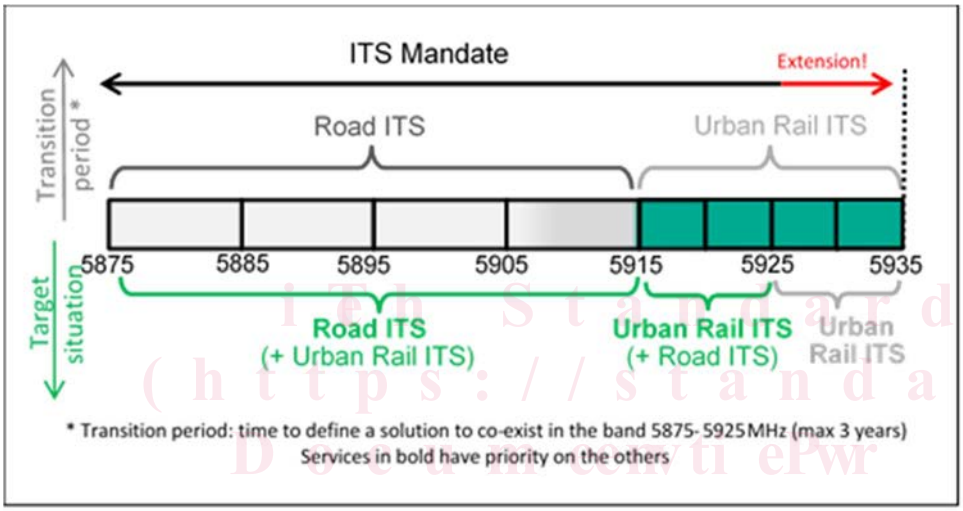

Figure 1: Road ITS and Urban Rail ITS bands

Sharing mechanisms will be specified in a subsequent technical specification which is anticipated to be referenced in a harmonised standard. Indeed, equipment being made available on the market has to be in conformity with the RED, especially article 3.2, and a harmonised standard will have to describe all conditions for the conformity especially with article 3.2. If the manufacturer declares conformity using a notified body the same condition requirements would apply.

The essential requirement according to RED article 3.2. is that radio equipment is constructed so that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

1 Scope

The present document proposes methods to ensure co-channel coexistence in the frequency range 5 915 MHz to 5 925 MHz where Urban Rail is the priority application.

In the present document, tramways are considered to be Road ITS because they are not segregated from road or pedestrian traffic.

NOTE: In the present document, no specific sharing methods for the operation of Urban Rail equipment in the bands, where Road ITS has priority, are considered given that Urban Rail equipment is not operating in these bands in areas where ITS equipment needs protection.

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 regarding a particular subject area.

[i.1] ETSI TS 102 792: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range".

[i.2] ETSI EN 302 637-2 (V1.4.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[i.3] ETSI TS 102 894-2 (V1.3.1): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".

[i.4] Void.

[i.5] ETSI EN 302 637-3 (V1.2.2): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[i.6] ETSI EN 302 663 (V1.2.1): "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.7] Void.

[i.8] Void.

[i.9] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".

[i.10] ETSI TR 103 442 (V1.1.1): "Railways Telecommunications (RT); Shared use of spectrum between Communication Based Train Control (CBTC) and ITS applications".

[i.11] Void.

[i.12] CEPT Report 71: "Report from CEPT to the European Commission in response to the Mandate to study the extension of the Intelligent Transport Systems (ITS) safety-related band at 5.9 GHz".

[i.13] IEEE 1474.1™-2004: "Communications-Based Train Control (CBTC) Performance and Functional Requirements".

[i.14] IEC 62290.1 (2014): "Railway applications - Urban guided transport management and command/control systems - Part 1: System principles and fundamental concepts".

[i.15] IEEE 802.11™-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".

[i.16] ETSI EN 301 893 (V2.1.1): "5 GHz RLAN Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.17] ETSI TR 103 111 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Spectrum requirements for Urban Rail Systems in the 5,9 GHz range".

[i.18] Void.

[i.19] Void.

[i.20] Void.

[i.21] Void.

[i.22] ETSI EN 302 931 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition".

[i.23] Void.

[i.24] Void.

[i.25] EN 50128: "Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems" (produced by CENELEC).

[i.26] EN 50129: "Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling" (produced by CENELEC).

[i.27] Void.

[i.28] Void.

[i.29] ISO 3166-1: "Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes".

[i.30] ISO 26262 (all parts): "Road vehicles -- Functional safety".

[i.31] IEC 62132-1:2015: "Integrated circuits - Measurement of electromagnetic immunity - Part 1: General conditions and definitions".

