ETSI TR 103 441 V1.1.1 (2018-09)

System Reference document (SRdoc);
Pan-European harmonized communications equipment operating in the 5 GHz frequency range for regulated applications for commercial vehicles

Reference
DTR/ERM-553

Keywords
DSRC, ITS, SRDoc

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Sous-Préfecture de Grasse (06) N° 7803/88

Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

The EU regulated the radio technology to be used in the 5,795 GHz to 5,815 GHz frequency range for the remote enforcement of the tachograph in the Commission Implementing Regulation 2016/799 [i.1] and for the weights & dimensions enforcement in the Directive 2015/719 [i.14]. The present document comprises the regulated radio requirements and use cases of this technology, and non-regulated characteristics of such systems. It refers to existing frequency regulation and compatibility studies, as well as to other services operated in the same frequency band.

The present document is intended to be used as input for a compatibility study at CEPT to include the enforcement of the digital tachograph and weights & dimensions in future frequency regulatory documents.

Introduction

The 5 GHz frequency band plays a key role in enforcing EU transport policy and contributes in several ways to road safety and health & safety at work, fair competition and protecting road infrastructure. It plays a key role enforcing social rules for drivers of heavy goods vehicles (HGV) [i.12]. The social rules require recording equipment in HGV, the digital tachograph, which itself is specified in a separate piece of EU legislation [i.13]. Further EU rules for the weights & dimensions of HGV [i.14] are enforced using the same technology and frequency band.

The electronic enforcement of the digital tachograph and weights & dimensions is done by a dedicated short range communication technology (DSRC) specified by CEN in CEN EN 12253 [i.3]. The data stored in the digital tachograph can be read out over a radio link from the vehicle unit (VU) when it is in the vicinity of an interrogator device, also called Remote Early Detection Communication Reader (REDCR). DSRC is based on a passive backscatter technology that exhibits excellent localization properties by sharply limiting the area where radio communication is possible. What makes it possible to read out a distinct VU out of several others around, even when it is passing by at high speed and is only for 100 ms in range.

1 Scope

The present document provides information on the intended applications, the technical parameters, the relation to the existing spectrum regulation and additional new radio spectrum requirements for communication equipment for the smart tachograph application regulated in Regulation (EU) No. 165/2014 [i.13] and weights and dimensions for heavy goods vehicles application regulated in Directive (EU) 2015/719 [i.14].

The present document includes necessary information to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), including:

- Detailed information about the market regulation (annex A).
- Technical information (annex B).
- Relation to existing spectrum regulation (annex C).
- Expected compatibility issues (annex D).

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] Commission Implementing Regulation (EU) 2016/799 of 18 March 2016 implementing Regulation (EU) No 165/2014 of the European Parliament and of the Council laying down the requirements for the construction, testing, installation, operation and repair of tachographs and their components.

[i.2] Commission Implementing Regulation (EU) 2018/502 of 28 February 2018 amending Implementing Regulation (EU) 2016/799 laying down the requirements for the construction, testing, installation, operation and repair of tachographs and their components.

[i.3] CEN EN 12253 (2004): "Road transport and traffic telematics - Dedicated short-range communication - Physical layer using microwave at 5,8 GHz".

[i.4] CEN EN 13372 (2004): "Road Transport and Traffic Telematics (RTTT) - Dedicated short-range communication - Profiles for RTTT applications".

[i.5] ETSI EN 300 674-1 (2004): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band; Part 1: General characteristics and test methods for Road Side Units (RSU) and On-Board Units (OBU)".

[i.6] ETSI EN 300 674-2-1 (V2.1.1) (2016): "Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band; Part 2: Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Sub-part 1: Road Side Units (RSU)".

[i.7] ETSI EN 300 674-2-2 (V2.1.1) (2016): "Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band; Part 2: Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Sub-part 2: On-Board Units (OBU)".

[i.8] 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.9] ETSI TR 102 654 (V1.1.1) (2009): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Co-location and Co-existence Considerations regarding Dedicated Short Range Communication (DSRC) transmission equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range and other potential sources of interference".

[i.10] CEPT/ERC Recommendation 70-03 (2017): "Relating to the use of Short Range Devices (SRD)".

[i.11] Recommendation ITU-T K.52: "Guidance on complying with limits for human exposure to electromagnetic fields".

[i.12] Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85.

[i.13] Regulation (EU) No 165/2014 of the European Parliament and of the Council of 4 February 2014 on tachographs in road transport, repealing Council Regulation (EEC) No 3821/85 on recording equipment in road transport and amending Regulation (EC) No 561/2006 of the European Parliament and of the Council on the harmonisation of certain social legislation relating to road transport.

[i.14] Directive (EU) 2015/719 of the European Parliament and of the Council of 29 April 2015 amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic.

[i.15] ACEA Report (2017): "Vehicles in use Europe".

NOTE: Available at https://www.acea.be/uploads/statistic_documents/ACEA_Report_Vehicles_in_use-Europe_2017.pdf.

[i.16] ETSC PIN report 2013 (2014-02): "7th Annual PIN Report on Track to Reach the 2020 Target".

NOTE: Available at http://etsc.eu/wp-content/uploads/2014/02/PIN_Annual_report_2013_web.pdf.

[i.17] ETSC PRAISE report 7 (2011-10): "Tackling Fatigue: EU Social Rules and Heavy Goods Vehicle Drivers".

NOTE: Available at http://archive.etsc.eu/documents/Report7_final.pdf.

[i.18] SafetyNet 2009: "Fatigue".

NOTE: Available at https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/specialist/knowledge/pdf/fatigue.pdf.

[i.19] ROSPA (2017-08): "Road Safety Factsheet".

NOTE: Available at https://www.rospa.com/rospaweb/docs/advice-services/road-safety/drivers/driver-fatigue-factsheet.pdf.

[i.20] HUK-Verband Büro für KfZ Technik, Langwieder, K. Sporner, A & Hell, W. (1994): "Struktur der Unfälle mit Getöteten auf Autobahnen im Freistaat Bayern im Jahr 1991".

[i.21] ETSC (2001): "The Role of Driver Fatigue in Commercial Road Transport Crashes".

NOTE: Available at http://etsc.eu/wp-content/uploads/The-role-of-driver-fatigue-in-commercial-road-transport-crashes.pdf.

[i.22] ETSC (2013-10): "Position on the Proposal for a Directive Amending Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum weights in international traffic".

NOTE: Available at http://archive.etsc.eu/documents/ETSC_Position_Amending_Weights_and_Dimensions_22_October_2013.pdf.

[i.23] EC COM(2013) 195: "Proposal for a Directive of the European Parliament and of the Council Amending Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum weights in international traffic".

NOTE: Available at http://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2013)0195_/com_com(2013)0195_en.pdf.

[i.24] WTO S/C/W/324 (2010-10): "Road Freight Transport Services".

NOTE: Available at https://docs.wto.org.

[i.25] EC (2016): "Ex-post evaluation of social legislation in road transport and its enforcement".

NOTE: Available at https://ec.europa.eu/transport/sites/transport/files/facts-fundings/evaluations/doc/2016-ex-post-eval-road-transport-social-legislation-final-report.pdf.

[i.26] Project Remove (2005-12): "Work Package 4 Cost-benefit Analysis".

NOTE: Available at http://www.is-wim.org/doc/remove_WP4_costbenefit_analysis.pdf.

[i.27] Council Regulation (EEC) 3820/85 of 20 December 1985 on the harmonization of certain social legislation relating to road transport.

[i.28] Regulation (EC) 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85 (Text with EEA relevance) - Declaration.

[i.29] EC C(2011) 3759 Commission implementing Decision of 7.6.2011 on the calculation of daily driving time in accordance with Regulation (EC) No 561/2006 of the European Parliament and of the Council.

[i.30] Directive 2002/15/EC of the European Parliament and of the Council of 11 March 2002 on the organisation of the working time of persons performing mobile road transport activities.

[i.31] Council Directive 96/53/EC of 25 July 1996 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic.

[i.32] ETSI EN 300 440 (V2.1.1) (03-2017): "Short Range Devices (SRD); Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.33] Commision Decision 2006/771/EC of 9 November 2006 on harmonisation of the radio spectrum for use by short-range devices.

[i.34] Commission implementing Decision (EU) 2017/1483 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2006/804/EC.

[i.35] ETSI TR 102 960 (V1.1.1) (11-2012): "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (RTTT DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range; Evaluation of mitigation methods and techniques".

[i.36] ETSI TS 102 792 (V1.2.1) (06-2015): "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.37] ETSI EN 302 571 (V2.1.1) (02-2017): "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.

[i.38] ECC Report 228 (2015): "Compatibility studies between Intelligent Transport Systems (ITS) in the band 5855-5925 MHz and other systems in adjacent bands".

[i.39] ECC Report 101 (2007): "Compatibility studies in the band 5855-5925 MHz between Intelligent Transport Systems (ITS) and other systems".

[i.40] ETSI EN 302 502: "Broadband Radio Access Networks (BRAN); 5,8 GHz fixed broadband data transmitting systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.41] CEPT Report 57 (2015): "To study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5350-5470 MHz and 5725-5925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services".

[i.42] CEPT Report 64 (2016): "To study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5350-5470 MHz and 5725-5925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services".

[i.43] ECC Report 244 (2016): "Compatibility studies related to RLANs in the 5725-5925 MHz band".

[i.44] ERC Report 72 (1999): "Compatibility studies related to the possible extension band for HIPERLAN at 5 GHz".

[i.45] ECC Report 68 (2005): "Compatibility studies in the band 5725-5875 MHz between Fixed Wireless Access (FWA) systems and other systems".

[i.46] ECC Recommendation (06)04: "Use of the band 5725-5875 MHz for Broadband Fixed Wireless Access (BFWA)".

[i.47] CEPT Report 015 (2007): "to identify the conditions relating to the provision of harmonised radio frequency bands in the European Union for Broadband Wireless Access applications".

[i.48] ETSI TR 102 889-2 (V1.1.1) (2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Short Range Devices (SRD); Part 2: Technical characteristics for SRD equipment for wireless industrial applications using technologies different from Ultra-Wide Band (UWB)".

[i.49] ETSI EN 303 258: "Wireless Industrial Applications (WIA); Equipment operating in the 5 725 MHz to 5 875 MHz frequency range with power levels ranging up to 400 mW; Harmonised Standard for access to radio spectrum".

[i.50] ECC Report 206: "Compatibility studies in the band 5725-5875 MHz between SRD equipment for wireless industrial applications and other systems".

[i.51] ECC Report 157 (2011): "The impact of spurious emissions of radars at 2,8, 5,6 and 9,0 GHz on other radiocommunication services/systems".

[i.52] ECC REPORT 102 (2007): "Public protection and disaster relief spectrum requirements".

[i.53] ECC Report 110 (2007): "Compatibility studies between Broad-Band Disaster Relief (BBDR) and other systems".

[i.54] ETSI EN 302 065-3: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Requirements for UWB devices for ground based vehicular applications".

