CEPT Report 53

Report A from CEPT to the European Commission in response to the Mandate

“To develop harmonised technical conditions for the 694[1]-790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives”

Report approved on 28 November 2014 by the ECC

[1] Provisional lower band edge subject to precise definition within the scope of this Mandate

0 EXECUTIVE SUMMARY

This CEPT Report has been developed within European Conference of Postal and Telecommunications Administrations (CEPT) in the framework of the EC Mandate on the 700 MHz (see ANNEX 1:).

CEPT is mandated to undertake the following tasks:

1. Develop a *preferred technical (including channelling) arrangement* and identify *common* and *minimal (least restrictive) technical conditions*[2] for wireless broadband use in the 694[3]-790 MHz frequency band for the provision of electronic communications services, subject later to a precise definition of the lower band edge under task (3), as well as PPDR services that can make use of such technical conditions. These conditions should be sufficient:

    a. to avoid interference between wireless broadband use and other services in the 694[3]-790 MHz band and in adjacent bands, and in particular to ensure the appropriate protection of broadcasting and PMSE services below the lower band edge, as well as compliance with EU harmonised conditions for the 790-862 MHz band[4];

    b. to facilitate cross-border coordination, including at the EU external borders;

2. In performing (1), study the possibility of identifying *suitable spectrum to accommodate* incumbent uses in the 694[3]-790 MHz band such as PMSE (in particular wireless microphones)[5], and develop *common technical conditions* for the coexistence of such uses with wireless broadband use in the band, taking into account spectrum sharing requirements and efficient spectrum use;

3. In addition to and based on (1) and taking utmost account of the possibility of international harmonisation[6], assess the need to refine the conditions developed under (1), in particular *the common and minimal (least restrictive) technical conditions*, in order to ensure that they are sufficiently precise for the development of EU-wide equipment. The overall aim of a coordinated European approach should be considered, as implemented through detailed national decisions on frequency rearrangements in line with international frequency coordination obligations;

Task 3 will be addressed further to WRC-15.

CEPT considered the various tasks (1 and 2) as described in the EC Mandate on 700 MHz (see ANNEX 1:) and studied the following issues:

1. Preferred channelling arrangement in 694 -790 MHz

a. channelling arrangement for MFCN

In this Report MFCN is understood as a network for Wireless Broadband use for the provision of Electronic Communications Services (WBB/ECS).

CEPT confirmed the lower edge at 694 MHz as the only option to be studied in the WRC-15 preparation and discussed possible channelling arrangements on that basis. CEPT identified one channelling arrangement for mobile/fixed communications networks (MFCN).

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[2] Such as the definition of appropriate BEMs (Block Edge Masks)
[3] This provisional lower band edge is subject to a precise definition within the scope of this Mandate. It is identical with the provisional lower limit stipulated in WRC-12 Resolution 232 which is subject to additional refinement at the WRC-15
[4] Subject to Commission Decision 2010/267/EU
[5] For example in unused parts of the band such as a center gap of a potential FDD arrangement
[6] Such as resolutions at the ITU WRC-15

Within the band 694-790 MHz the MFCN channelling arrangement shall be as follows:

- The block sizes shall be in multiples of 5 MHz, which does not preclude smaller channel bandwidths within a block

- Paired frequency arrangement (FDD):
  - terminal station transmitter: 703-733 MHz
  - base station transmitter: 758-788 MHz

- Unpaired frequency arrangement
  - Supplemental downlink[7] using ‘zero up to four’ of the following frequency blocks: 738-743 MHz, 743-748 MHz, 748-753 MHz and 753-758 MHz. This decision on the number of contiguous blocks would be taken at national level. This national approach ensures flexibility for combination with other alternative options described hereafter.

Maximum inter-regional harmonisation is achieved by basing the paired channelling arrangement on the lower duplexer of the APT 700 MHz band plan allowing for economies of scale. As this would only provide for 63% utilisation of the band by MFCN, placing up to 4 blocks of 5 MHz MFCN SDL in the duplex gap would result in a utilisation of 83% by MFCN. This arrangement is illustrated in 0 and described in ANNEX 2:.

Figure 1: Channelling arrangement for MFCN in the 700 MHz band: FDD 2x30MHz and Supplemental Downlink (SDL) option in the duplex gap

694-703	703-708	708-713	713-718	718-723	723-728	728-733	733-738	738-743	743-748	748-753	753-758	758-763	763-768	768-773	773-778	778-783	783-788	788-791
Guard band	Uplink						Gap	SDL (A)				Downlink						Guard band
9 MHz	30 MHz (6 blocks of 5 MHz)						5 MHz	20 MHz (zero up to four blocks of 5 MHz)				30 MHz (6 blocks of 5 MHz)						3 MHz

(A) SDL option: There are alternative options being considered in CEPT (see description in section 1b below). “The zero up to four blocks of 5 MHz approach” provides flexibility for combining different options.

b. Alternative options for PMSE, PPDR, M2M and other services on a national basis within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30 MHz)

This section describes options other than MFCN that are being considered within CEPT as an alternative to the SDL option within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30 MHz).