[i.32] ETSI TS 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats".

[i.33] ETSI TS 103 301: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services".

[i.34] Void.

[i.35] AEC - Q100: "Failure Mechanism Based Stress Test Qualification For Integrated Circuits".

[i.36] SAE J2735: "Dedicated Short Range Communications (DSRC) Message Set Dictionary™".

[i.37] Void.

[i.38] 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 Text with EEA relevance.

[i.39] Brussels, 13.3.2019 C (2019) 1789 final ANNEX 3 to the Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the deployment and operational use of cooperative intelligent transport systems.

[i.40] ETSI TR 103 704 (V1.1.1): "Urban Rail ITS and Road ITS applications in the 5,9 GHz band; Measurement campaign to confirm simulation parameters to define Urban Rail ITS protected zones in 5 915 MHz to 5 925 MHz".

[i.41] RSCOM17-26 rev.3 (Final) Brussels, 18 October 2017 DG CONNECT/B4: "Opinion of the RSC pursuant to Advisory Procedure under Article 4 of Regulation 182/2011/EU and Article 4.2 of Radio Spectrum Decision 676/2002/EC - Subject: Mandate to CEPT to study the extension of the Intelligent Transport Systems (ITS) safety-related band at 5.9 GHz".

[i.42] Car 2 Car consortium report: "Survey on ITS-G5 CAM statistics", December 2018.

[i.43] Commission Implementing Decision (EU) 2020/1426 of 7 October 2020 on the harmonised use of radio spectrum in the 5 875-5 935 MHz frequency band for safety-related applications of intelligent transport systems (ITS) and repealing Decision 2008/671/EC.

[i.44] Commission Implementing Decision (EU) 2019/1345 of 2 August 2019 amending Decision 2006/771/EC updating harmonized technical conditions in the area of radio spectrum use for short-range devices.

[i.45] ETSI EN 303 867: "Rail telecommunications (RT); Urban rail radiocommunications equipment operating in the 5 875 MHz to 5 935 MHz frequency band; Harmonised Standard for access to radio spectrum".

[i.46] ETSI TR 103 853: "System Reference document (SRdoc); Road ITS equipment operating in the 5,9 GHz band with channel bandwidths larger than 10 MHz".

[i.47] ETSI TS 103 745: "Urban Rail ITS and Road ITS applications in the 5855-5925 MHz frequency band; Requirements for the shared use of spectrum".

[i.48] Next Generation V2X - IEEE 8 02.11bd™ as fully backward compatible evolution of IEEE 802.11p - CAR 2 CAR Communication Consortium - 2023-02-02.

[i.49] C-ITS Point of Contact (CPOC) Protocol in the EU C-ITS Security Credential Management System (EU CCMS) - Release 3.0 January 2024.

[i.50] ECC/DEC/(08)01 of 14 March 2008 on the harmonised use of Safety-Related Intelligent Transport Systems (ITS) in the 5875-5935 MHz frequency band, latest updated on 18 November 2022.

[i.51] ETSI EN 302 571 (V2.1.1): "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

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

5 GHz ITS frequency band: band from 5 875 MHz to 5 935 MHz

Communications-Based Train Control (CBTC): Automatic Train Control (ATC) system using radio for train to wayside data communications

NOTE: The general functional requirements of CBTC systems have been standardized by the IEEE in IEEE 1474.1 [i.13], and by the IEC standard 62290.1 [i.14], which give the following definition:

- A CBTC system is a continuous, automatic Communication-Based Train Control system utilizing:
  - high-resolution train location determination, independent of track circuits;
  - continuous, high-capacity, bidirectional train-to-wayside data communications; and
  - train borne and wayside processors capable of implementing Automatic Train Protection (ATP) functions, as well as optional Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) functions.

road ITS: ITS systems based on vehicle-to-vehicle, vehicle-to-infrastructure and infrastructure-to-infrastructure communications for the exchange of information between road vehicles and their environment

NOTE: In the present document Road ITS includes all kinds of ground based ITS except Urban Rail ITS systems.

road ITS station: station transmitting in the 5 GHz ITS frequency band, as defined in ETSI EN 302 665 [i.9]

static detection method: method used by a Road ITS station to detect that it is in a geographical area where Urban Rail protection is requested, even if there is no train in the area and therefore no actual need to mitigate

Urban Rail: public transport system permanently guided at least by one rail, intended for the operation of local, urban and suburban passenger services with self-propelled vehicles and segregated from general road and pedestrian traffic

Urban Rail ITS: Urban Rail system controlled by a CBTC application with communications operating in the 5 GHz ITS frequency band

NOTE: Trams are not included in this definition.