[i.55] CEPT Report 010 (2006): "UWB Specific Applications".

[i.56] Commission Decision 2009/343/EC of 21 April 2009 amending Decision 2007/131/EC on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

[i.57] ECC Decision (06)04: "The harmonised conditions for devices using Ultra-Wideband (UWB) technology in bands below 10.6 GHz".

[i.58] ETSI EN 301 783: "Commercially available amateur radio equipment; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.59] ECC Report 210 (2014): "Compatibility/sharing studies related to Broadband Direct-Air-to-Ground Communications (DA2GC) in the frequency bands 5855-5875 MHz, 2400-2483.5 MHz and 3400-3600 MHz".

[i.60] ECC Report 272: "Earth Stations operating in the frequency bands 4-8 GHz, 12-18 GHz and 18-40 GHz in the vicinity of aircraft".

[i.61] ECC Report 250 (2016): "Compatibility studies between TTT/DSRC in the band 5805-5815 MHz and other systems".

[i.62] ECC Report 109 (2007): "The aggregate impact from the proposed new systems (ITS, BBDR AND BFWA) in the 5725-5925 MHz band on the other services/systems currently operating in this band".

[i.63] CEPT Report 26 (2009): "Annual update of the technical annex of the Commission Decision on the technical harmonisation of radio spectrum for use by short range devices".

[i.64] CEPT Report 44 (2013): "Annual update of the technical annex of the Commission Decision on the technical harmonisation of radio spectrum for use by short range devices".

[i.65] CEPT Report 59 (2016): "Annual update of the technical annex of the Commission Decision on the technical harmonisation of radio spectrum for use by short range devices".

[i.66] CEPT Report 005 (2005): "Short range devices spectrum harmonisation".

[i.67] CEPT Report 014 (2006): "Develop a strategy to improve the effectiveness and flexibility of spectrum availability for Short Range Devices (SRDs)".

[i.68] ECC Report 181 (2012): "Improving spectrum efficiency in the SRD bands".

3 Symbols and abbreviations

3.1 Symbols

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

G_b boresight gain of antenna
G_c conversion gain (vehicle unit)

G_r	antenna gain relative to boresight gain of antenna
P_{sens}	receiver sensitivity of REDCR in boresight including antenna gain
P_{VUsens}	receiver sensitivity of vehicle unit in boresight including antenna gain
θ	angle deviation from boresight
Θ_{vd}	angle deviation from vertical downward direction

3.2 Abbreviations

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

ACEA	European Automobile Manufacturers Association
ASK	Amplitude Shift Keying
CEN	Comité Européen de Normalisation
CEPT	European Conference of Postal and Telecommunications Administrations
DEC	Decision
DSRC	Dedicated Short Range Communication
EC	European Commission
E.I.R.P.	Equivalent Isotropic Radiated Power
ETSC	European Transport Safety Council
EU	European Union
HGV	Heavy Good Vehicle
ISM	Industrial Scientific and Medical
PIN	Performance Index
PRAISE	Preventing Road Accidents and Injuries for the Safety of Employees
PSK	Phase Shift Keying
RED	Radio Equipment Directive
REDCR	Remote Early Detection Communication Reader (interrogator device)
RF	Radio Frequency
ROSPA	Royal Society for the Prevention of Accidents
RX	Receive
SRD	Short Range Device
TTT	Transport and Traffic Telematics
TX	Transmit
VU	Vehicle Unit

4 Market regulatory background

4.1 Rationale for a market regulation

The digital tachograph and the enforcement of weights & dimensions both impact traffic safety and fair competition on the road transport market. Additionally, the digital tachograph is used to guarantee correct working conditions for truck drivers as prerequisite for safe driving. Since road transport is done on an international basis, the EU regulated the radio technology to be used for the remote enforcement of the tachograph in Appendix 14 of the Commission Implementing Regulation 2016/799 [i.1] and for the weights & dimensions enforcement in Article 10d of the Directive 2015/719 [i.14]. Details and background of the rationale can be found in annex A of the present document.

4.2 Technical prerequisites regulated by the European Union

4.2.1 Interrogation use cases

The Commission Implementing Regulation 2016/799 [i.1] foresees two interrogation use cases:

1) The vehicle unit is read out by a fixed or portable interrogator device located at the roadside which is directed towards the centre of the windscreen of the passing by vehicles to be inspected (see figure 1).

2) The vehicle unit is read out from a mobile interrogator device situated within a moving vehicle and directed towards the centre of the windscreen of the vehicle to be inspected (see figure 2).

NOTE 1: In [i.1] the interrogator device is called Remote Early Detection Communication Reader (REDCR).

NOTE 2: The vehicle unit can only be read out by one REDCR at the same time. Figure 1 and figure 2 show just the principle where these interrogator devices can be located, and in which direction they are pointing.

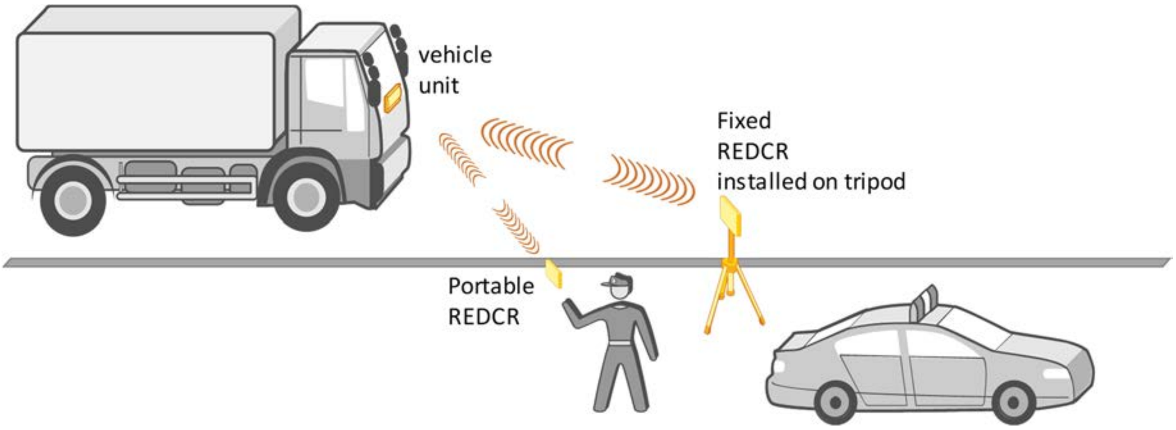


Figure 1: REDCR location in the roadside interrogation use case (basic principle)

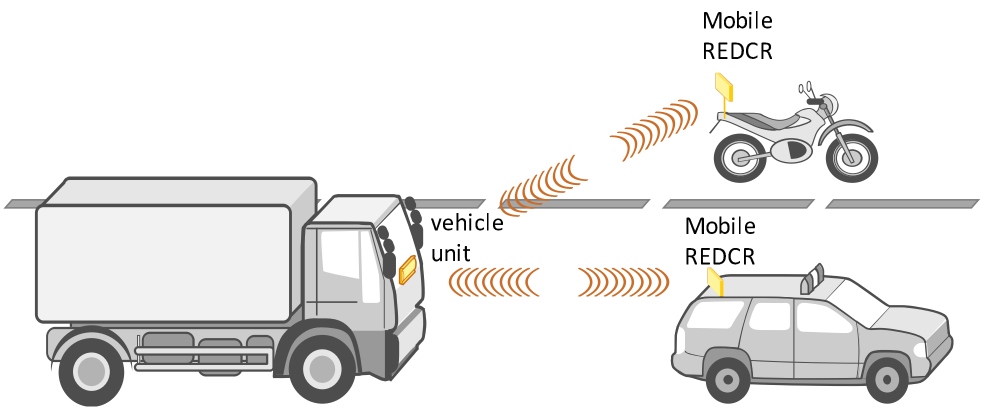


Figure 2: REDCR location in the vehicle based interrogation use case (basic principle)

4.2.2 Radio technology

The Commission Implementing Regulation 2016/799 [i.1] foresees that the radio communication between the vehicle unit and the interrogator device is operating according to CEPT/ERC Rec. 70-03 [i.10], is using 5,8 GHz DSRC, and is tested against the appropriate parameters of ETSI EN 300 674-1 [i.5]. Further, to deal with the compatibility to operational parameters of other standardized 5,8 GHz DSRC systems, the equipment used for remote tachograph monitoring should conform to parameters from CEN EN 12253 [i.3] and CEN EN 13372 [i.4].

Because of the Radio Equipment Directive 2014/53/EU [i.8] (RED), for the interrogator ETSI EN 300 674-2-1 [i.6] and for the vehicle unit ETSI EN 300 674-2-2 [i.7] apply.

An excerpt of these parameters relevant for radio interference can be found in table 4, table 6, table 7, and table 9 in clause B.1.2.

4.2.3 Antenna characteristics and mounting

The Commission Implementing Regulation 2016/799 [i.1] foresees that the boresight of the vehicle unit antenna is approximately parallel with the road surface. All other antenna characteristics should be chosen in such a way that they efficiently support the use cases described in clause 4.2.1 and that they are conforming the parameters D5, D5a, U5, and U5a in table 4 and table 6 of clause B.1.2.

The Commission Implementing Regulation 2018/502 [i.2] further foresees that the position of the DSRC-VU antenna should be optimized for a use case where the REDCR is installed in 15 m distance in front of the vehicle at 2 m height, targeting the horizontal and vertical centre of the windscreen. For light vehicles an installation corresponding to the upper part of the windscreen is suitable. For all the other vehicles the DSRC antenna should be installed either near the lower or near the upper part of the windscreen.

The REDCR antenna should be optimized for the specific purpose and read circumstances (use case) in which the REDCR has been designed to operate.

NOTE: In addition to the market regulatory framework, the antennas should also be conforming the other design parameters and limits given in clause B.1.2.

4.2.4 Interference to other DSRC equipment

The Commission Implementing Regulation 2016/799 [i.1] foresees that the remote interrogation of vehicles should not be done when closer than 200 m to a 5,8 DSRC gantry (e.g. road tolling).

5 Other technical presumptions

5.1 Interrogation use cases not specified by regulation

5.1.1 General presumptions for interrogation use cases

Despite the use cases defined by the Commission Implementing Regulation 2016/799 [i.1] other DSRC-VU readout scenarios are necessary or possible to enforce or install a tachograph in a vehicle.

In general, the test or interrogation of a specific DSRC-VU requires that only this VU is communicating with the interrogation device. Depending on the use case, this implicitly defines the requirements for the antenna diagram, transmit power level, and receiver sensitivity of the REDCR, since for the DSRC-VU these radio parameters are all specified in the Commission Implementing Regulation 2016/799 [i.1] and cannot be adapted to any use case.

5.1.2 Testing the installation in a garage or interrogation on a parking lot

After installation of a new tachograph in a vehicle, the correct operation of the DSRC-VU is tested with a handheld device. This device will be pointed in direction of the DSRC-VU from a distance typically not exceeding 3 m. A trigger button is used to initiate the DSRC-VU readout.

