ECC Report <No>

Coexistence between RMR in the 900 MHz range and other applications in adjacent bands

approved DD Month YYYY

0 EXECUTIVE SUMMARY

The present ECC Report studies the compatibility of Railway Mobile Radio (RMR) in the 900 MHz range with adjacent applications as part of the answer to the mandate from the European Commission on FRMCS.

The studies show that the 900 MHz frequency range is feasible for RMR systems, under the condition that the RMR cab-radio fulfils some blocking requirements more stringent than those currently specified by 3GPP for band #8.

tbc

Requirements on RMR BS:

Table 1: Requirements on GSM-R and FRMCS BS receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 31 dB
Maximum CW interfering signal in 870-874.4 MHz Note 2	-2430 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: These requirements cover both blocking and 3rd-order intermodulation. It is up to ETSI to define a relevant interfering signal against which the conformity test will be performed. In this Report, the interfering signal considered is 200 kHz wide.

Requirements on GSM-R cab-radio:

Table 2: Additional requirements on GSM-R cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum 1 RB interfering signal in 916.1-918.9 MHz Note 2	-210 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: These requirements cover both blocking and 3rd-order intermodulation. It is up to ETSI to define a relevant interfering signal against which the conformity test will be performed. In this Report, the RFID interfering signal considered is 400 kHz wide.

Improved GSM-R cab-radios as per ETSI TS 102 933-1 are currently under deployment and do not fulfil the requirement above. Considering this and the specific equipment life cycle in the railway environment, anAn alternative mitigation technique can be to register at national level the location of the RFID interrogators[1] so that they can be coordinated to avoid harmful interference to GSM-R cab-radios. HenceConsidering this and the specific equipment life cycle in the railway environment which applies to the GSM-R improved cab-radios currently under deployment, the additional requirement in the table above can be made optional in the ETSI specification only for the GSM-R cab-radio.

GSM-R carrier at 919.6 MHz:

In some cases, the GSM-R cab-radio receiving at 919.6 MHz may face harmful interference from 25 mW SRD due to blocking.

The coupling loss required may lead in some cases to harmful interference for the GSM-R cab-radio operating at 919.6 MHz. [It is thus proposed to have a 200 kHz guard-band in 919.3-919.5 MHz between SRD and RMR. XOR No protection can be ensured to a GSM-R carrier centred at 919.6 MHz, meaning that this specific carrier

[1] This procedure is allowed as per Note 7 relative to the table on the harmonised technical conditions for SRD in Decision (EU) 2018/1538.

would be harmonised on a non-protected basis. XOR Hence the GSM-R carrier centred at 919.6 MHz would be excluded from the harmonisation measure.]

Requirements on FRMCS cab-radio:

Table 3: Requirements on FRMCS cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum ~~1 RB~~ interfering signal in 880-918.9 MHz Note 3	-21~~0~~ dBm
Maximum CW interfering signal in 925.6-927 MHz	-13 dBm
Maximum CW interfering signal in 927-960 MHz	-10 dBm
Maximum 5 MHz LTE interfering signal (lowest carrier at 927.6 MHz)	-13 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: These requirements cover both blocking and 3rd-order intermodulation.
Note 3: It is up to ETSI to define a relevant interfering signal against which the conformity test will be performed. In this Report, the RFID interfering signal considered is 400 kHz wide.

Furthermore, in order to ensure a peaceful coexistence between RFID interrogators, including when used in private sidings, and RMR cab-radios above 919.4 MHz, it is necessary that RFID interrogators fulfil a spurious emission level of -36 dBm/100kHz above 919.6 MHz.

No additional requirement is necessary on unwanted emissions from other SRD.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
ACLR	Adjacent Channel Leakage Power Ratio
BS	Base Station
CEPT	European Conference of Postal and Telecommunications Administrations
CSS	Chirp Spread Spectrum
DC	Duty Cycle
DL	Downlink
EC	European Commission
ECC	Electronic Communications Committee
e.i.r.p.	equivalent isotropic radiated power
EN	European Norm
ERM	Electromagnetic compatibility and Radio spectrum Matters
e.r.p.	effective radiated power
ETSI	European Telecommunications Standards Institute
E-UTRA	Evolved Universal Terrestrial Radio Access
FFR	Fractional Frequency Reuse
FRMCS	Future Railway Mobile Communication System
GSM-R	Global System for Mobile communications for Railway
ICI	Inter-Cell Interference
LTE	Long Term Evolution
MFCN	Mobile and Fixed Communication Networks
MSR	Multi-Standard Radio
NAP	Network Access Point
NBN	Narrow-Band Network
NN	Network Node
NR	New Radio
OOB	Out-Of-Band
RED	Radio Equipment Directive
RFID	Radio Frequency Identification
RMR	Railway Mobile Radio
RxQual	Reception Quality

Abbreviation	Explanation
Sens	Sensitivity
SRD	Short Range Devices
TC RT	Technical Committee for Rail Telecommunications (ETSI)
TN	Terminal Node
TR	Technical Report
TRR	Tactical Radio Relay
TS	Technical Specification
UAS	Unmanned Aircraft System
UE	User Equipment
UIC	Union Internationale des Chemins de fer
UL	Uplink
UNB	Ultra-Narrow Band
WBN	Wide-Band Network
Max_I_{IB}	Maximum in-block emission of the interferer at the cab-radio antenna connector
Max_I_{OOB}	Maximum unwanted output power of the interferer

1 INTRODUCTION

The present ECC Report gathers the technical studies on Railway Mobile Radio (RMR) in the 874.4-880 MHz / 919.4-925 MHz band to answer the mandate from the European Commission on the Future Railway Mobile Communication System (FRMCS). In accordance with the principle of technology and service neutrality, a variety of technologies could be deployed in the frequency band 874.4-880 MHz / 919.4-925 MHz.As per technology neutrality principle, railways will have freedom to roll out GSM-R and its successor anywhere in the 874.4-880 MHz / 919.4-925 MHz band. Hence GSM-R in 874.4-876 MHz / 919.4-921 MHz is also considered in the studies.

The EC Decision (EU) 2018/1538 harmonised the frequency bands and the related technical conditions for the availability and efficient use of spectrum by short-range devices within the 874-874.4 MHz and 915-919.4 MHz frequency bands.

The following cases are to be studied:

- Coexistence with MFCN
  - Impact of MFCN BS above 925 MHz on RMR cab-radio in 919.4-925MHz
  - Impact of MFCN aerial UE below 915 MHz on RMR cab-radio in 919.4-925 MHz
  - Requirements for additional filtering in RMR cab-radio
- Coexistence with SRD
  - Impact of 500mW networked SRD on RMR BS around 874.4 MHz
  - Impact of RFID on RMR cab-radio around 919.4 MHz
  - Impact of 500mW networked SRD on RMR cab-radio around 919.4 MHz
  - Impact of networked wideband data transmission on RMR cab-radio around 919.4 MHz
  - Impact of non-specific 25mW SRD on RMR cab-radio around 919.4 MHz
  - Requirements for additional filtering in RMR cab-radio

[Impact of out of-band and spurious emissions from these applications adjacent to RMR are not studied in this Report.] ECC Report 200 assessed the impact of SRD unwanted emissions on GSM-R terminals based on the assumptions available at that time; some parameters are not up to date (e.g. C/(N+I), antenna height, propagation model, etc.) and FRMCS was not considered.

Furthermore,The adjacent channel compatibility studies between governmental systems (UAS and TRR) and RMR are not studied in thise present Report.

2 FREQUENCY USE

This section is aimed at depicting the frequency range occupation under consideration in the 900 MHz range.

Figure 1: Band plan for 870-880 MHz

Note: 500mW SRD in data networks are harmonised in 874-874.4 MHz in the Decision EU 2018/1538, while the band 870-874.4 MHz is listed in ERC Recommendation 70-03 Annex 2.