Figure 2: Alternative options for PMSE, PPDR and M2M within the given channeling arrangement for MFCN in the 700 MHz band including FDD (2 x30 MHz)

Options under consideration											
Frequency bands (MHz)	694-703		703-733	733-738		738-743	743-748	748-753	753-758	758-788	788-791
	694-698	698-703		733-736	736-738						
PMSE	PMSE		MFCN Uplink (see figure 1)	PMSE						MFCN downlink (see figure 1)	
PPDR (2x5MHz) FDD		PPDR UL							PPDR DL		
PPDR (2x3MHz) FDD				PPDR UL							PPDR DL
M2M (2x3MHz) FDD				M2M							M2M
PPDR (2 (2 X 5 MHz) / 2x10 MHz) FDD				PPDR UL				PPDR DL			
Blocks size (MHz)	4 MHz	5 MHz		3 MHz	2MHz	5 MHz	5 MHz	5 MHz	5 MHz		3 MHz

[7] MFCN SDL could aggregate the usual downlink channel of a MFCN paired (FDD) band with a supplemental downlink channel(s) in the unpaired spectrum to increase the downlink capacity.

The following options shown in figure 2 and bulleted below might be combined with each other and/or with the usage of a number of MFCN SDL blocks in order to provide flexibility for administrations depending on their needs. When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases.

- PMSE could use the guard band 694-703 MHz and the unused part of the duplex gap (733-758 MHz) according to the technical conditions developed in this report.

- The implementation of PPDR in the 700 MHz band is a national decision.

  The Mandate notes, “That finding enough available spectrum for PPDR and PMSE is also priority of the RSPP [14]. Therefore, the exclusive designation of the 700 MHz band to a single application such as WBB may not appear to be a sustainable approach.”

  The technical parameters (channelling arrangement and common least restrictive technical conditions (BEM) for MFCN in Annex 2 can also be used for the provision of broad band PPDR services within the paired frequency arrangement (703-733 MHz and 758-788 MHz), provided that the implementation is in line with the assumptions made for MFCN networks (including the protection requirements).

  A set of options for broadband PPDR are currently studied by CEPT. These options may be considered for implementation by administrations to respond to spectrum demand for PPDR on a national level, and include solutions outside the 700 MHz band (e.g. 400 MHz) and/or the possible use of guard band and duplex gap of the 700 MHz with a conventional duplex: for example, the following options are under study 2 x 5 MHz (698-703 / 753-758 MHz), 2x 3 MHz (733-736 / 788-791 MHz), 2 X 10 MHz (733-743 / 748-758 MHz), 2 X 2 X 5 MHz (733-738 / 748-753 MHz and 738-743/ 753-758 MHz). Different possible PPDR combinations will be evaluated. . Direct Mode Operation may be also foreseen.

- Other services could use parts of the duplex gap with the same BEM as for MFCN SDL (see section 3.2 of this report)

- Machine-to-Machine (M2M) communications are being considered in the 733-736 MHz and 788-791 MHz spectrum blocks. The usage of the spectrum blocks for special applications, including M2M, as well as the associated technical conditions has not been studied in detail in this report. In particular, the protection of DTT below 694 MHz needs to be carefully studied.

These national options may result in several scenarios of cross-border coexistence between CEPT administrations. A conventional duplex approach ensures that cross border coordination between PPDR networks and MFCN SDL systems would be manageable with appropriate field-strength levels to be defined later by CEPT.

2. Common least restrictive technical conditions (LRTC)

The technical conditions derived below for the frequency range 694-790 MHz are optimised for, but not limited to, MFCN (two-way) derived both for base stations (BS) and terminal stations (TS). The BEMs have been developed to protect other MFCN blocks (including the option for SDL), as well as other services and applications in adjacent bands. Additional measures may be required at a national level to further facilitate the coexistence with other services and applications using the guard bands or the duplex gap. The same BS BEM is used for SDL blocks in the duplex gap. BEMs for BS and TS are developed for equipment used in commercial mobile networks, as well as for PPDR applications operating in the paired channelling arrangement (703-733 and 758-788 MHz) for MFCN in accordance with task 1 of the Mandate.

The Base Station (BS) BEM consists of several elements. The in-block power limit is applied to a block licensed to an operator. The out-of-block elements consist of a baseline level, designed to protect the spectrum (paired and SDL) of other MFCN operators as well as adjacent services, and transitional levels enabling filter roll-off from in-block to baseline levels. Additionally, elements are provided for guard bands between MFCN and other services as well as for spectrum between 733 and 758 MHz not used by MFCN (including SDL). When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases.

The BEM is based on minimum coupling loss (MCL) analysis and simulations. The BEM elements are defined on a per cell or per antenna basis, depending on the co-existence scenario from which they have been derived.