A similar device could be used to readout a DSRC-VU of a parked truck by the police.

Since these handheld devices will be battery powered and the reading distance is short, the transmit power level can be low. The receiver sensitivity should be limited to avoid unintentionally reading out the DSRC-VU of other trucks parked nearby. The exact values of the radio characteristics are up for further investigations, but the transmit power level should be limited to values reasonable for handheld devices to protect humans from harmful RF exposure (see Recommendation ITU-T K.52 [i.11]).

Also because of the short reading distance, the opening angle of the REDCR antenna can be wide, what makes it possible to use a small low gain single patch antenna integrated in the handheld device. For more details on the possible antenna characteristics see clause 5.3.2.

5.1.3 REDCR mounted on a gantry

For automatic enforcement of the digital tachograph, fixed enforcement stations are possible, where the DSRC-VU can be localized by radio detection and matched to a certain vehicle passing the enforcement station in free flow traffic. These digital tachograph enforcement stations can have a REDCR for each lane mounted on a gantry above the street, like in a multilane free flow tolling enforcement station.

In these installations the boresight of the REDCR antenna will be typically tilted by 45° downwards against the driving direction of the traffic. To achieve the necessary interrogation performance in such free flow scenarios, typically a transmit power level of 33 dBm E.I.R.P. is needed.

5.2 Mounting of vehicle unit antenna

The Commission Implementing Regulation 2016/799 [i.1] does not foresee at which height the DSRC-VU is mounted, and whether it is mounted inside or outside the vehicle.

Therefore, it can be considered that the DSRC-VU can be mounted either inside the vehicle behind the windscreen, or outside on the front in the centre of the vehicle. In case of a fully metalized windscreen without a not metalized area in front of the VU antenna, the only possibility is to mount the DSRC-VU outside the vehicle.

For light vehicles the mounting in the upper part of the windscreen is described in the Commission Implementing Regulation 2018/502 [i.2] to be suitable. This corresponds to a mounting height of about 1,5 m above ground.

As typical mounting position for an HGV the centre at the bottom of the windscreen is shown in the regulation [i.1]. This corresponds to a mounting height of about 2 m above ground.

In addition, the Commission Implementing Regulation 2018/502 [i.2] mandates that the DSRC-VU antenna is installed in all other than light vehicles either near the lower or near the upper part of the windscreen.

In summary, in most cases the DSRC-VU antenna will be mounted in an HGV inside a non-metalized windscreen in the centre of the vehicle at a height of 2 m above ground. All other mounting options together are expected to be used in less than 2 % of all installations.

5.3 Typical antenna characteristics

5.3.1 Vehicle unit antenna

5.3.1.1 Vehicle unit antenna overview

The vehicle unit antennas have a relative wide opening angle as defined in the Commission Implementing Regulation 2016/799 [i.1], to make a readout from an adjacent lane possible, as needed for the interrogation use cases described in clause 4.2.1.

Typically, either the same antenna or similar antennas are used for the DSRC-VU transmitter and for the receiver. Usually, the antenna diagram is symmetric around boresight and given by the angle deviation θ from boresight. Since its boresight is directed in parallel with the road surface (see clause 4.2.3) and it is pointing in driving direction, azimuth and elevation characteristics are usually identical to the characteristic over θ. For more than 90° angle deviation θ from boresight (to the back) the VU is shielded by the vehicle compartment and it can be expected that the sensitivity to signals from outside the vehicle in this direction is very low. Therefore, also any emission into this direction to the outside of the vehicle can be neglected.

5.3.1.2 Vehicle unit RX antenna

A typical VU antenna diagram is shown in figure 3. The boresight receiver sensitivity range (P_{VUsens}) including antenna gain is specified by the parameters D11b and D12 in CEN EN 12253 [i.3] and ETSI EN 300 674-2-2 [i.7]:

$$-60 \text{ dBm} \leq P_{\text{VUsens}} \leq -43 \text{ dBm}.$$

Typically, the boresight receiver sensitivity P_{VUsens} is -47 dBm including antenna gain.

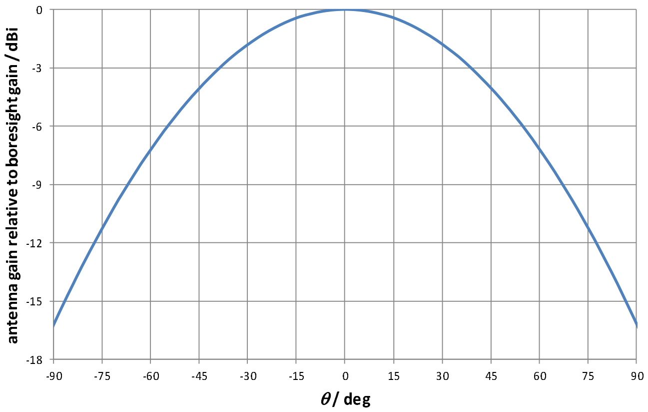


Figure 3: Example for a vehicle unit antenna diagram relative to boresight

5.3.1.3 Vehicle unit TX antenna

Because the DSRC-VU uses backscatter technology without an internal oscillator for the generation of the uplink signal, the REDCR sends an unmodulated continuous wave down link signal while the VU is transmitting. The VU receives this signal, amplifies it by the conversion gain, modulates it with the uplink data, and transmits it back to the REDCR. Because of this, the TX power level of the DSRC-VU is not constant, it depends on the REDCR transmit power level in direction of the DSRC-VU, the distance to the REDCR, and when mounted within the vehicle on the attenuation of the windscreen. The maximum allowed boresight TX power level of the DSRC-VU is -14 dBm (see also table B.3 parameter U4a).

The antenna diagram of the VU TX antenna is usually identical to the RX antenna, as already described in clause 5.3.1.1. Therefore, figure 3 shows also the conversion gain of the DSRC-VU relative to boresight for a typical TX antenna. As described above, the TX power level of the VU does not depend on the conversion gain alone, but also among other parameters on the relative position of the REDCR and the direction of its boresight.

The maximum conversion gain in boresight is specified by the parameters U12b in CEN EN 12253 [i.3] and ETSI EN 300 674-2-2 [i.7] (see also table 6). The angular mask for the minimum conversion gain, defined by the parameter U12a in CEN EN 12253 [i.3], is specified in the Commission Implementing Regulation 2016/799 [i.1] and is slightly different from the values specified in ETSI EN 300 674-2-2 [i.7].

In summary, the conversion gain G_c of a DSRC-VU should be in following range:

$$G_c \geq 1 \text{ dB for } \theta \leq \pm 35° \text{ and additionally } G_c \geq 1 \text{ dB in the horizontal plane for Azimuth} \leq \pm 45°,$$

$$\text{and for all directions } G_c \leq 10 \text{ dB applies.}$$

5.3.2 REDCR antennas for different use cases

5.3.2.1 Antenna type overview

The antennas are typically an integral part of the REDCR and cannot be changed by the user, since they are optimized for a certain use case.

For interrogation devices mounted on a gantry as described in clause 5.1.3, or mounted on a tripod as described in clause 4.2.1 and shown in figure 1, high gain RX antennas to increase the reception range are typically used.

For mobile interrogation from a vehicle the antenna size is limited by the size of the vehicle (e.g. a motorcycle) and by the air drag when the antennas are mounted on the rooftop of a car. So, either small high gain antennas like for fixed or nomadic installations, or even smaller antennas with reduced gain can be used.

For handheld interrogation devices antenna size and weight are essential. In practice, only small antennas are suitable for this use case.

The examples given in the following clauses are expectations based on tolling implementations, since no REDCR and DSRC-VU implementations existed at the time of preparation of the present document. Therefore, other antenna types and characteristics meeting the proposed limits are not excluded from future implementations.

5.3.2.2 Antenna for fixed REDCR mounted on a tripod at the roadside

For an REDCR on a tripod at the roadside (see figure 1) the antenna is mounted in approximately 2 m height with the antenna boresight pointing parallel to the road surface against the driving direction of the vehicles.

A high gain antenna with a typical transmit power level of 33 dBm E.I.R.P. in boresight as shown in figure 4 and figure 5 can be used. 33 dBm E.I.R.P. is the maximum power level allowed for REDCR devices (see table 4 parameter D4). There were no spatial TX power masks defined for this use case when the present document was under preparation. A proposal for such masks based on the gantry use case as described in clause 5.3.2.4 is also shown in figure 4 and figure 5, but this proposal needs further investigation concerning radio interference.

A typical receiver antenna diagram relative to boresight is shown in figure 6 and figure 7. The typical receiver sensitivity for an REDCR on a tripod in boresight of the antenna is -110 dBm including antenna gain.

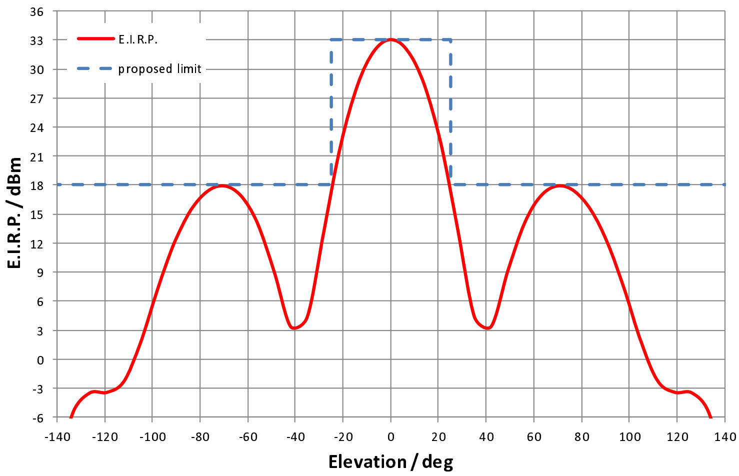


Figure 4: Example of TX elevation antenna diagram for an REDCR mounted on a tripod or a vehicle

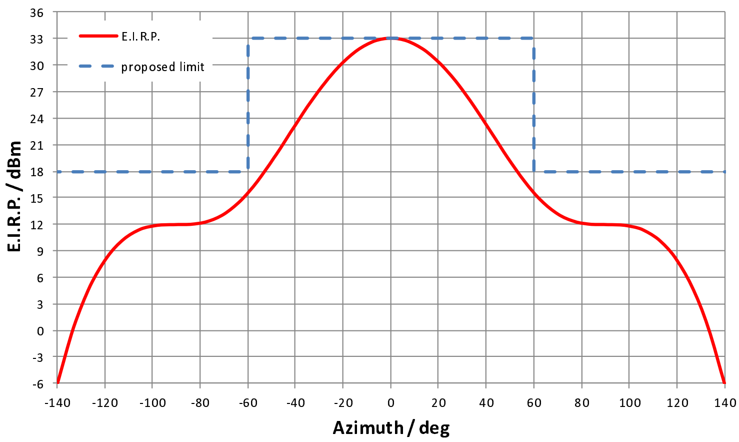


Figure 5: Example of TX azimuth antenna diagram for an REDCR mounted on a tripod or a vehicle