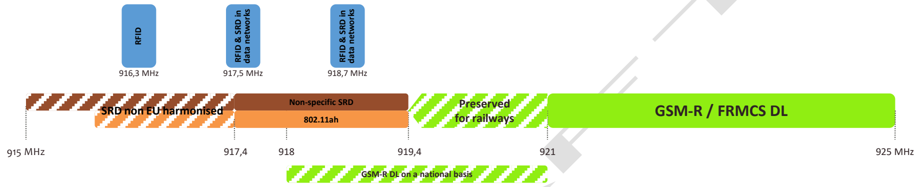

Figure 2: Band plan for 915-925 MHz

Notes:

- 25 mW non-specific SRD are harmonised in 917.4-919.4 MHz in the Decision EU 2018/1538, while the band 915-919.4 MHz is listed in ERC Recommendation 70-03 Annex 2.
- Wideband data transmission (802.11ah on the figure) is harmonised in 917.4-919.4 MHz in the Decision EU 2018/1538, while the band 915.8-919.4 MHz is listed in ERC Recommendation 70-03 Annex 3.
- The 874-874.4 MHz and 915-919.4 MHz frequency bands are harmonised at EU level for short-range devices under Decision (EU) 2018/1538[2].
- At present it is known that 3 countries in Europe are using these the frequency band 873-876 MHz / 918-921 on a national basis for GSM-R[3]. In some CEPT countires, these bands are used by other governmental systems.

~~For GSM-R, the band 873-876 MHz / 918-921 MHz may be used on a national basis[4]. Furthermore, in some CEPT countires, these bands are used by governmental systems.~~

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018D1538&from=EN

[3] Germany, Switzerland and Liechtenstein

[4] ~~This band is not harmonised neither at EU level nor at CEPT level. Three CEPT countries, Germany, Switzerland and Liechtenstein, are currently using the band 873-876 MHz / 918-921 MHz for GSM-R.~~

3 RMR TECHNICAL PARAMETERS

RMR encompasses GSM-R and FRMCS, where GSM-R is a narrowband system based on GSM/GPRS/EDGE and FRMCS is a wideband system based on LTE/NR.

All values not related to specifications are typical values provided by the industry.

Table 4: BS characteristics

Parameter	Value	Reference
Frequency band	874.4-880 MHz (UL) / 919.4-925 MHz (DL)	
Antenna gain	17 dBi	
Feeder and coupling losses	4 dB	
Noise figure	5 dB	Report ITU-R M.2039-3 Table 5 (interface No. 4) Table 2 (interface No. 1)
Protection criterion	D = 1 dB	cf. Annex 2

D = desensitization

Table 5: Cab-radio characteristics

Parameter	Value	Comment
Antenna	HUBER+SUHNER 1399.99.0121	*
Antenna height	4m	
Maximum antenna gain	5 dBi	
HW losses	3 dB[5]	
Noise figure	5 dB	data from cab-radio manufacturer
Protection criterion	D = 2.2 dB for GSM-R D = 1.7 dB for FRMCS	cf. Annex 2

D = desensitization

* In the horizontal plane, the cab-radio antenna pattern can be considered as omnidirectional. In the vertical plane, the cab-radio antenna pattern is as follows.

[5] It may be as high as 6 dB in some circumstances.

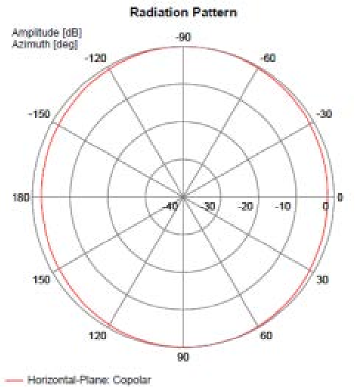

Figure 3: Cab-radio horizontal antenna pattern at 880 MHz

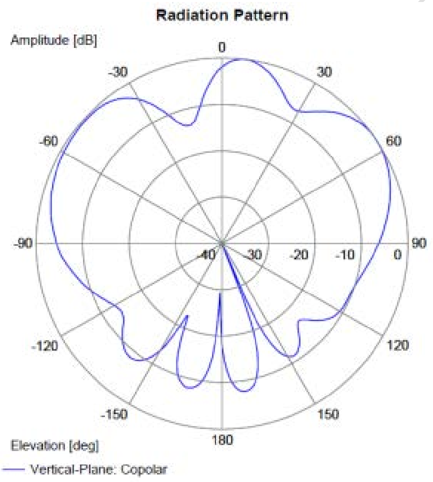

Figure 4: Cab-radio vertical antenna pattern at 880 MHz

4 COEXISTENCE BETWEEN RMR CAB-RADIO AND MFCN IN THE 900 MHZ RANGE

This section aims at determining the robustness required for the RMR cab-radio, i.e. the maximum interfering signal level from MFCN BS and MFCN "aerial UE" that a cab-radio must be able to face.

4.1 COEXISTENCE BETWEEN RMR CAB-RADIO AND MFCN BS ABOVE 925 MHZ

4.1.1 Blocking and intermodulation

Based on UIC's report O-8736 where field measurements of emissions from UMTS BS and a potential increase of MFCN BS EIRP in the long term when moving to 10 MHz channels (as described in Report ITU-R M.2292-0 Table 3) are documented, ETSI TS 102 933-1 v1.3.1 onwards has specified an enhanced blocking / intermodulation threshold for GSM-R cab-radios so that they are able to cope with MFCN emissions above 925 MHz.

Table 6: GSM-R improved cab-radio receiver characteristics

Parameter	Value
Sensitivity	-104 dBm
Level of the wanted signal	-101 dBm = Sens + 3 dB
Maximum CW interfering signal in 925.6-927 MHz	-13 dBm
Maximum CW interfering signal in 927-960 MHz	-10 dBm
Maximum 5 MHz LTE interfering signal (lowest carrier at 927.6 MHz)	-13 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: These requirements cover both blocking and 3rd-order intermodulation.

These requirements remain valid and can be directly applied to FRMCS cab-radios.

~~4.1.1~~4.1.2 Considerations on RMR minimum signal level and radio planning level~~Assessment of the proposed receiver characteristics based on field measurements~~

<Bouygues' contribution SE7(20)002A1>~~tbc~~

4.1.3 MFCN out-of-band emissions

<BNetzA's contribution SE7(19)247>

4.2 COEXISTENCE BETWEEN RMR CAB-RADIO AND MFCN AERIAL UE BELOW 915 MHZ

According to ECC Report 309, the term "aerial UE" is equally applicable to unmanned aircraft (drone) and manned aircraft.

Aerial UE characteristics:

- Max output power: 23 dBm
- Antenna gain: 0 dBi (cf. ECC Report 309)

When assuming an MFCN aerial UE at 30m separation distance[6] from the cab-radio (expected to be the minimum exclusion zone from rail tracks), the maximum interfering power Max_I_{IB} that a cab-radio must be able to face at its antenna connector can be calculated from the following formula:

$$AerialUE\_EIRP - L = Max\_I_{IB}$$

$$L = PL - G_{cab-radio} + HWlosses$$

where PL is the free space path loss, $G_{cab\text{-}radio}$ is the cab-radio antenna gain of 5 dBi, and HW losses are 3 dB.

$$Max\_I_{IB} = 23 - 61.2 + 5 - 3 = -36.2 \text{ dBm}$$

As seen in Annex 2, the maximum acceptable desensitization for an FRMCS cab-radio (worst case compared to GSM-R) is 1.7 dB. Thus, the maximum MFCN aerial UE interfering signal below 915 MHz that an RMR cab-radio may face is -36.2 dBm for a desensitization of 1.7 dB. In order to be able to cope with MFCN aerial UE, the following receiver characteristics are required for RMR cab-radios.