Urban Rail station: Urban Rail device transmitting CBTC messages in the 5 GHz ITS frequency band

vehicle: all types of land mobile device

3.2 Symbols

Void.

3.3 Abbreviations

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

ACK	ACKnowledgment
AP	Access Point
API	Application Programming Interface
ASECAP	Association Européenne des Concessionnaires d'Autoroutes et d'Ouvrages à Péage (European Association of Operators of Road Tolling Infrastructure)
ASIL	Automotive Safety Integrity Level
ASN	Abstract Syntax Notation
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
BS	Base Station
BSS	Basic Service Set
CABS	Cooperative Awareness Basic Service
CAM	Cooperative Awareness Message
CAS	Cooperative Awareness basic Service
CBTC	Communications-Based Train Control

CBTC BS	Communications-Based Train Control Base Station
CCH	Control Channel
CDD	Common Data Dictionary
CEN	Comité Européen de Normalisation (European Committee for Standardization)
C-ITS	Cooperative Intelligent Transportation Systems
C-ITS-S	Cooperative ITS Station
CMS	Certificate Management System
C/N	Carrier-to-Noise
CRA	Communication Relevance Area
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CTS	Clear To Send
DCC	Decentralized Congestion Control
DE	Data Element
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Data Frame
DIFS	Distributed coordination function Interframe space
DSRC	Dedicated Short-Range Communications
DSSS	Direct Sequence Spread Spectrum
E2E	End-to-End
EIRP	Equivalent Isotropic Radiated Power

NOTE: Unless stated otherwise, EIRP denotes the maximum value over all directions.

EMC	ElectroMagnetic Compatibility
FCS	Frame Check Sequence
FWA	Fixed Wireless Access
GN	GeoNetworking
GPS	Global Positioning System
HF	High Frequency
IBSS	Independent Basic Service Set
ID	IDentity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISO	International Standards Organization
ITS	Intelligent Transport Systems
ITS-G5	IEEE 802.11 radio access technology in the 5,9 GHz band
ITS-S	Intelligent Transport Systems Station
ITU-R	International Telecommunication Union - Radio
I2V	Infrastructure-to-Vehicle
LDM	Local Dynamic Map
LF	Low Frequency
LTE	Long Term Evolution
MAC	Medium Access Control
MAP	Map data
MCO	MultiChannel Operation
NLOS	No Line Of Sight
OBU	On Board Unit
OCB	Outside the Context of a BSS
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency-Division Multiplexing
OJEU	Official Journal of the European Union
PHY	PHYsical layer
PKI	Public Key Infrastructure
PR	Protection Ratio
PSD	Platform Screen Doors
PZ	Protection Zone
PZM	Protection Zone Message
RATP	Régie Autonome des Transport Parisien

NOTE: Metro operator of Paris.

RED	Radio Equipment Directive
RER	Reseau Express Regional

NOTE: Suburban metro lines in Paris.

RF	Radio Frequency
R-ITS	Road Intelligent Transport Systems
RMO	Restricted Mode of Operations
R-RMO	Region of Restricted Mode of Operations
RSU	Road Side Unit or Rail Side Unit
RSSI	Received Signal Strength Indicator
RTS	Request To Send
SAE	Society of Automotive Engineers
SIFS	Short InterFrame Space
SIL4	Safety Integrity Level 4
SINR	Signal Interference + Noise Ratio
SPAT	Signal Phase and Timing
SRD	Short Term Devices
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
T-ITS-S	Train ITS Station
TS	Technical Specification
TS-ITS-S	Track Side ITS Station
T-OBU	Train OnBoard Unit
TX	Transmitter
UDP	User Datagram Protocol
UR	Urban Rail
UR-CAM	Urban Rail CAM
UR-DENM	Urban Rail DENM-like message
UR-ITS-S	Urban Rail ITS Station

NOTE: An UR-ITS-S is either a T-ITS-S or a TS-ITS-S.

UTC	Coordinated Universal Time
V-ITS-S	Vehicle ITS Station
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
WGFM	Working Group Frequency Management
WGS	World Geodetic System
Wi-Fi®	MAC & PHY specified in IEEE 802.11 [i.15]
XML	eXtensible Markup Language
ZC	Zone Controller

4 Spectrum framework and technical descriptions of Urban Rail and Road ITS technologies

4.1 Current spectrum regulatory framework

The present document is compiled on the Commission Implementing Decision (EU) 2020/1426 [i.43].