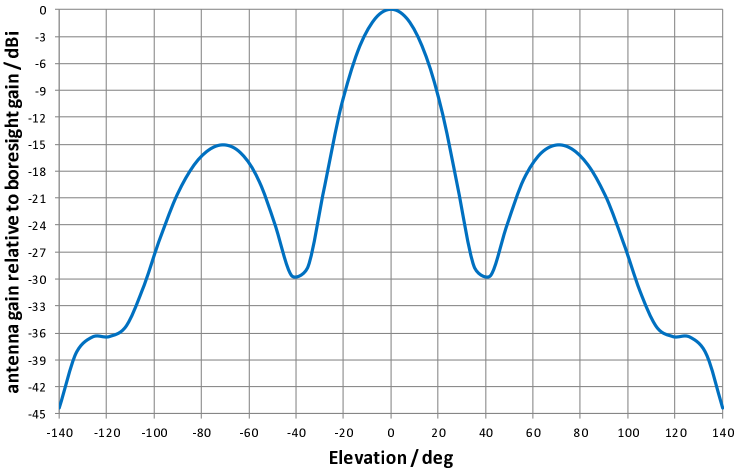


Figure 6: Example of RX elevation antenna diagram relative to boresight gain for an REDCR mounted on a tripod or a vehicle

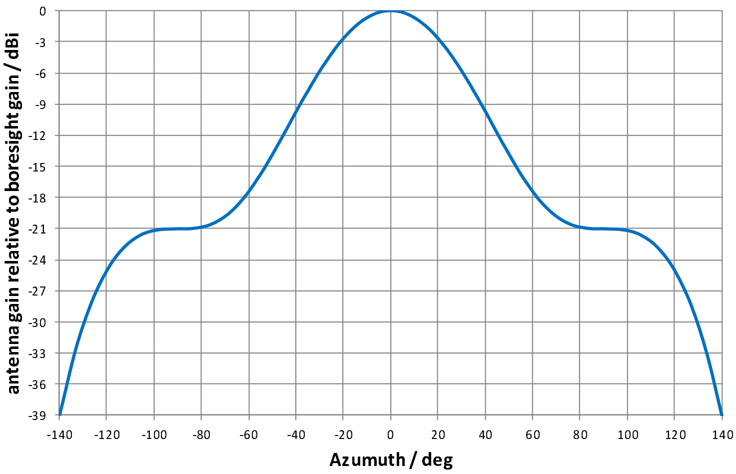


Figure 7: Example of RX azimuth antenna diagram relative to boresight gain for an REDCR mounted on a tripod or a vehicle

5.3.2.3 Antenna for mobile REDCR mounted on a vehicle

For an REDCR mounted on a minivan the antenna is located typically in 1,5 m to 2 m height with the antenna boresight pointing parallel to the road surface against the driving direction of the vehicles. For this use case the antenna diagram can be identical to the antennas used for the interrogation from the roadside as shown in figure 4 to figure 7.

For smaller vehicles smaller antennas with less gain might be advantageous (see figure 2). These antennas will usually exhibit identical antenna diagrams for azimuth and elevation. The typical transmitted power level of such an antenna is shown in figure 8 together with a proposed spatial TX power mask. But this proposal needs further investigation concerning radio interference, since there was no such mask defined for this use case when the present document was under preparation.

A typical receiver antenna diagram for this use case is shown in figure 9. The typical receiver sensitivity for an REDCR with a small vehicle antenna (e.g. for a motor cycle) in boresight of the antenna is -107 dBm including antenna gain.

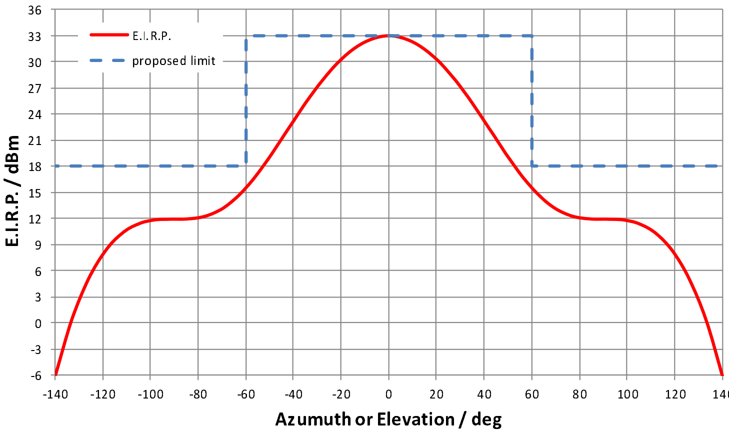


Figure 8: Example of TX antenna diagram relative to boresight for a small REDCR mounted on a vehicle or a handheld interrogator

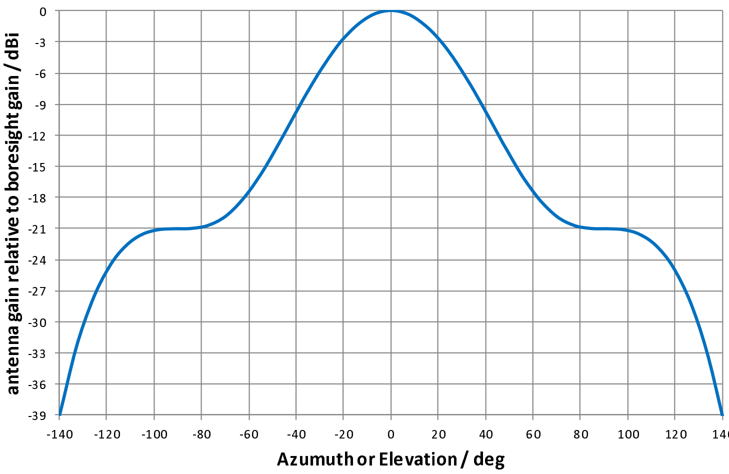


Figure 9: Example of RX antenna diagram for a small REDCR relative to boresight gain mounted on a vehicle or a handheld interrogator

5.3.2.4 Antenna for a fixed REDCR mounted on a gantry

For an REDCR on a gantry as described in clause 5.1.3 the antenna is mounted typically in 6 m to 7 m height with the antenna boresight pointing 45° downwards to the road surface against the driving direction of the vehicles.

A high gain antenna is used, with a typical transmitted power level as shown in figure 10 and figure 11. The spatial TX power mask shown in figure 10 is taken from CEN EN 12253 [i.3]. The parameter D4a describes there, that the main beam of the antenna should be limited to ±70° around the vertical downward direction. There is no spatial TX power mask defined in the horizontal plane (azimuth).

A typical receiver antenna diagram for this use case is shown in figure 12 and figure 13. The typical receiver sensitivity for an REDCR on a gantry in boresight of the antenna is -110 dBm including antenna gain.

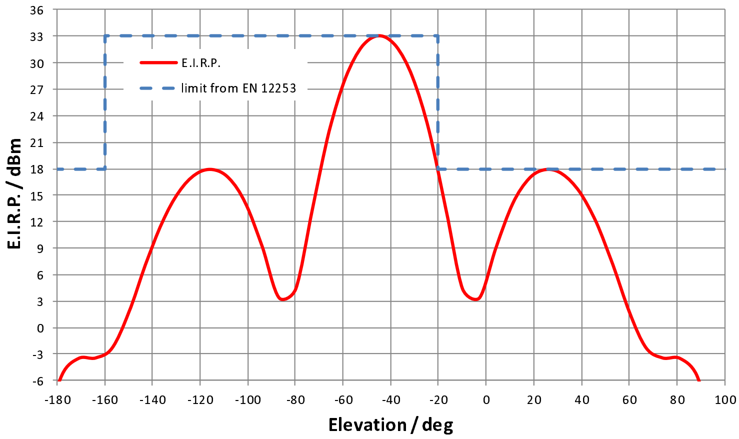


Figure 10: Example of TX elevation antenna diagram for an REDCR mounted on a gantry and tilted downwards by 45°

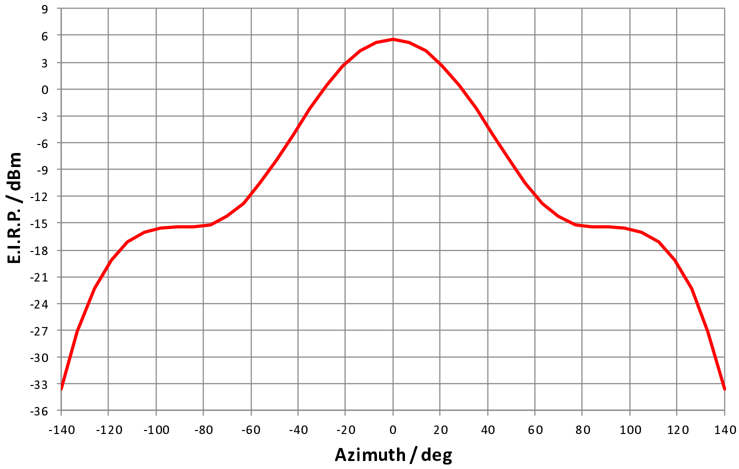


Figure 11: Example of TX azimuth antenna diagram for an REDCR mounted on a gantry and tilted downwards by 45°

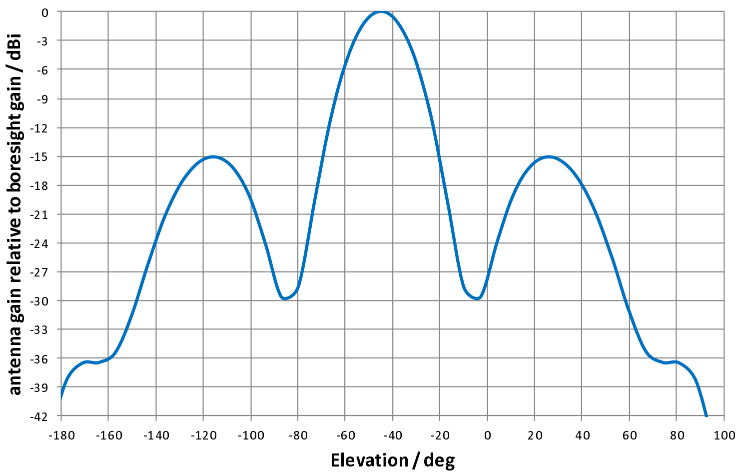


Figure 12: Example of RX elevation antenna diagram relative to boresight gain for an REDCR mounted on a gantry and tilted downwards by 45°

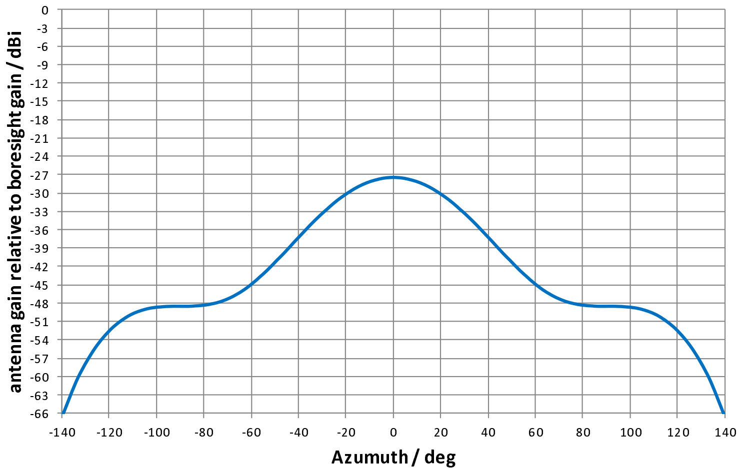


Figure 13: Example of RX azimuth antenna diagram relative to boresight gain for an REDCR mounted on a gantry and tilted downwards by 45°

5.3.2.5 Antenna for handheld REDCR

Handheld REDCR devices are either used for interrogation from the roadside by a policeman, or in a garage to check the functionality of a DSRC-VU. For the interrogation from the roadside, higher RF performance is necessary than in the garage use case and therefore such devices might use antennas with higher gain and higher TX power levels. The characteristics of these devices can be similar to the small vehicle REDCR as shown in figure 8 and figure 9.