Table 7: Requirements on RMR cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum 5 MHz LTE interfering signal in 880-915 MHz Note 2	-33 dBm[7]

Note 1: The antenna connector of the radio module is the reference point.
Note 2: This requirement covers both blocking and 3rd-order intermodulation.

These requirements are already fulfilled by GSM-R cab-radios specified in ETSI TS 102 933-1 (≥ -12 dBm below 915 MHz).

[6] ECC Report 309 determines separation distance needed to protect RMR cab-radio from aerial UE
[7] -36.2 dBm for a desensitization of 1.7 dB is equivalent to -33 dBm for a desensitization of 3 dB.

5 COEXISTENCE BETWEEN RMR CAB-RADIO AND SRD BELOW 919.4 MHZ

This section aims at determining the robustness required for the RMR cab-radio, i.e. the maximum interfering signal level from SRD that a cab-radio must be able to face given that the spectrum should be used to maximum efficiency. Full technical characteristics of SRD considered in this Report are given in Annex 3.

ECC Report 200 assessed the impact of SRD unwanted emissions on GSM-R terminals based on the assumptions available at that time; some parameters are not up to date (e.g. C/(N+I), antenna height, propagation model, etc.) and FRMCS was not considered.

5.1 500 MW SRD

In this study, worst case scenarios for RMR cab-radios are considered where 500 mW SRD are in close proximity to rail tracks, in direct line-of-sight and of the following types:When considering the characteristics of 500 mW SRD in data networks and the various technologies possible, two worst cases for RMR cab-radios arise:

- NAP placed above rooftop;
- NN (outdoor relay nodes) placed at 5m height.

They are not typical scenarios.

Table 8: 500 mW SRD characteristics

Parameter	Value	Comment
Upper channel	918.5-918.9 MHz	
Bandwidth	1 kHz to 200 kHz	
Maximum ERP	500 mW	
Maximum EIRP	29.1 dBm	
Antenna height	NAP: 25m *1 NN: 5m *2	*1 valid for CSS and UNB *2 valid for NBN

5.1.1 500 mW SRD NAP above rooftop

For certain types of data networks, NAP are installed at up to 25m; then the coexistence scenario for a 500 mW SRD NAP is above rooftop. In other cases, NAP are installed at 7m or 5m so is below rooftop. The worst case scenario of a NAP at 25 meters height is considered here andCoexistence between 500 mW SRD NAP above rooftop and RMR cab-radio is similar to coexistence between MFCN BS (also above rooftop) and RMR cab-radio.

From Report ITU-R M.2292-0 and ETSI TS 102 933-1, the loss L between the MFCN BS EIRP[8] and the maximum interfering power received at the cab-radio antenna connector Max_I_{IB}[9] (defined for a desensitization of 3 dB) can be deduced.

$$MFCN\_BS\_EIRP - L = Max\_I_{IB}$$

$$L = MFCN\_BS\_EIRP - Max\_I_{IB} = 58 - (-13) = 71 \text{ dB}$$

[8] 58 dBm EIRP = 46 dBm output power + 15 dBi antenna gain – 3 dB feeder loss (cf. Table 3 in Report ITU-R M.2292-0)

[9] -13 dBm (cf. ETSI TS 102 933-1)

The same loss is applied between the NAP EIRP and the interfering power received at the cab-radio antenna connector.

$$Max\_I_{IB} = NAP\_EIRP - CL = 29.1 - 71 = -41.9 \text{ dBm}$$

In order to cope with 500 mW NAP above rooftop, the maximum ~~CW~~ interfering signal below 918.9 MHz for RMR cab-radios shall be -42 dBm for a desensitization of 3 dB.

5.1.2 500 mW NN at 5m height

The purpose of this section is to assess whether a maximum interfering level of -39 dBm is sufficient for RMR cab-radios to cope with 500 mW NN at 5m height.

When assuming 25m separation distance, the loss L between the NN and the cab-radio can be described as follows:

$$L = PL - G_{cab-radio} + HWlosses$$

where $G_{cab-radio}$ is assumed to be 0 dBi since the elevation angle from the cab-radio is close to 0°. HW losses are 3 dB (cf. Table 5). The free space propagation model is used.

$$PL = 59.6 \text{ dB}$$

$$L = 59.6 - 0 + 3 = 62.6 \text{ dB}$$

The loss is 8.4 dB lower than the one related to the NAP above rooftop. Thus, in order to cope with 500 mW NN below rooftop, the maximum ~~CW~~ interfering signal below 918.9 MHz for RMR cab-radios shall be -33.5 dBm (= -41.9 + 8.4) for a desensitization of 3 dB.

This section is also valid for NAP below rooftop.

5.1.3 Receiver requirements for RMR cab-radio below 918.9 MHz

In order to face a potential densification of 500 mW SRD along rail tracks, a margin of 3 dB is added to the maximum ~~CW~~ interfering signal below 918.9 MHz for RMR cab-radios. Based on worst case scenarios, t~~T~~he following receiver characteristics are thus required for RMR cab-radios.

Table 9: Requirements on RMR cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum ~~CW~~ interfering signal in 916.1-918.9 MHz Note 2	-30.5 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: This requirement covers both blocking and 3rd-order intermodulation.

5.2 RFID

When considering the impact of RFID interrogator on RMR cab-radio, three worst case scenarios are studied (only outdoor cases are considered):

- an horizontal interrogator to scan containers from above the truck (1);
- a vertical interrogator facing the opposite direction of the rail tracks (2);
- a vertical interrogator facing the rail tracks (3).

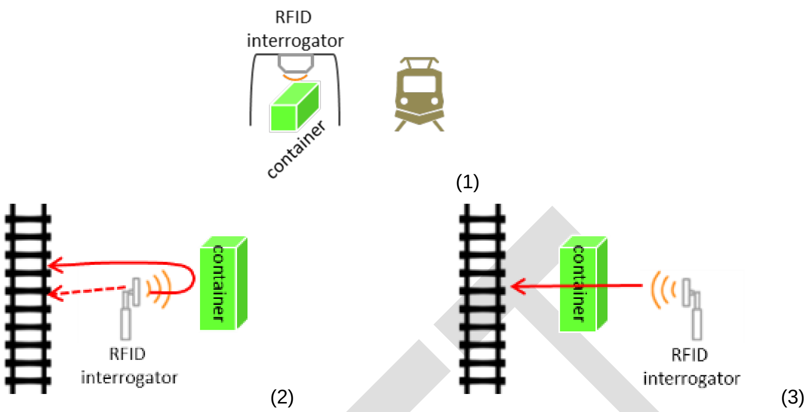

Figure 5: RFID scenarios

These scenarios reflect typical RFID use cases expected in private sidings connected to the main railway network, like in container storage areas, freight intermodal nodes, etc.

Table 10: RFID interrogator characteristics

Parameter	Value	Comment
Frequency ranges	916.1-916.5 MHz 917.3-917.7 MHz 918.5-918.9 MHz	
Bandwidth	400 kHz	
Maximum ERP	4 W	
Maximum EIRP	38.2 dBm	
Antenna	Laird™ PAV90209H	
Antenna height	4.5m for (1) 2.4m for (2) and (3)	
Maximum antenna gain	9 dBi	
Front to back ratio	18 dB	
Ground distance from rail tracks	25m for (1) and (3) 20m for (2)	

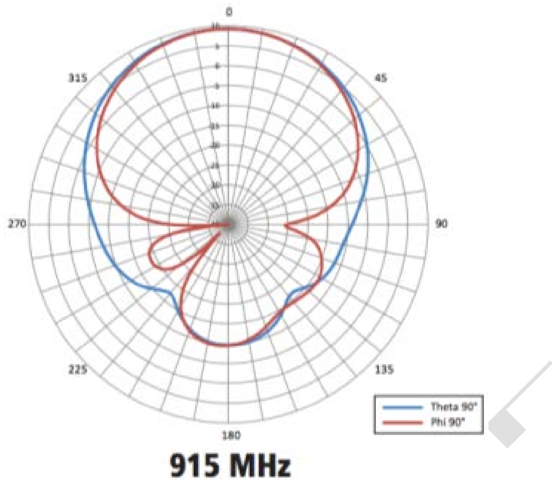

Figure 6: RFID interrogator antenna pattern
Theta = vertical plane / Phi = horizontal plane when the interrogator is placed vertically

The maximum interfering power Max_I_{IB} that a cab-radio must be able to face at its antenna connector can be calculated from the following formula:

$$RFID\_EIRP - L = Max\_I_{IB}$$

$$L = PL + D_{RFID} - G_{cab-radio} + HWlosses$$

where *PL* is the free space path loss, D_{RFID} is the RFID antenna discrimination depending on the scenario considered, $G_{cab\text{-}radio}$ is the cab-radio antenna gain including the discrimination and depending on the scenario considered, and HW losses are 3 dB.

In scenario (1): ▪ *PL* = 59.6 dB ▪ D_{RFID} = 35 dB ▪ $G_{cab\text{-}radio}$ = 0 dBi ▪ *L* = 97.6 dB ▪ Max_I_{IB} = -59.4 dBm	In scenario (2), reflection on the container: ▪ *PL* = 58.5 dB with 2m additional propagation distance towards/from the container (due to reflection) ▪ D_{RFID} = 6~~0~~ dB to account for the reflection loss ▪ $G_{cab\text{-}radio}$ = 0 dBi ▪ *L* = 67~~1~~.5 dB ▪ Max_I_{IB} = -29~~3~~.3 dBm
In scenario (2), backwards emissions: ▪ *PL* = 57.7 dB ▪ D_{RFID} = 18 dB ▪ $G_{cab\text{-}radio}$ = 0 dBi ▪ *L* = 78.7 dB ▪ Max_I_{IB} = -40.5 dBm	In scenario (3): ▪ *PL* = 59.6 dB ▪ D_{RFID} = 0 dB ▪ $G_{cab\text{-}radio}$ = 0 dBi ▪ *L* = 62.6 dB ▪ Max_I_{IB} = -24.4 dBm

As seen in Annex 2, the maximum acceptable desensitization for an FRMCS cab-radio (worst case compared to GSM-R) is 1.7 dB. Based on the worst case scenario in the table above, the maximum RFID interfering signal below 918.9 MHz that an RMR cab-radio may face is -24.4~~3.3~~ dBm for a desensitization of 1.7 dB. In order to be able to cope with 4 W RFID interrogators in worst case situations, the following receiver characteristics are required for RMR cab-radios.

Table 11: Requirements on RMR cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum RFID interfering signal in 916.1-918.9 MHz Note 2	-210 dBm[10]

Note 1: The antenna connector of the radio module is the reference point.
Note 2: This requirement covers both blocking and 3rd-order intermodulation.

5.3 OTHER 25 MW SRD

The loss *L* between the 25 mW SRD and the cab-radio can be described as follows:

$$L = PL - G_{cab-radio} + HWlosses$$

where *PL* is the path loss for 20m separation distance (worst case), $G_{cab-radio}$ is -5 dBi (below horizontal plane in Figure 4), HW losses are 3 dB (cf. Table 5). The 25 mW short-range device is considered outdoor while in most cases they are inside a building. The free space propagation model is used.

$$PL = 57.7 \text{ dB}$$

$$L = 57.7 - (-5) + 3 = 65.7 \text{ dB}$$

The maximum interfering power received at the cab-radio antenna connector Max_I_{IB} can be deduced.

$$Max\_I_{IB} = SRD\_EIRP - L = 16.1 - 65.7 = -49.6 \text{ dBm}$$

As seen in Annex 2, the maximum acceptable desensitization for an FRMCS cab-radio (worst case compared to GSM-R) is 1.7 dB. Based on the table above, the maximum 25 mW SRD interfering signal below 919.4 MHz that an RMR cab-radio may face is -49.6 dBm for a desensitization of 1.7 dB. In order to be able to cope with 25 mW SRD, the following receiver characteristics are required for RMR cab-radios.

Table 12: Requirements on RMR cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum CW interfering signal in 918.9-919.4 MHz Note 2	-46 dBm[11]

Note 1: The antenna connector of the radio module is the reference point.
Note 2: This requirement covers both blocking and 3rd-order intermodulation.

This value could be relaxed by 17 dB with respect to SRD operating indoor. This would lead to a blocking level of -63 dBm, whih is already fulfilled by both GSM-R and LTE/NR specifications. Considering:

- the elements above,
- that the requirement of a blocking level of -210 dBm below 918.9 MHz should lead to some additional filtering in 918.9-919.4 MHz,
- that only wideband data transmission devices may be operated both indoor and outdoor,

[10] -24.43.3 dBm for a desensitization of 1.7 dB is equivalent to -21.20.1 dBm for a desensitization of 3 dB.
[11] -49.6 dBm for a desensitization of 1.7 dB is equivalent to -46.4 dBm for a desensitization of 3 dB.

it is considered not necessary to define a specific requirement on RMR receivers in 918.9-919.4 MHz.

5.4 SPECIFIC CASE OF GSM-R OPERATING AT 919.6 MHZ

The lowest GSM-R carrier within the band under consideration for harmonisation is centred at 919.6 MHz.

In ETSI TS 145 005, Table 6.3-1 in section 6.3, protection ratios are specified in dB for a desensitization $D_{STANDARD}$ of 20 dB (see section 6.1).

- Co-channel, $[C/Ic]_{dB}$ = 9 dB
- First adjacent channel, $[C/Ia1]_{dB}$ = -9 dB

The selectivity can be obtained by the following formula in dB:

$$S_{a1} = I_{a1} - I_c = [C/I_c] - [C/I_{a1}] = 18 \text{ dB}$$

When considering a desentisation of 2.2 dB (cf. Annex 2) and a noise figure of 5 dB (cf. Table 5), the associated blocking level is -99.8 dBm.

The loss *L* between the SRD EIRP and the maximum interfering power received at the cab-radio antenna connector Max_I_{IB} is given by the following formulas.

$$L = SRD\_EIRP - Max\_I_{IB}$$

where SRD_EIRP is 16.1 dBm (25mW ERP).

$$L = 115{,}9 \text{ dB}$$

When the 25 mW SRD operate indoor, an additional wall loss of 17 dB should be taken into account, giving a loss of 98.9 dB. The number of SRD in close proximity to rail tracks is supposed to be a low proportion.

In some cases, the GSM-R cab-radio receiving at 919.6 MHz may face harmful interference from 25 mW SRD due to blocking.

Such a loss value may lead in some cases to harmful interference. [It is thus proposed to have a 200 kHz guard-band in 919.3-919.5 MHz between SRD and RMR. XOR No protection can be ensured to a GSM-R carrier centred at 919.6 MHz, meaning that this specific carrier would be harmonised on a non-protected basis. XOR Hence the GSM-R carrier centred at 919.6 MHz would be excluded from the harmonisation measure.]

5.5 OVERALL REQUIREMENTS ON RMR CAB-RADIO RECEIVER CHARACTERISTICS WITH RESPECT TO SRD

In order to be able to cope with SRD emissions below 919.4 MHz, the following receiver characteristics are required for RMR cab-radios.