REDCR used in a garage will typically contain a single patch antenna to make the device as small as possible. An example for an antenna diagram typical for this garage use case is shown in figure 14. As already pointed out in clause 5.1.2, the TX power level and the sensitivity of these small devices are up for further investigations.

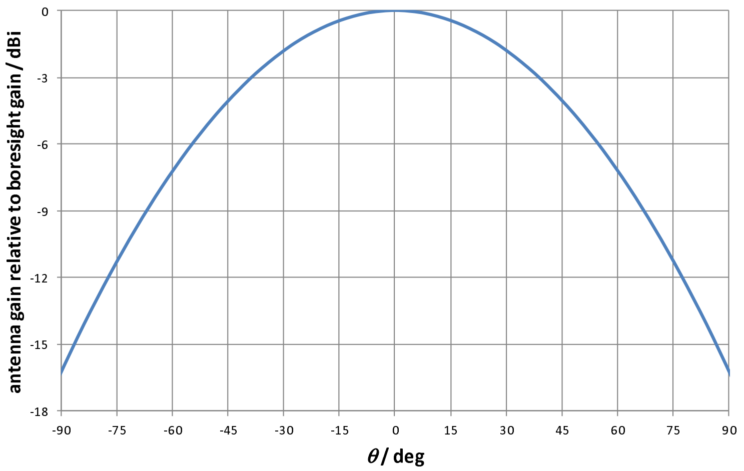


Figure 14: Example of antenna diagram relative to boresight gain for a small handheld REDCR

6 Current radio regulations

The DSRC technology used for the digital tachograph and the enforcement of weights & dimensions is specified in the harmonised standards ETSI EN 300 674-2-1 [i.6] and ETSI EN 300 674-2-2 [i.7]. In the CEPT/ERC Recommendation 70-03 [i.10] this technology is called transport and traffic telematics (TTT). The CEPT/ERC Recommendation 70-03 [i.10] limits the use in the frequency range from 5 795 MHz to 5 805 MHz in France to automatic toll collection only. The transmit power level of 33 dBm E.I.R.P. is implemented in all CEPT countries. The frequency range from 5 805 MHz to 5 815 MHz requires individual licence in some CEPT countries.

The implementing Decision (EU) 2017/1483 [i.34] defines that the use of 2 W E.I.R.P. in the frequency range from 5 795 MHz to 5 815 MHz is only applicable to road tolling applications.

Details on the current radio regulation are given in annex C.

As conclusion, the digital tachograph and the enforcement of weights & dimensions are at the time of preparation of the present document not included in radio regulations.

7 Main conclusions

Since the digital tachograph and the enforcement of weights & dimensions uses the same CEN DSRC technology as road tolling, several compatibility studies concerning this technology are already available. The main differences are the antenna diagrams of the REDCR and the DSRC-VU, as well as new use cases of this technology not included in the radio regulation at the time of preparation of the present document. Proposed antenna diagrams for these use cases are described in clause 5.3. The key radio parameters of the REDCR and the DSRC-VU are summarized in table 1 to table 3, details can be found in annex B.

Table 1: Key radio parameters of the DSRC vehicle unit (DSRC-VU)

	Value	Units
DSRC-VU receiver parameters		
Sensitivity (including antenna gain)	-60 to -43	dBm
Blocking (Class 2)	≥ -30	dBm
Modulation of received signal	2-ASK	
Protection Criteria (I/N)	-3	dB
DSRC-VU transmitter parameters		
Maximum output power level, E.I.R.P.	-14	dBm
TX frequency band	5,795 to 5,815	GHz
Conversion Gain (lower limit)	1	dB
Conversion Gain (upper limit)	10	dB
DSRC-VU antenna		
Antenna polarization	LHCP	
Cross-polar discrimination, ellipticity of polarization	≥ 6	dB
DSRC-VU antenna mounting		
Car windscreen loss (when applicable)	3	dB
Mounting height above ground	1 to 2,2	m
Elevation of boresight	0° horizontal	

Table 2: Key radio parameters of a roadside or vehicular REDCR

	Value	Units
Roadside or vehicular REDCR receiver parameters		
Receiver bandwidth	500	kHz
Blocking	≥ -30	dBm
Receiver sensitivity (including antenna gain) typical (see also table 8) maximum	≤ -104 -110 -115	dBm dBm dBm
Modulation of received signal	2-PSK	
Protection criterion (I/N)	≤ -3	dB
Roadside or vehicular REDCR transmitter parameters		
TX output power level, E.I.R.P.	≤ 33	dBm
TX frequency band	5,795 to 5,815	GHz
Roadside or vehicular REDCR antenna		
Antenna polarization	LHCP	
Antenna gain outside RSU active angle relative to boresight gain	≤ -15	dB
Cross-polar discrimination, ellipticity of polarization	≥ 10	dB
roadside or vehicular REDCR antenna mounting		
REDC mounting height above ground per use case:		
• Vehicle • Tripod • Gantry	1,5 m to 2 m 2 m 6 m to 7 m	
Elevation of boresight per use case:		
• Gantry • All other	45° downwards 0° horizontal	

Table 3: Key radio parameters of a handheld REDCR

	Value	Units
Handheld REDCR receiver parameters		
Receiver bandwidth	500	kHz
Reading range	≥ 3	m
Blocking	≥ -30	dBm
Modulation of received signal	2-PSK	
Protection criterion (I/N)	-3	dB
Handheld REDCR transmitter parameters		
TX output power level, E.I.R.P.	< 33 in line with ITU-T K.52 [i.11]	dBm
TX frequency band	5,795 to 5,815	GHz
Handheld REDCR antenna		
Antenna polarization	LHCP	
Cross-polar discrimination, ellipticity of polarization	≥ 6	dB
Handheld REDCR antenna mounting		
REDC mounting height above ground	1 m to 1,5 m	
Elevation of boresight	0° horizontal	

Annex A: Detailed information about the market regulation

A.1 Motivation for the digital tachograph

A.1.1 Health and safety at work - and road safety

In 2011 4 254 people lost their lives in collisions involving HGV [i.16]. This constitutes a significant amount of traffic fatalities in the EU. Collisions involving HGV, if they occur, tend to cause fatalities or severe injuries mainly to the occupants of involved passenger cars or unprotected road users. Though there is little data on the exact causes of collisions in commercial road transport extensive research has been conducted in this field.

A.1.2 Fatigue

Fatigue is a gradual and cumulative process that is associated with a 'loss of efficiency and disinclination of for any kind of effort' [i.17]. Fatigue reduces reaction time (a critical element of safe driving). It also reduces vigilance, alertness and concentration so that the ability to perform attention - based activities (such as driving) is impaired. The quality of decision - making may also be affected. Fatigue is related to a whole range of reasons, from lifestyle to the actual time driving. Sleepiness refers to the acute risk of falling asleep and is related to the amount of time a person has been awake. The effects of sleepiness are similar to those of fatigue [i.18].

The Royal Society for the Prevention of Accidents in the UK believes that around 20 % of all accidents are related to fatigue [i.19]. A German study in 1991 concluded that 24 % of all crashes on Bavarian motorways were related to drivers falling asleep at the wheel [i.20]. A Dutch study in 2011 showed that particularly long-distance truck drivers are more than double as likely to fall asleep on the wheel than drivers of passenger cars: 23 % compared to 10 % [i.17].

Fatigue related accidents tend to lead to more fatalities and serious injuries, the reduced reaction time of the driver or absence of reaction (in case of sleep) results in high-speed impacts. The role of fatigue in commercial transport is lower than for overall road transport, still fatigue related accidents involving HGV result in unproportionally high fatality rates. The European Transport Safety Council (ETSC) found in 2001 that fatigue only played a role in 6 % of analysed crashes involving HGV, 37 % of them led to fatalities [i.21].

A.1.3 Passenger Transport

In 2012 8,2 % of all passenger transport or 826 billion passenger kilometres was driven by bus or coach. Coach and bus transport has increased in importance with EU enlargement. The market is highly segmented in size and type. It is dominated by enterprises owning an average of 16 vehicles. The market is highly competitive and price sensitive, with labour costs being a key part of the costs [i.25].

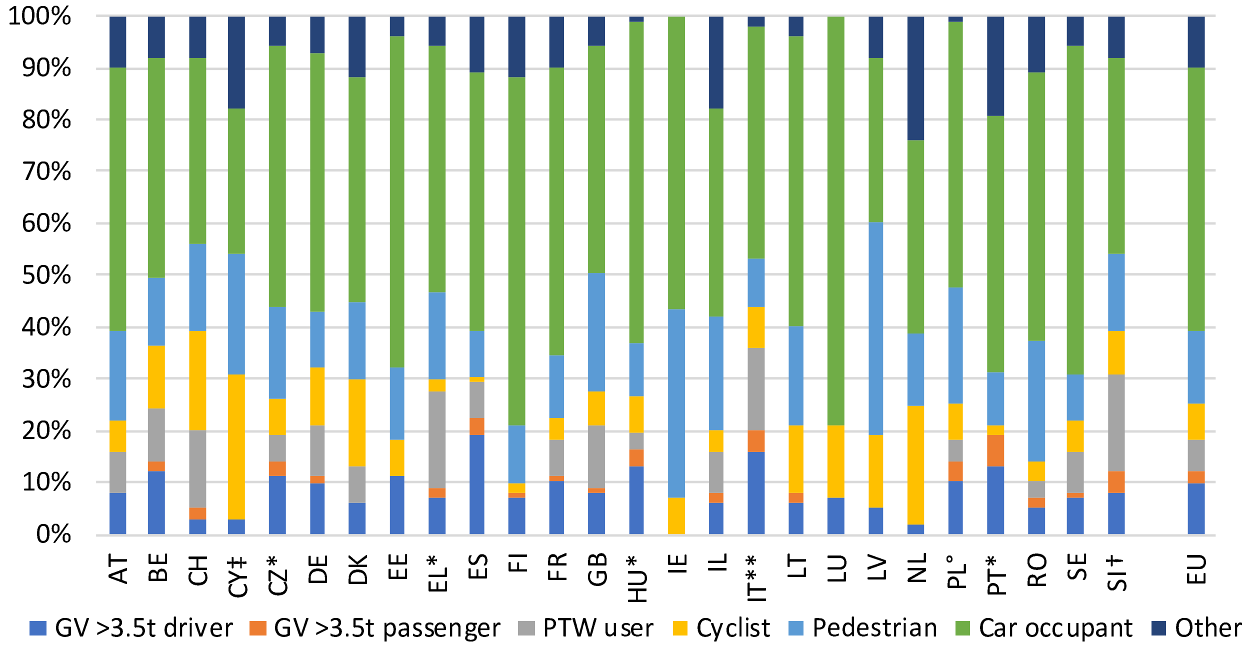
A.2 Motivation for regulation of weights & dimensions

A.2.1 Collision impact

The large mass of HGV translates into a greater impact when HGV collide with other road users, causing casualties. Passenger cars are particularly affected as can be seen from figure A.1, which is based on data from the European Transport Safety Council (ETSC) (see http://archive.etsc.eu/documents/Background_Tables_Flash24.pdf and http://etsc.eu/euroadsafetydata/).