Table 13: Requirements on RMR cab-radio receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3 dB
Maximum 1 RB interfering signal in 916.1-918.9 MHz Note 2	-210 dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: This requirement covers both blocking and 3rd-order intermodulation. It is up to ETSI to define a relevant interfering signal against which the conformity test will be performed. In this Report, the RFID interfering signal considered is 400 kHz wide.

Improved GSM-R cab-radios as per ETSI TS 102 933-1 are currently under deployment and do not fulfil the requirement above. Considering this and the specific equipment life cycle in the railway environment, an~~An~~ alternative mitigation technique can be to register at national level the location of the RFID interrogators[12] so that they can be coordinated to avoid harmful interference to GSM-R cab-radios. Hence~~Considering this and the specific equipment life cycle in the railway environment which applies to the GSM-R improved cab-radios currently under deployment~~, the additional requirement in the table above can be made optional in the ETSI specification only for the GSM-R cab-radio.

5.6 IMPACT FROM SRD SPURIOUS EMISSIONS

5.6.1 RFID interrogators

When considering the worst case scenario (3~~2~~) for RFID interrogator described in section 5.2, which gives a loss of 61.5 dB, and the maximum co-channel interfering power of -112.2 dBm/MHz that can be accepted by an FRMCS cab-radio at its antenna connector (as seen in Annex 2), the maximum spurious emission level from an RFID interrogator would be -49.6~~50.7~~ dBm/MHz.

Currently, the European Harmonised Standard EN 302 208 allows an unwanted emission level of:

- -46 dBm/kHz in 919.6-919.7 MHz;
- -36 dBm/10kHz in 919.7-922.7 MHz;
- -36 dBm/100kHz above 922.7 MHz.

This is 23.6~~5~~ to 33.6~~5~~ dB above the limit calculated in the first paragraph.

It is assumed that the scenarios considered in section 5.2 correspond to a duty cycle of 2.5% (cf. Annex 3). As a consequence, it is considered that a maximum spurious emission level of -36 dBm/100kHz from an RFID interrogator should be sufficient to ensure peaceful coexistence between RFID interrogators and RMR cab-radios in all cases, including those in private sidings.

The highest RFID interrogator channel is centred at 918.7 MHz, meaning operating in 918.5-918.9 MHz. For FRMCS, the lowest possible RB starts around 919.6 MHz. Hence, the spurious level of -36 dBm/100kHz needs to be fulfilled from 919.6 MHz upwards.

When considering ETSI TS 101 601 Annex B, it appears that such spurious limitation is feasible for RFID interrogators.

5.6.2 Other SRD

3GPP-based systems are designed to deal with typical spurious emission levels as specified in ERC/REC 74-01, noting that some specific more stringent requirements are defined within 3GPP for coexistence between BS and UE operating in different frequency bands.

With respect to 500mW SRD, it is noted that Adaptive Power Control (APC) is required, with the ability to reduce the equipment's ERP from its maximum to ≤ 5 mW.

It is thus considered that spurious emission levels defined in ERC/REC 74-01 are sufficient to ensure coexistence of SRD with RMR cab-radios.

[12] This procedure is allowed as per Note 7 relative to the table on the harmonised technical conditions for SRD in Decision (EU) 2018/1538.

6 COEXISTENCE BETWEEN RMR BS AND SRD BELOW 874.4 MHZ

This section aims at determining the robustness required for the RMR BS, i.e. the maximum interfering signal level from SRD that a BS must be able to face. Full technical characteristics of SRD considered in this Report are given in Annex 3.

6.1 500 MW SRD

When considering the characteristics of 500 mW SRD in data networks and the various technologies possible, NAP in some cases are installed below rooftop and the~~one~~ worst case for RMR BS arises when~~:~~ NAP are installed~~placed~~ above rooftop. Coexistence between 500 mW NAP above rooftop and RMR BS is similar to coexistence between two MFCN BS (also above rooftop) belonging to two different operators. The technical characteristics are provided in section 5.1.

The maximum interfering power Max_I_{IB} that a cab-radio must be able to face at its antenna connector can be calculated from the following formula:

$$NAP\_EIRP - L = Max\_I_{IB}$$

$$L = PL + D_{Rail} - G_{Rail}$$

where *PL* is free space path loss for 100m, D_{Rail} is the RMR BS antenna discrimination of 1 dB, G_{Rail} is the RMR BS antenna gain of 13 dB including the feeder and coupling losses.

$$Max\_I_{IB} = NAP\_EIRP - CL = 29.1 - 71.2 - 1 + 13 = -30.1 \text{ dBm}$$

Editor's note: This loss value may be updated based on the conclusions of PT1 regarding the coupling loss between MFCN BS and RMR BS at 920 MHz.

6.1.1 Receiver requirements for RMR BS below 874.4 MHz

In order to cope with 500 mW NAP above rooftop, the maximum ~~CW~~ interfering signal below 874.4 MHz for RMR BS shall be -30 dBm for a desensitization of 1 dB[13].

Table 14: Requirements on GSM-R and FRMCS BS receiver characteristics

Parameter	Value
Level of the wanted signal	Sens + 3~~1~~ dB
Maximum ~~CW~~ interfering signal in 870-874.4 MHz	-24~~30~~ dBm

Note 1: The antenna connector of the radio module is the reference point.
Note 2: These requirements cover both blocking and 3rd-order intermodulation. It is up to ETSI to define a relevant interfering signal against which the conformity test will be performed. In this Report, the interfering signal considered is 200 kHz wide.

6.2 IMPACT FROM 500MW SRD SPURIOUS EMISSIONS

In this case, the situation is similar to two MFCN operators immediately adjacent to each other in frequency. Hence, as in 3GPP specifications, no specific requirement is needed on 500mW SRD operating below 874.4 MHz and ERC/REC 74-01 should apply.

[13] -30 dBm for a desensitization of 1 dB is equivalent to -24.2 dBm for a desensitization of 3 dB.

7 CONCLUSION

tbc

Editor's note: copy/paste of the executive summary

ANNEX 1: EC MANDATE TO CEPT ON FRMCS

SE(18)Info041_FRMC
S Mandate to CEPT.p

ANNEX 2: PROTECTION CRITERIA FOR GSM-R AND FRMCS RECEIVERS

A2.1 INTRODUCTION

Mobile and Fixed Communication Networks (MFCN) are confronted with three main interference mechanisms: unwanted emissions from other systems, blocking and intermodulation distortion. These effects result in receiver desensitisation, which is often used as criterion to evaluate performance degradation. In that regard, several ECC reports involving MFCN have respectively considered 1 and 3 dB desensitisation as acceptable protection criterion for BS and MS, respectively. This is applicable for general public applications for which there is no stringent performance and/or availability requirement.

By contrast, GSM-R is a widely used mission-critical system which provides railway voice services and carries ETCS and whose particularities in terms of availability and interoperability must be duly taken into account. This will also be valid for FRMCS. In that regard, this annex aims at providing a suitable protection criterion in terms of “maximum allowable interference power” for both GSM-R/FRMCS BS and cab-radios which should also be made to be resilient and robust to interference.

A2.2 PROTECTION OF GSM-R AND FRMCS BS

Experience has shown that 1 dB receiver desensitisation as protection criterion for GSM-R BS (similar to MFCN BS) is sufficient to meet the performance requirements associated with GSM-R.

GSM-R networks may implement EDGE for ETCS over IP or other data applications. As such, GSM-R can be considered as an IMT-2000 system, and Report ITU-R M.2039-3 Table 5 (interface No. 4) [5] applies. This table gives a 5 dB noise figure for EDGE BS, which results in -116 dBm/200kHz total noise power[14] for a GSM-R BS.

The maximum allowable interference power must be 6 dB below the calculated noise floor for the desensitisation not to exceed 1 dB, and therefore amounts to -122 dBm/200kHz.

The 5 dB noise figure value is also applicable to LTE/NR BS, see Report ITU-R M.2039-3 Table 2 (interface No. 1). Hence the maximum allowable interference for an LTE/NR based FRMCS BS is -115 dBm/MHz.

A2.3 PROTECTION OF GSM-R CAB-RADIO

Experience has shown that 3 dB receiver desensitisation as protection criterion for MFCN UE is sufficient to meet the performance requirements associated with public mobile network operators. However, because of the criticality of GSM-R and of the high requirements on availability, this criterion is not seen as appropriate for GSM-R cab-radios.

A2.3.1 Necessary C/(N+I) at the cab-radio receiver

GSM TS 05.05 [14] clause 6.3 specifies the co-channel “reference interference ratio”, which is C/I = 9 dB, for a desensitization of 20 dB and a given “reference interference performance” defined in Table 2. With such a desensitization, it appears C/(N+I) ≈ C/I.

[14] The thermal noise equals $-174\,\mathrm{dBm/Hz}$, which leads to $-174\frac{\mathrm{dBm}}{\mathrm{Hz}} + 10 * log_{10}(200\ \mathrm{kHz}) = -121\ \mathrm{dBm}$ thermal noise for a $200\ \mathrm{kHz}$ GSM-R channel bandwidth, to which must be added the $5\ \mathrm{dB}$ noise figure.

The minimum performance that the GSM receiver must be able to achieve in this interference situation, i.e. C/(N+I) = 9 dB, is provided in Figure 1 below, which is an extract of Table 2 of GSM TS 05.05.

GSM 850, ER-GSM 900 and GSM 900						
Type of channel		Propagation conditions				
		TU3 (no FH)	TU3 (ideal FH)	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)
FACCH/H	(FE	22 %	6,7 %	6,7 %	6,7 %	5,7 %
FACCH/F	(FE	22 %	3,4 %	9,5 %	3,4 %	3,5 %
SDCCH	(FE	22 %	9 %	13 %	9 %	8 %
RACH	(FE	15 %	15 %	16 %	16 %	13 %
SCH	(FE	17 %	17 %	17 %	17 %	18 %
TCH/F14,4	(BE	10 %	3 %	4,5 %	3 %	3 %
TCH/F9,6 & H4,8	(BE	8 %	0,3 %	0,8 %	0,3 %	0,2 %
TCH/F4,8	(BE	3 %	10^{-4}	10^{-4}	10^{-4}	10^{-4}
TCH/F2,4	(BE	3 %	10^{-5}	10^{-4}	10^{-5}	10^{-5}
TCH/H2,4	(BE	4 %	10^{-4}	$2\ 10^{-4}$	10^{-4}	10^{-4}
TCH/FS	(FE	21α %	3α %	6α %	3α %	3α %
class Ib	(RBE	$2/\alpha$ %	$0{,}2/\alpha$ %	$0{,}4/\alpha$ %	$0{,}2/\alpha$ %	$0{,}2/\alpha$ %
class II	(RBE	4 %	8 %	8 %	8 %	8 %

Figure 7: Specified performance level of GSM receivers

As one can see, for a full rate transport channel (TCH/FS), the Class II Residual Bit Error Rate (RBER), which is the BER after error correction, is 8 % for all channel models, except in TU3 without FH (urban journey at 3 km/h) where it is 4 %. This performance is rather poor and corresponds to a barely intelligible voice communication. As an illustration, the table below is an extract of GSM TS 05.08 [15] which shows the mapping between BER and voice quality in GSM downlink. From this table, we can deduce that a maximum of about 3 % BER is necessary to provide an acceptable voice quality.

Table 15: BER to Voice Quality mapping in GSM downlink

RxQual	BER	Voice Quality
0	BER < 0.2 %	Very good
1	0.2 % < BER < 0.4 %	Good
2	0.4 % < BER < 0.8 %	
3	0.8 % < BER < 1.6 %	Quite good
4	1.6 % < BER < 3.2 %	
5	3.2 % < BER < 6.4 %	Poor
6	6.4 % < BER < 12.8 %	
7	12.8 % < BER	Very poor

Since GSM-R provides railway emergency calls, it cannot be operated with the performance level specified in Figure 9. Therefore, a protection criterion of C/(N+I) = 9 dB is not sufficient to meet the requirements associated with GSM-R.

Indeed, some sources in the literature indicate that a C/(N+I) = 12 dB needs to be considered as a design target:

- ECC Report 229 Table 4 [18]
- “Considerations regarding a radio planning procedure for the GSM-R network covering the Bucuresti-Constanta railway corridor” [19]
- “GSM-R Radio Planning Guidelines” [20]

Therefore, it is believed that C/(N+I) = 12 dB ensures good operation of GSM-R cab-radios, and this value will be retained in the following sections of this contribution when deriving the protection criterion for GSM-R cab-radio.

A2.3.2 Minimum guaranteed wanted signal level

State-of-the-art cab-radio receivers have a typical noise figure of 5 dB (data from cab-radio manufacturer), and therefore the noise floor is -116 dBm/200kHz (the same as in GSM-R BS receivers, see section A2.2).

Considering a necessary 12 dB C/(N+I), alongside with a 3 dB interference degradation margin[15], the minimum signal wanted signal level at the cab-radio antenna connector is -116 dBm + 12 dB + 3 dB = -101 dBm.

A2.3.3 Intra-system interference

Like every mobile network, GSM-R must accept a certain level of intra-system interference coming from adjacent cells. ECC Report 229 Table 4 [18] indicates that the intra-system interference is 20 dB on average below the wanted signal.

A2.3.4 Maximum acceptable external interference level

The minimum wanted signal level of $-101\mathrm{dBm}/200\mathrm{kHz}$ (see section A2.3.2) must be $12\ \mathrm{dB}$ above the total noise and interference[16] power, which is thus $-113\ \mathrm{dBm}/200\mathrm{kHz}$. The thermal noise power is $-116\mathrm{dBm}/200\mathrm{kHz}$ (see section A2.3.2). The internal interference level is $20\ \mathrm{dB}$ below the wanted signal level, and therefore amounts to $-121\ \mathrm{dBm}/200\mathrm{kHz}$[17]. From this, we can deduce that the maximum level of external interference at the GSM-R cab-radio receiver is:

$$10 \times \log_{10}\left(10^{-113\ \mathrm{dBm}/10} - 10^{-116\ \mathrm{dBm}/10} - 10^{-121\ \mathrm{dBm}/10}\right) = -117.7\ \mathrm{dBm}/200\mathrm{kHz}$$

This maximum level of $-117.7\mathrm{dBm}/200\mathrm{kHz}$ corresponds to a maximum desensitization of 2.2 dB acceptable at the GSM-R cab-radio antenna connector.

$$10 \times \log_{10}\left(10^{-116\ \mathrm{dBm}/10} + 10^{-117.7\ \mathrm{dBm}/10}\right) - (-116\ \mathrm{dBm}) = 2.2\ \mathrm{dB}$$

A2.4 PROTECTION OF FRMCS CAB-RADIO

The same methodology as described in the previsous sections can be applied to LTE/NR cab-radios.

---

[15] This margin allows the receiver to face a desensitization due to internal and external interference (see GSM TR 03.30 Annex A [16] and GSM TR 05.50 clause H.3.3 [17]).

[16] This accounts for both internal and external interference.

[17] -101 dBm – 20 dB, see Section A2.3.3.

Inter-cell interference (ICI) is an important limiting factor in LTE/NR networks or, more generally, in all technologies reusing the same frequencies within a limited geographical area. There are several measures that can be taken to reduce it, and a complete listing of all possibilities that could be used in FRMCS is beyond the scope of this report. The frequency reuse scheme assumed in this coexistence study is shown in the figure below. It is a very basic version of the so-called *Fractional Frequency Reuse* (FFR). It consists in configuring FRMCS BS in such a way that the antenna pointing towards the left can only use the first 25 RBs (numbered #1 to #25), and the antenna pointing towards the right, the 25 remaining RBs (numbered #26 to #50). In this way, ICI is limited to a single adjacent cell as shown below (for the sake of simplicity, radiations at the rear of antennas are not considered).