Overloading vehicles further exacerbates the impact of HGV accidents and increases road safety risks. Overloading increases braking distance and increases the severity of a collision. Overloading wears the vehicle: it may lead to brake malfunction and damage the frame of the HGV or its trailers. Which in turn may also have an impact on how well the cargo is secured. All these factors reduce the steering control of an HGV and may lead to loss of control in accident situations [i.22].

Around 30 % of all controlled HGV are overloaded, loads often exceed 10 % of the authorized weight, sometimes as much as 20 % [i.23].



NOTE 1: Data averaged over the years ...
2009 to 2011 for AT, BE, CH, DE, DK, EE, ES, FI, FR, GB, IE, IL, LT, LU, LV, NL, PL, RO, SE
*) 2009 to 2010 for CZ, EL, HU, PT
**) 2008 to 2010 for IT
†) 2010 to 2011 for SI
‡) 2009 and 2011 for CY

NOTE 2: °) PL data includes all goods vehicles

Figure A.1: Percentages by type of road user of deaths in collisions involving goods vehicle over 3,5 t

A.2.2 Competition

Road transport, no matter if freight or passenger transport is highly competitive. The cost sensitivity and thin margins encourage infringing on social rules or overloading the vehicle.

Overloading also undermines the traditional concept of free market forces in terms of supply and demand and the consequential price charged for the service provided. This creates prejudicial competition within the EU, as it creates an illegal and unfair advantage for some operators, allowing them to charge lower prices for the same journey, with a resulting negative effect on price levels. This can lead to non-compliance with legislation in many other areas associated with the operator, such as maintenance and driver's hours, as well as with the bona fide transport companies who are unable to compete with the haulage operators that operate illegally.

A.2.3 Road freight transport

45 % of freight in the EU is moved on roads. Around two-thirds are intra-Member State and one-third between Member States. 90 % of the enterprises in the road freight sector are small enterprises with less than 10 employees and account for around 30 % of the turn-over. Competition is mainly over price, with labour costs constituting key determinant to competitiveness [i.24].

Small freight transport operators tend to serve larger freight operators. There is a strong dependency from the large operators, most of the market is run via sub-contracts between larger operators and small operators or consortia thereof. The market is highly competitive and price-sensitive. This development is further aggravated by the expansion of the EU Single Market and the economic downturn in the past decade [i.25].

A.2.4 Infrastructure wear

A.2.4.1 Damage types

Overloaded vehicles have an impact on road surfaces and bridges. The type of damage depends on road surface. Asphalt is prone to rutting, concrete tends to crack. Bridges are further affected not only through the wear of the road surface but at risk of potential structural damage.

A.2.4.2 Road wear

There was some extensive research carried out in the Netherlands on the topic of damage to road pavement in 2001. In summary, it showed that in the Netherlands a yearly bill of € 12,0 million up to € 22,0 million is spent on national roads for repairing damage caused by overloaded vehicles. The costs for repairing secondary roads are € 5,1 million up to € 18,8 million yearly (price level 2001). The repairs also relate with traffic delays, and show a social cost of € 1,6 million up to € 3,0 million per year (price level 1997). Therefore, the road pavement damage caused by overloaded vehicles amounts to 2,3 % to 5,3 % of the budget.

From the Dutch figures, the following was extrapolated for the EU in 2005: The total road maintenance budget of the 15 EU countries is around € 10,500 million. Assuming the same percentages (2,3 % to 5,3 %) for the 15 EU countries, is the same as the Netherlands then € 239 million to € 557 million is being spent yearly on repairing road damage caused by overloaded vehicles [i.26].

A.2.4.3 Bridges

The damage caused to bridges due to vehicle overloading is an even more complex matter, here not only is the pavement on the bridge damaged, but also (parts of) the construction of the bridge may be damaged. The sensitivity to overloading depends on things like construction, materials and age. Additionally, the sensitivity to overloading varies with each type of bridge or even with each individual bridge. In general, when considering the damage to bridges the gross vehicle weight is more relevant than the increased individual axle loads. Figures on the socio-economic damage overloading causes to bridges are not easily available [i.26].

A.3 Motivation for enforcing EU Transport Policy

A.3.1 Market regulation

Considering the huge pressure on the road transport market the European Union is regulating the market to guarantee working conditions, competition and road safety.

A.3.2 Regulation of drive & rest times/digital tachograph

In 1985 Council started to regulate drive and rest times of drivers in Council Regulation (EEC) 3820/85 [i.27], establishing a set of common rules, mainly daily drive and rest times, to avoid the distortion of competition, improve road safety and provide proper working conditions for drivers. This regulation was later replaced with Regulation 561/2006 [i.28] and an implementing act to harmonise common calculation methods for drive and rest times - Commission Implementing Decision C(2011) 3759 [i.29]. The overall working time of drivers was regulated in the Working Time Directive 2002/15/EC [i.30] that regulates daily, weekly and monthly work times for drivers, employed and self-employed alike.

To enforce drive and rest times Regulation 3820/85 [i.27] already made recording equipment in commercial road transport vehicles an obligation. The recording equipment, the tachograph, is specified EU wide and is based on its own legislation. Regulation 165/2014 [i.13] on tachographs in road transport is the latest legislation (smart tachograph). It foresees in Article 9 a remote communication link for the smart tachograph to allow for enforcement authorities to facilitate targeted roadside checks.

Commission Implementing Regulation 2016/799 [i.1] specifies in Appendix 14 the 'Remote Communication Function' of the tachograph as ETSI CEN DSRC.

A.3.3 Regulation of weights & dimensions enforcement

Heavy goods vehicles transporting goods in Europe, buses and coaches, need to comply with certain rules on weights and dimensions for road safety reasons and to avoid damages to roads, bridges and tunnels. Directive 96/53/EC [i.31] sets maximum common measures, ensuring that Member States cannot restrict the circulation of vehicles which comply with these limits from performing international transport operations within their territories. To avoid that national operators benefit from undue advantages over their competitors from other Member States when performing national transport, they are bound to comply with the standards set for international transport. Directive 96/53/EC [i.31] has been amended by Directive 2015/719 [i.14].

The amendments made in Directive 2015/719 [i.14] foresees in Article 10d on-board weight sensors and remote enforcement of weights & dimensions via a DSRC interface.

Annex B: Technical information

B.1 Parameters relevant for radio regulation

B.1.1 Number of radio devices and activity factor

Since the tachograph is mandatory for HGV and busses in the EU where the maximum permissible mass of the vehicle exceeds 3,5 t ([i.28] Chapter I, Article 2), the number of vehicle units is equal to the total number of these vehicles. In the annual ACEA report [i.15] the number of HGV with a mass above 3,5 t is reported to be around 6,2 Million in the EU and the number of Busses is around 0,7 Million. Therefore, in total the number of operative vehicle units is around 7 Million within the EU.

Each country can decide how many interrogator devices (remote early detection communication reader (REDCR)) are reasonable for its territory. Therefore, it is more difficult to estimate this number. It is expected to be in the order of one interrogator per one million inhabitants. As rough estimation, this would result in around 510 REDCR in the EU.

In the roadside interrogation use cases described in clause 4.2.1 each REDCR is assumed to be used in average 6 hours a day. This results in an average of less than 10 minutes activity time of each of the 7 Million vehicle units per **year**.

When the REDCR is mounted on a gantry and part of a fixed enforcement installation as described in clause 5.1.3, it will be permanently active. Depending on the number of these fixed installations, the activity time of the vehicle units can go up to not more than 40 minutes per **year.**

When active, a REDCR is transmitting with 100 % Duty Cycle. This applies to fixed roadside interrogators and to REDCR mounted on a gantry.

Mobile interrogator devices in a vehicle or handheld devices in a garage or at the roadside are manually triggered with a TX on time between 100 ms and a second. The pause in between two readings is at least one second for the roadside use case, given by the minimum distance of vehicles on the motor way. In a garage the device will be used only occasionally with off times longer than 30 minutes.

B.1.2 Radio parameters

B.1.2.1 General information about the radio parameters

The Commission Implementing Regulation 2016/799 [i.1] specifies a thorough list of mandatory PHY and MAC parameters for the REDCR and the vehicle unit. It also specifies which of these parameters should be conformance tested in accordance with ETSI EN 300 674-1 [i.5].

In the present document, only parameters that are relevant for radio regulation i.e. radio interference are listed. A complete list is given in Appendix 14 of the Commission Implementing Regulation 2016/799 [i.1]. In addition, some of the listed parameters are taken from ETSI EN 300 674-1 [i.5], ETSI EN 300 674-2-1 [i.6], ETSI EN 300 674-2-2 [i.7], ETSI TR 102 654 [i.9], and CEN EN 12253 [i.3] and implicitly some radio parameters result from the interrogation use cases defined in clause 5.1, clause 5.1.2 and clause 5.1.3. For each of the parameters a reference to the originating document or to the use cases is given.

Some radio parameters originate from typical implementations on the market. These parameters are summarized in table 5, table 8 and table 10.

Also, the DSRC technology dictates some radio design parameters, e.g. that the vehicle unit antenna is an integral part of the DSRC-VU.

B.1.2.2 Transmitter parameters of the REDCR

The relevant transmitter parameters of the REDCR defined by the Commission Implementing Regulation 2016/799 [i.1] are summarized in table B.1. Additional radio parameters of typical implementations can be found in table B.2.