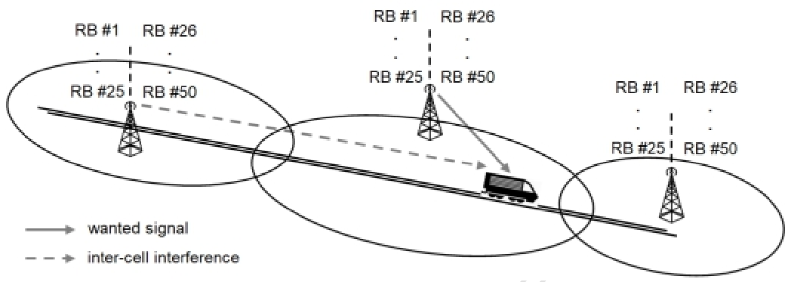

Figure 8: Assumed fractional frequency reuse scheme and inter-cell interference

As for GSM-R, it is likely that FRMCS requires a higher C/(N+I) than the one considered by 3GPP for MFCN. An increase of 5.6 dB is assumed here[18], taking into account the fractional frequency reuse.

The ratio between the wanted signal and the intra-system needs to be reassessed. According to RT(19)073016 (Figure 9) and to ECC Report [#B] on coexistence between FRMCS in 1900-1910 MHz and other applications in adjacent bands (Figure 12), the C/I_{intra} to be considered is 14 dB taking into account the fractional frequency reuse.

This gives the following results:

- For a 1.4 MHz LTE carrier, the maximum level of external interference at the FRMCS cab-radio receiver is -112.2 dBm/MHz, corresponding to a maximum desensitization of 1.7 dB acceptable at the FRMCS cab-radio antenna connector.
- For a 5 MHz LTE carrier, the maximum level of external interference at the FRMCS cab-radio receiver is -111.3 dBm/MHz, corresponding to a maximum desensitization of 2.0 dB acceptable at the FRMCS cab-radio antenna connector.

Hence a protection criterion of -112.2 dBm/MHz (i.e. desensitization of 1.7 dB) is considered for the FRMCS cab-radio.

[18] A C/(N+I) of 4 dB has been measured during a PoC conducted at 1900 MHz: it corresponds to a minimum bit rate of 2 Mb/s DL, which is roughly the DL throughput targeted after the migration (see Table 6 in ECC Report 294). The C/(N+I) value used in 3GPP is -1.6 dB; meaning the C/(N+I) increase for railway usage is around 5.6 dB.
According to 3GPP for band #39 (1900 MHz):

- Occupied BW = 9 MHz
- Noise figure = 9 dB (TR 36.942, Tables 4.6 and 4.8)
- N = -95.4 dBm
- Sens = -97.0 dBm
- C/(N+I) = -1.6 dB

ANNEX 3: SRD TECHNICAL PARAMETERS

A3.1 SRD IN DATA NETWORKS

A3.1.1 EU Commission Decision~~regulation~~

Table 16: 500 mW devices

Parameter	Value	Technology
Frequency bands	874-874.4 MHz[19]	all
	916.1-916.5 MHz[20] 917.3-917.7 MHz 918.5-918.9 MHz	all
Maximum power	500 mW e.r.p. APC required (20 dB range)	all
Duty cycle	≤ 10 % for fixed NAP ≤ 2.5 % otherwise	al
Bandwidth	≤ 200 kHz	all

Table 17: 25 mW devices

Parameter	Value
Frequency band	917.4-919.4 MHz
Maximum power	25 mW e.r.p.
Duty cycle	≤ 1 %
Bandwidth	≤ 600 kHz Typical: 200 kHz and 600 kHz

A3.1.2 Indoor/outdoor deployment ratio for TN of data networks SRD

Table 18: Assumption about the indoor/outdoor ratio of TN

	Indoor	outdoor
Scenario1	30%	70%
Scenario2	50%	50%
Scenario3	70%	30%

[19] Harmonised frequency band as per Decision EU 2018/1538

[20] Dependent upon the results of work item SE24_61

~~A3.1.2~~A3.1.3 NBN (mesh networks)

Table 19: NBN characteristics

Parameter	NAP	NN (relay)	TN (terminal)
Bandwidth	200 kHz		
Antenna height	7 m	5 m	1.5 m
Antenna pattern	Omnidirectional		
Maximum e.i.r.p.	29 dBm		
OOB emissions	cf. EN 303 204 & TR 102 886		
Maximum duty cycle	10 %	2.5 %	0.1 %
Average duty cycle	2.5 %	0.7 %	0.05~~1~~ %
Maximum density	10/km²	90/km²	1900/km²
Average density	5/km²	45/km²	950/km²
Outdoor/Indoor (%)	100/0	100/0	~~0/100~~See Table 18

Regulatory Duty Cycle parameters are based on transmissions in any continuous one hour time interval. An NBN NN with a very much lower long-term average duty cycle may occasionally operate at up to 2.5% DC when measured over a given one hour interval. Assuming that all the devices (NAP, NN or TN) within a given square kilometre will be emitting at max DC during the whole day is extremely pessimistic and even unrealistic.

~~A3.1.3~~A3.1.4 CSS (spread spectrum one-hop networks)

Table 20: CSS characteristics

Parameter	NAP	TN
Bandwidth	125 kHz **	
Antenna height	25 m (outdoor) 1.5 m (indoor)	1.5 m (indoor/ outdoor)
Antenna pattern	omnidirectional	
Maximum e.i.r.p.	29 dBm ~~/ 16 dBm~~	16 dBm
OOB emissions	cf. TR 103 526	
Maximum duty cycle	10~~0.7~~ %	1~~0.02~~ %
Typical duty cycle	0.5 %	0.007 %

Parameter	NAP	TN
Maximum density	3.5/km²	3000TBC/km²
Typical density	0.5/km²	360/km²
Outdoor/Indoor (%)	1080%/20 %	10%/90%See Table 18

Regulatory Duty Cycle parameters are based on transmissions in any continuous one hour time interval. A CSS TN with a very much lower long-term average duty cycle may occasionally operate at up to 1% DC when measured over a given one hour interval. Assuming that all the devices (NAP or TN) within a given square kilometre will be emitting at max DC during the whole day is extremely pessimistic and even unrealistic.

* It should be noted that in the proposed approach, NAP deployed with 16 dBm e.i.r.p or lower are proposed to be modelled as TN.

** One or two 250 kHz channels are also anticipated operated with an e.i.r.p of 16 dBm (NAP and TN).

A3.1.4A3.1.5 UNB (ultra-narrowband one-hop networks)

Table 21: UNB characteristics

Parameter	NAP Sc#1	NAP Sc#2	TN
Bandwidth	1 kHz	1 kHz	250 Hz
Antenna height	25 m	7 m	1.5 m
Antenna pattern	omnidirectional		
Maximum e.i.r.p.	29 dBm	29 dBm	16 dBm
OOB emissions	cf. TR 103 435		
Maximum duty cycle	10%	10%	1 %

Formatted Table

Formatted Table

Formatted Table

Parameter	NAPSc#1	NAPSc#2	TN
TypicalAverage duty cycle	0.7TBC%	3%	0.06TBC %
Maximum density	0.1TBC/km²	0.1/km²	2000TBC/km²
TypicalAverage density	0.01TBC/km²	0.01/km²	343TBC/km²
Outdoor/Indoor (%)	100%/0%TBC	100%/0%	TBCSee Table 18

Note 1: Regulatory Duty Cycle parameters are based on transmissions in any continuous one hour time interval. A UNB TN with a very much lower long-term average duty cycle may occasionally operate at up to 1% DC when measured over a given one hour interval. Assuming that all the devices (NAP or TN) within a given square kilometre will be emitting at max DC during the whole day is extremely pessimistic and even unrealistic.