Table B.1: REDCR DSRC transmitter parameters from the Commission Implementing Regulation 2016/799 [i.1]

Item No	Parameter	Value(s)	Remark
D1	Downlink Carrier Frequencies	There are four alternatives which may be used by an REDCR: • 5,7975 GHz • 5,8025 GHz • 5,8075 GHz • 5,8125 GHz	within CEPT/ERC Rec. 70-03. Consistent with: CEN EN 12253 [i.3] and CEN EN 13372 [i.4]. Frequencies are selected by the implementer of the REDCR.
D1a (*)	Tolerance of Carrier Frequencies	within ±5 ppm	Consistent with CEN EN 12253 [i.3].
D2 (*)	REDCR Transmitter Spectrum Mask	***Class B:*** • Co-channel uplink at 1,5 MHz: ≤ -17 dBm in 500 kHz. • Co-channel uplink at 2,0 MHz: ≤ -27 dBm in 500 kHz. • Adjacent channel uplinks: ≤ -37 dBm in 500 kHz. ***Class C:*** • Co-channel uplink at 1,5 MHz: ≤ -27 dBm in 500 kHz. • Co-channel uplink at 2,0 MHz: ≤ -27 dBm in 500 kHz. • Adjacent channel uplinks: ≤ -47 dBm in 500 kHz.	Within CEPT/ERC Rec. 70-03. According to Class B and Class C as defined in CEN EN 12253 [i.3].
D4 (*)	Maximum E.I.R.P.	E.I.R.P. ≤ +33 dBm Within CEPT/ERC Rec. 70-03 [i.10] (unlicensed) and within National Regulation.	Consistent with CEN EN 12253 [i.3].
D4a	Angular E.I.R.P. mask	According to declared and published specification of interrogator designer.	Consistent with CEN EN 12253 [i.3].
D5	Polarization	Left hand circular.	Consistent with CEN EN 12253 [i.3].
D5a	Cross Polarization (XPD)	In boresight: XPD_{BS} ≥ 15 dB -3 dB out of boresight: XPD_{-3dB} ≥ 10 dB	Consistent with CEN EN 12253 [i.3].
D6 (*)	Modulation	Two level amplitude modulation.	Consistent with CEN EN 12253 [i.3].
D6a (*)	Modulation Index	0,5 to 0,9.	Consistent with CEN EN 12253 [i.3].
D6b	Eye Pattern	≥ 90 % (time) / ≥ 85 % (amplitude).	
D7 (*)	Data Coding	FM0: '1' bit has transitions only at the beginning and end of the bit interval. '0' bit has an additional transition in the middle of the bit interval compared to the '1' bit.	Consistent with CEN EN 12253 [i.3].
D8 (*)	Bit rate	500 kBit/s.	Consistent with CEN EN 12253 [i.3].
D8a	Tolerance of Bit Clock	better than ±100 ppm.	Consistent with CEN EN 12253 [i.3].
NOTE: REDCR DSRC transmitter parameters subject to conformance testing in accordance with relevant parameter test from ETSI EN 300 674-1 [i.5] are marked with an asterisk (*).			

Table B.2: REDCR DSRC transmitter parameters from typical implementations to fulfil the requirements of different use cases

Item No	Parameter	Value(s)	Remark
D4	Typical E.I.R.P. in boresight	Requirement from CEN EN 12253 [i.3]: E.I.R.P. ≤ +33 dBm: • For the use cases described in clause 4.2.1 (interrogator) and clause 5.1.3 (gantry): E.I.R.P. = +33 dBm typically. • For the use case in the garage described in clause 5.1.2 typically: E.I.R.P. < +33 dBm.	For an REDCR boresight is typically parallel with the road surface or tilted 45° downwards from a gantry.
D4a	Typical angular E.I.R.P. mask	Requirement from CEN EN 12253 [i.3]: $\lvert\Theta_{vd}\rvert$ ≤ 70°: E.I.R.P. ≤ +33 dBm (≤ D4) $\lvert\Theta_{vd}\rvert$ > 70°: E.I.R.P.≤ +18 dBm (D4 - 15 dB)	Θ_{vd} is the angle deviation from the vertical downward direction. Θ_{vd} is equal to the elevation plus 90°. For an REDCR boresight is typically parallel with the road surface or tilted 45° downwards from a gantry. Typical antenna diagrams are shown in clause 5.3.2.
D16	Duty Cycle	See activity factor in clause B.1.1.	Based on use cases defined in clause 4.2.1 and clause 5.1.

B.1.2.3 Transmitter parameters of the vehicle unit

The relevant transmitter parameters of the DSRC-VU defined by the Commission Implementing Regulation 2016/799 [i.1] are summarized in table B.3.

Table B.3: DSRC vehicle unit transmitter parameters from the Commission Implementing Regulation 2016/799 [i.1]

Item No.	Parameter	Value(s)	Remark
U1 (*)	Sub-carrier Frequencies	The DSRC-VU supports: • 1,5 MHz and • 2,0 MHz	Selection of sub-carrier frequency (1,5 MHz or 2,0 MHz) depends on the CEN EN 13372 [i.4] profile selected.
U1a (*)	Tolerance of Sub-carrier Frequencies	within ±0,1 %.	Consistent with CEN EN 12253 [i.3].
U1b	Use of Side Bands	Same data on both sides.	Consistent with CEN EN 12253 [i.3].
U2 (*)	Transmitter Spectrum Mask	1) Two options for f_{Tx} ± 1,5 MHz, f_{Tx} ± 2 MHz, f_{Tx} ± 3 MHz, f_{Tx} ± 3,5 MHz, f_{Tx} ± 6,5 MHz, and f_{Tx} ± 7 MHz Set A: -39 dBm in 500 kHz bandwidth Set B: -35 dBm in 500 kHz bandwidth The limit is not valid for the used sub-carrier frequency, i.e. 1,5 MHz or 2 MHz. 2) In band TX power level ≤ U4a in 500 kHz. 3) Emission in any other uplink channel: - 35 dBm in 500 kHz bandwidth.	Consistent with CEN EN 12253 [i.3] and ETSI EN 300 674-1 [i.5].
U4a (*)	Maximum Single Side Band E.I.R.P. (boresight)	Two options: • U4a-0: -14 dBm • U4a-1: -21 dBm	Consistent with CEN EN 12253 [i.3]. According to declared and published specification of equipment designer.
U4b (*)	Maximum Single Side Band E.I.R.P. (35°)	Two options: • Not applicable • - 17 dBm	Consistent with CEN EN 12253 [i.3]. According to declared and published specification of equipment designer.
U5	Polarization	Left hand circular.	Consistent with CEN EN 12253 [i.3].
U5a	Cross Polarization	In boresight: XPD_{BS} ≥ 10 dB -3 dB out of boresight: XPD_{-3dB} ≥ 6 dB	Consistent with CEN EN 12253 [i.3].
U6	Sub-Carrier Modulation	2-PSK. Encoded data synchronized with sub-carrier: Transitions of encoded data coincide with transitions of sub- carrier.	Consistent with CEN EN 12253 [i.3].
U6b	Duty Cycle	Duty Cycle: 50 % ± α, α ≤ 5 % (see also activity factor in clause B.1.1)	Consistent with CEN EN 12253 [i.3].
U6c	Modulation on Carrier	Multiplication of modulated sub- carrier with carrier.	Consistent with CEN EN 12253 [i.3].
U7 (*)	Data Coding	NRZI (No transition at beginning of '1' bit, transition at beginning of '0' bit, no transition within bit).	Consistent with CEN EN 12253 [i.3].
U8 (*)	Bit Rate	250 kbit/s.	Consistent with CEN EN 12253 [i.3].
U8a	Tolerance of Bit Clock	Within ±1 000 ppm.	Consistent with CEN EN 12253 [i.3].
U12a (*)	Conversion Gain (lower limit)	1 dB for each side band within a circular cone around boresight of ±35° opening angle and within -45° ± 45° corresponding to the plane parallel to the road surface of the installed DSRC-VU (Azimuth).	Consistent with CEN EN 12253 [i.3]. Based on the interrogation use cases defined in clause 4.2.1.
U12b (*)	Conversion Gain (upper limit)	10 dB for each side band.	Consistent, but not equal to CEN EN 12253 [i.3], due to the interrogation use cases defined in clause 4.2.1.
NOTE: Vehicle unit DSRC transmitter parameters subject to conformance testing in accordance with relevant parameter test from ETSI EN 300 674-1 [i.5] are marked with an asterisk (*).			

B.1.2.4 Receiver parameters of the REDCR

The relevant receiver parameters of the REDCR defined by the Commission Implementing Regulation 2016/799 [i.1] are summarized in table B.4. Additional radio parameters of typical implementations and from ETSI EN 300 674-2-1 [i.6] in accordance with Directive 2014/53/EU [i.8] can be found in table B.5.

Table B.4: REDCR DSRC receiver parameters from the Commission Implementing Regulation 2016/799 [i.1]

Item No.	Parameter	Value(s)		Remark
U1 (*)	Sub-carrier Frequencies	An REDCR supports: 1,5 MHz or 2,0 MHz or both. • U1-0: 1,5 MHz • U1-1: 2,0 MHz		Consistent with CEN EN 12253 [i.3]. Selection of sub-carrier frequency depends on the CEN EN 13372 [i.4] profile selected.
U5a	Cross Polarization	In boresight: -3 dB out of boresight:	XPD_{BS} ≥ 15 dB XPD_{-3dB} ≥ 10 dB	Consistent with CEN EN 12253 [i.3].
U9	Bit Error Rate (B.E.R.) for communication	$\leq 10^{-6}$		Consistent with CEN EN 12253 [i.3].
D11	Communication Zone	The spatial region within which the DSRC-VU is situated such that its transmissions are received by the REDCR with a BER. of less than that given by U9.		Consistent with CEN EN 12253 [i.3] See clause 5.3.2 for more details.
NOTE: Receiver parameters of the REDCR subject to conformance testing in accordance with relevant parameter test from ETSI EN 300 674-1 [i.5] are marked with an asterisk (*).				

Table B.5: REDCR DSRC receiver parameters from typical implementations to fulfil the requirements of different use cases

Item No.	Parameter	Value(s)	Remark
U11a	REDCR receiver sensitivity	For the use cases defined in clause 4.2.1 P_{sens} ≤ -104 dBm measured with a loss-less left hand circular polarized isotropic antenna at the location of the REDCR receive antenna. A typical value for P_{sens} is -110 dBm. See clause 5.3.2 and the note at the end of this table for more details.	This requirement comes from the interrogation use cases defined in clause 4.2.1 and clause 5.1. It is defined at the antenna, since the receiver antenna is typically an integral part of the REDCR and cannot be changed by the user.
U11b	REDCR receiver antenna gain	Typical antenna gains $G_r(\theta)$ relative to boresight gain G_b are: $\theta = 20°$ $G_r \leq G_b$ - 3 dB $\theta > 60°$ $G_r \leq G_b$ - 15 dB See clause 5.3.2 for more details and example antenna diagrams for different use cases.	This requirement comes from the interrogation use cases defined in clause 4.2.1 and clause 5.1. θ is the angle deviation from boresight. Typically, boresight is parallel with the road surface.
U14	Blocking	For an unmodulated monochromatic unwanted signal, the blocking capability is ≥ -30 dBm at a maximum allowed BER of 2 × 10^{-2} and a wanted DSRC signal 6 dB above the sensitivity limit measured at the antenna connector.	From ETSI EN 300 674-2-1 [i.6] in accordance with Directive 2014/53/EU [i.8].
U15	Protection Criteria (I/N)	-3 dB	Interference level 3 dB below receiver noise floor. See also ETSI TR 102 654 [i.9].
NOTE: The receiver sensitivity is specified in ETSI EN 300 674-2-1 [i.6] at the antenna **connector**. For an upcoming revision it is under discussion to specify several receiver classes there to take different antenna gains into account. Because the antenna is expected to be an integral part of the REDCR, it is more useful to specify the sensitivity P_{sens} at the antenna including the antenna gain. Since the antenna gain is practically irrelevant for the system performance when the sensitivity at the antenna stays the same, this avoids the complication and possible misinterpretation of different sensitivity classes for different antenna gains.			

B.1.2.5 Receiver parameters of the vehicle unit

The relevant receiver parameters of the DSRC-VU defined by the Commission Implementing Regulation 2016/799 [i.1] are summarized in table B.6. Additional radio parameters of typical implementations and from ETSI EN 300 674-2-1 [i.6] in accordance with Directive 2014/53/EU [i.8] can be found in table B.7.

Table B.6: DSRC-VU receiver parameters from the Commission Implementing Regulation 2016/799 [i.1]

Item No.	Parameter	Value(s)		Remark
D3	DSRC-VU Minimum Frequency Range	5,795 GHz to 5,815 GHz		Consistent with CEN EN 12253 [i.3].
D5a	Cross-0	In boresight: -3 dB out of boresight:	XPD_{BS} ≥ 10 dB XPD_{-3dB} ≥ 6 dB	Consistent with CEN EN 12253 [i.3].
D9 (*)	Bit Error Rate (B.E.R.) for communication	≤ 10^{-6} when incident power level at DSRC-VU is in the range given by D11a to D11b.		Consistent with CEN EN 12253 [i.3].
D10	Wake-up trigger for DSRC-VU	DSRC-VU wakes up on receiving any frame with 11 or more octets (including preamble).		Consistent with CEN EN 12253 [i.3]. No special wake-up pattern is necessary. DSRC-VU may wake up on receiving a frame with less than 11 octets.
D10a	Maximum Start Time	≤ 5 ms		Consistent with CEN EN 12253 [i.3].
U11	Communication Zone	The spatial region within which the VU is situated such that its transmissions are received by the VU with a BER. of less than that given by D9.		Consistent with CEN EN 12253 [i.3]. See clause 5.3.1 for more details.
D11a (*)	Power Limit for communication (upper).	- 24 dBm		Consistent with CEN EN 12253 [i.3].
D11b (*)	Power Limit for communication (lower). (receiver sensitivity including antenna gain)	Incident power: - 43 dBm in boresight - 41 dBm within -45° ± 45° corresponding to the plane parallel to the road surface of the installed DSRC-VU (Azimuth)		Consistent, but not equal to CEN EN 12253 [i.3]. Extended requirement for horizontal angles up to ±45°, due to the use cases defined in clause 4.2.1.
D12 (*)	Cut-off power level of DSRC-VU	- 60 dBm		Consistent with CEN EN 12253 [i.3].
NOTE: Receiver parameters of the vehicle unit subject to conformance testing in accordance with relevant parameter test from ETSI EN 300 674-1 [i.5] are marked with an asterisk (*).				

Table B.7: DSRC-VU receiver parameters from typical implementations to fulfil the requirements of different use cases

Item No.	Parameter	Value(s)	Remark
D11c	DSRC-VU receiver antenna gain	The receiver antenna is an integral part of the DSRC-VU and cannot be changed by the user. The receiver antenna gain is chosen by the equipment designer in accordance with the intended use of the device conforming parameters D5a, D11a and D11b.	This requirement comes from the interrogation use cases defined in clause 4.2.1 and clause 5.1. A typical antenna diagram is shown in figure 3.
D14	Blocking	For an unmodulated monochromatic unwanted signal 50 MHz out of band, a maximum allowed BER of 10^{-6}, and a wanted DSRC signal 6 dB above the sensitivity limit, the blocking capability at the antenna is given by following two options: • Class 1: -35 dBm • Class 2: -30 dBm	From ETSI EN 300 674-2-2 [i.7] in accordance with Directive 2014/53/EU [i.8].
D15	Protection Criteria (I/N)	-3 dB	Interference level 3 dB below receiver noise floor. See also ETSI TR 102 654 [i.9].

Annex C: Relation to existing spectrum regulation

C.1 Short Range Devices (SRD)

C.1.1 General regulation for SRD

All SRD are regulated by CEPT/ERC recommendation 70-03 [i.10] and EC DEC 2006/771/EC [i.33] (amended by (EU) 2017/1483 [i.34]). These EC decisions are based on ECC Report 109 [i.62], CEPT Report 26 [i.63], CEPT Report 44 [i.64], and CEPT Report 59 [i.65].

General studies on spectrum efficiency and spectrum harmonisation for the SRD frequency bands can be found in CEPT Report 005 [i.66], CEPT Report 014 [i.67], and ECC Report 181 [i.68].

C.1.2 Non-specific short range devices

The frequency band 5 725 MHz to 5 875 MHz is also allocated for nonspecific short range devices (SRD) specified by ETSI EN 300 440 [i.32] and regulated by the commission implementing Decision (EU) 2017/1483 [i.34].

C.1.3 Road tolling and other DSRC equipment

Road tolling is using the same DSRC technology and frequency range as the digital tachograph and the enforcement of weights & dimensions specified in the harmonised standards ETSI EN 300 674-2-1 [i.6] and ETSI EN 300 674-2-2 [i.7]. Therefore, the Commission Implementing Regulation 2016/799 [i.1] foresees a guard distance of 200 m to any other DSRC application.

C.2 ITS-G5

The interference from ITS-G5 to a DSRC-VU has been investigated by ECC and by ETSI. The results are reported in ETSI TR 102 960 [i.35], ECC Report 101 [i.39], and ECC Report 228 [i.38]. Several mitigation techniques are specified in ETSI TS 102 792 [i.36]. The implementation of these mitigation measures is mandated for ITS-G5 systems by the harmonised standard ETSI EN 302 571 [i.37].

These mitigation techniques foresee ITS stations that send out a mitigation message to protect mobile DSRC installations, or an entry in a geoposition database for the protection of fixed DSRC installations. For the operation of the digital tachograph and the enforcement of weights & dimensions these measures should be implemented to make an operation free of harmful interference possible.

C.3 Radio networks

Different radio network services were standardized and studied that use the same band as the digital tachograph and the enforcement of weights & dimensions:

- Broadband Radio Access Networks specified in ETSI EN 302 502 [i.40].
- Wireless Access Systems including Radio Local Area Networks studied in CEPT Report 57 [i.41] and CEPT Report 64 [i.42].
- Radio Local Area Networks studied in ECC Report 244 [i.43].
- Fixed Wireless Access studied in ECC REPORT 68 [i.45].
- Broadband Fixed Wireless Access following the ECC Recommendation (06)04 [i.46].

- Broadband Wireless Access studied in CEPT Report 015 [i.47].
- The HIPERLAN study in the ERC REPORT 72 [i.44] from 1999 might be outdated.

C.4 Wireless industrial applications

The radio interface of wireless industrial applications is described in the system reference document ETSI TR 102 889-2 [i.48] and specified in ETSI EN 303 258 [i.49]. The results of the frequency sharing studies are summarized in the ECC Report 206 [i.50].

C.5 Radars

There are three different radar applications in the same band:

- Weather radars
- Tank level probing
- Military radars

Technical characteristics of weather radars can be found in ECC Report 157 [i.51].

C.6 Disaster relief

Compatibility studies and spectrum requirements of disaster relief applications can be found in ECC REPORT 102 [i.52] and ECC Report 110 [i.53].

C.7 Ultra wide band

The transmit power levels of equipment using Ultra Wide Band technology in the 5,8 GHz frequency range is very low. Requirements for the usage of this technology in vehicles are given in ETSI EN 302 065-3 [i.54]. Other applications of Ultra Wide Band technologies are listed in CEPT Report 010 [i.55]. The technology usage is regulated by the ECC Decision (06)04 [i.57] and the Commission decision 2009/343/EC [i.56].

C.8 Other radio applications

Other radio applications also using the frequency band 5 725 MHz to 5 875 MHz or adjacent bands are:

- Industrial scientific and medical (ISM).
- Amateur radios as specified in ETSI EN 301 783 [i.58].
- Broadband Direct-Air-to-Ground Communications as studied in ECC Report 210 [i.59].
- Fixed satellite services, earth stations as studied in ECC Report 272 [i.60].

C.9 Other compatibility studies

ECC Report 109 [i.62] comprises the results of compatibility studies for several different systems in the 5 725 MHz to 5 925 MHz band.

ECC Report 250 [i.61] comprises the results of compatibility studies between road tolling TTT/DSRC in the band 5 805 MHz to 5 815 MHz and other services/systems.

Annex D: Expected compatibility issues

D.1 Short range devices (SRD)

Nonspecific SRD might cause interference to the digital tachograph and the enforcement of weights & dimensions when operated in vehicles or when in line of sight (e.g. when built into drones).

The interference to such devices is expected be limited to a small area close to the REDCR.

For any other DSRC application, the Commission Implementing Regulation 2016/799 [i.1] foresees a guard distance of 200 m.

D.2 ITS-G5

Based on compatibility studies with CEN DSRC road tolling, ITS-G5 is expected to cause interference to the digital tachograph and the enforcement of weights & dimensions without mitigation techniques.

When the mitigation techniques specified in ETSI TS 102 792 [i.36] are implemented as mandated for ITS-G5 systems by the harmonised standard ETSI EN 302 571 [i.37] no compatibility issues are expected.

D.3 Radio networks

Whether radio network applications are interfered by the digital tachograph and the enforcement of weights & dimensions is unclear. Interference from fixed radio links to the REDCR cannot be totally ignored but it is expected to happen extremely seldom.

D.4 Wireless industrial applications

Close to motorways interference from and to wireless industrial applications is possible, this needs further investigation.

D.5 Radars

Both, interference from and to radars is possible, but expected to happen extremely seldom.

D.6 Ultra wide band

The output power level of Ultra Wide Band technologies in the 5,8 GHz band is very low. Therefore, no harmful interference to the REDCR is expected. But when such a device is built into a vehicle close to the DSRC-VU, the compatibility to a DSRC-VU could be an issue.

D.7 Other applications

Disaster relief applications will be operated very seldom and not at the same time and region where the digital tachograph and the enforcement of weights & dimensions is operated. Therefore, there is no frequency sharing issue expected.

ISM applications are not expected to be operated on motorways and fixed satellite service earth stations are also not expected to be operated close to motorways. Therefore, frequency sharing should be possible.

The impact of Broadband Direct-Air-to-Ground on CEN DSRC tolling applications was already studied in ECC Report 210 [i.59].

History

Document history		
V1.1.1	September 2018	Publication