In the table above the regulatory values for Max DC are indicated, along with Typical DC values reflecting long-term average behaviour.

Formatted Table

Note 2: During the discussions at SE-24, it was revealed that the UL emission mask provided in TR 103 435 has shown to be inaccurate and is currently being reviewed by ERM TG28 as a matter of urgency.

A3.2 RFID

The technical characteristics of RFID are shown in the tables below. The information contained in the tables is consistent with ECC Report 200 and harmonised standard ETSI EN 302 208 v3.1.1 (2016-11), except where noted.

Table 22: RFID characteristics

Parameters	Interrogator - Fixed	Interrogator - Handheld	Tag
Frequency range	916.1-916.5 MHz 917.3-917.7 MHz 918.5-918.9 MHz	916.1-916.5 MHz 917.3-917.7 MHz 918.5-918.9 MHz	915.5-919.5 MHz
Transmitter Power, dBm	30.2 dBm	27.0 dBm	
Bandwidth	400 kHz	400 kHz	1600 kHz (Note 1)
Tx antenna gain, dBi	8.0	2.2	
Tx radiated power (e.r.p.), dBm	36 dBm (Note 2)	27 dBm (Note 2)	-10 dBm
Maximum e.i.r.p., dBm	38.2	29.2	-7.8
Antenna height	TBD	TBD	TBD
Antenna pattern	(Note 3)	(Note 3)	
OOB emissions	cf. Figure 6 in EN 302 208	cf. Figure 6 in EN 302 208	cf. Figure 9 in EN 302 208

Note 1: The tag backscatter is contained in two sidebands 320 kHz wide at fc ±640 kHz.
Note 2: Since RFID is primarily an indoor application using passive tags which is equivalent to a semi-shielded environment, an average of 20 dBm e.r.p. is suggested for compatibility studies (see Annex 2.5 in ECC Report 200 or Annex C of ETSI TR 103 151.
Note 3: See Annex 2.5 in ECC Report 200 for typical antenna patterns for fixed (e.g. hotspot, industrial, etc) and handheld (e.g. retail store) applications.

Five scenarios are considered:

- “Hotspot”: multiple RFID interrogators in a hotspot such as a large warehouse/distribution centre (dense interrogator scenario)
- “Airport”: RFID readers on conveyors at airport terminals for baggage handling (e.g. a baggage handling hall in an airport terminal building. Such systems would be carefully designed and have to satisfy the requirements of the airport frequency management department).
- “Store”: a line of interrogators at the check-outs of a store (a row of check-out counters at a supermarket; due to shorter distances only 500 mW e.r.p. is assumed)
- “Other”: a typical concentration of RFID interrogators in an outdoor environment (any other usage not specially defined)
- “Item tagging”: RFID in a store, i.e. an additional variation of the store scenario, in which individual items are tagged so that they may be identified

Table 23: Parameters used for RFID as interferer

Parameters	RFID Use Scenarios				
	Hotspot	Airport	Store/item tagging	Industrial	Other (Note 1)
ERP (dBm)	36	36	27	24	36
Antenna Gain (dBi)	8	8	2	8	8
Building Penetration Loss (Note 2) (dB)	16	16	7	16	(Note 1)
Density (per hotspot or per sq-km, Note 3)	480	480	20	400	12
DC, per channel (%)	2.5	2	12.5	50	1
Environment	Indoor	Indoor	Indoor	Indoor	Outdoor

Note 1: The most common "Other" RFID use scenario is RFID used for Automatic Vehicular Identification (AVI). For road tolling applications the antenna read zone is confined to a vehicle lane, and for parking lot and vehicular access applications the read zone is confined by using low transmit power. Therefore, 20 dBm is suggested for ERP in compatibility studies (combined transmit power and directional attenuation).

Note 2: The building penetration loss has been measured for indoor use scenarios and is shown in the table such that transmit power, antenna gain, and building loss result in an average of 20 dBm e.r.p. (see Annex 2.5 in ECC Report 200 or Annex C of ETSI TR 103 151).

Note 3: The values in the table are taken directly from Annex 2.5 in ECC Report 200. Since the time of publication, the number of Hotspot and Airport scenarios has been limited due to several factors. While there may be some cases where the high densities may be observed, they are rare and limited to a small geographic area. To some extent the same case is also true for Industrial scenarios. The most common RFID use scenario found today is retail store/item tagging. For this scenario the values in the table may apply is the typical sense, however, for retail "hotpot" areas like shopping malls, the density of RFID interrogators can be greater than the amount shown in the table.

A3.3 WIDEBAND DATA TRANSMISSION IN DATA NETWORKS

Table 24: WBN characteristics

Parameter	Value
Frequency band	917.4-919.4 MHz
Maximum power	25 mW e.r.p.
Duty cycle	≤ 10 % for fixed NAP ≤ 2.8 % otherwise polite spectrum access
Bandwidth	> 600 kHz ≤ 1 MHz

ANNEX 4: EXAMPLES OF LOSS OBSERVED BETWEEN MFCN AND GSM-R IN THE 900 MHZ FREQUENCY RANGE

<ANFR + SNCF + Bouygues' contribution SE7(20)004>

~~ANNEX 4:~~ANNEX 5: LIST OF REFERENCES

[1] Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment

[2] Decision EU 2018/1538: Commission Implementing Decision on the harmonisation of radio spectrum for use by short-range devices within the 874-876 and 915-921 MHz frequency bands

[3] ERC Recommendation 70-03 relating to the use of Short Range Devices

[4] Report ITU-R M.2039-3: Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses

[5] Report ITU-R M.2292-0: Characteristics of terrestrial IMT-Advanced systems for frequency sharing/interference analyses

[6] UIC O-8736: Assessment report on GSM-R current and future radio environment

[7] ETSI TS 102 933-1: GSM-R improved receiver parameters; Part 1: Requirements for radio reception

[8] ETSI TS 136 101: E-UTRA; User Equipment (UE) radio transmission and reception

[9] ETSI TS 138 101-1: NR; User Equipment (UE) radio transmission and reception; Frequency Range 1

[10] ETSI TS 101 601: ERM; The specification and implementation of design changes to interrogators and specification of the test plan for the Preliminary Tests and the Trial; Modification of interrogators and specification of test plans for the Preliminary Tests and Trial

~~[10]~~[11] GSM TS 05.05: GSM/EDGE; Radio transmission and reception

~~[11]~~[12] GSM TS 05.08: GSM/EDGE; Radio subsystem link control

~~[12]~~[13] GSM TR 03.30: GSM/EDGE Radio network planning aspects

~~[13]~~[14] GSM TR 05.50: GSM/EDGE Background for Radio Frequency (RF) requirements

~~[14]~~[15] ECC Report 200: Coexistence studies for proposed SRD and RFID applications in the frequency band 870-876 MHz and 915-921 MHz

~~[15]~~[16] ECC Report 229: Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band; 2015

~~[16]~~[17] ECC Report 309: Use of MFCN for the command & control and payload links of UAs within the current MFCN harmonised regulatory framework

~~[17]~~[18] C. M. Alexandrescu, L.-M. Nemtoi; Considerations regarding a radio planning procedure for the GSM-R network covering the Bucuresti – Constanta railway corridor; Scientific Bulletin of University Politehnica of Bucharest, Series C, Vol. 73, Issue 3, 2011

~~[18]~~[19] Jernbaneverket; GSM-R Radio Planning Guidelines; 2006