Table 1: contains the different elements of the BS BEM, and the power limits for the different BEM elements are shown from Table 2: to Table 8:.

To obtain a BS BEM for a specific block in the paired DL or SDL spectrum, the BEM elements that are defined in Table 1: are used as follows:

- In-block power limit is used for the block assigned to the operator.
- Transitional regions are determined, and corresponding power limits are used. The transitional regions may overlap with guard bands and adjacent bands, in which case transitional power limits are used. Transitional requirements do not apply in MFCN UL spectrum.
- For remaining spectrum assigned to MFCN UL and DL (including SDL spectrum, if applicable), for DTT spectrum below 694 MHz and for spectrum allocated to MFCN above 790 MHz, baseline power limits are used.
- For remaining guard band spectrum (i.e. not covered by transitional regions) guard band power limits are used.
- For spectrum between 733 and 758 MHz not used by MFCN (including SDL), duplex gap requirements apply.

Less stringent technical parameters may be agreed on a bilateral or multilateral basis for the operation of MFCN in the 694-790 MHz band, providing that they comply with the technical conditions applicable for the protection of other services, applications or networks and with cross-border obligations.

The technical studies in this report do not cover DTT usage in the 700 MHz band (including in the duplex gap) on the basis that the EC Mandate did not ask to deal with such usage.

Table 1: BS BEM elements

In-block	Block for which the BEM is derived.
Baseline	Spectrum used for MFCN UL and DL (including SDL, if applicable), for DTT and for MFCN above 790 MHz (UL and DL).
Transitional region	The transitional region applies from 0 to 10 MHz below and above the block assigned to the operator, except from in the uplink region of MFCN (703-733 MHz).
Guard bands	- Spectrum between the DTT allocation below 694 MHz and the lower edge of the MFCN uplink (694-703 MHz), - Spectrum between the upper edge of MFCN downlink and the lower edge of MFCN downlink above 790 MHz (if applicable) (788-791 MHz). In case of overlap between transitional regions and guard bands, transitional power limits are used.
Duplex Gap	Spectrum in the duplex gap which is not used by SDL. In case of overlap between transitional regions and the part of the duplex gap not used by SDL, transitional power limits are used.

Table 2: BS in-block power limit

Frequency range	Maximum mean e.i.r.p.	Measurement Bandwidth
Block assigned to the operator	Not mandatory. In case an upper bound is desired by an administration, a value of 64 dBm/5 MHz per antenna may be applied.	5 MHz

Table 3: BS baseline requirements

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies (703-733 MHz)	-50 dBm per cell (1)	5 MHz
Uplink frequencies of 800 MHz band (832-862 MHz)	-49 dBm per cell (1)	5 MHz
MFCN downlink frequencies (758-788 MHz), SDL blocks in the duplex gap, and downlink frequencies of 800 MHz band (791-821 MHz)	16 dBm per antenna	5 MHz

(1) In a multi sector site “cell” refers to one of the sectors.

Table 4: BS transition requirements in the range 733-788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
–10 to –5 MHz from lower block edge	18 dBm per antenna	5 MHz
–5 to 0 MHz from lower block edge	22 dBm per antenna	5 MHz
0 to +5 MHz from upper block edge	22 dBm per antenna	5 MHz
+5 to +10 MHz from upper block edge	18 dBm per antenna	5 MHz

Table 5: BS transition requirements above 788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
788-791 MHz for block with upper edge at 788 MHz	21 dBm per antenna	3 MHz
788-791 MHz for block with upper edge at 783 MHz	16 dBm per antenna	3 MHz
791-796 MHz for block with upper edge at 788 MHz	19 dBm per antenna	5 MHz
791-796 MHz for block with upper edge at 783 MHz	17 dBm per antenna	5 MHz
796-801 MHz for block with upper edge at 788 MHz	17 dBm per antenna	5 MHz

Table 6: BS Requirements for part of duplex gap not used by SDL

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
-10 to 0 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	16 dBm per antenna	5 MHz
More than 10 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	-4 dBm per antenna	5 MHz

Table 7: BS Requirements for guard bands

Frequency range	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
Spectrum between broadcasting band edge and FDD uplink lower band edge (694-703 MHz)	-32 dBm per cell (1)	1 MHz
Spectrum between downlink upper band edge and downlink of 800 MHz MFCN (788-791 MHz)	14 dBm per antenna	3 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

Table 8: BS Baseline requirements for DTT spectrum

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
For DTT frequencies below 694 MHz where broadcasting is protected	-23 dBm per cell (1)	8 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

The TS BEM consists of an in-block level, elements for the duplex gap not used by SDL, requirements for the guard band between DTT below 694 MHz and the MFCN UL, and a baseline level for DTT spectrum, see Table 9: to Table 12:. Further requirements will have to be taken into account by ETSI in the harmonised standards, which may require close cooperation between ETSI, CEPT and Standard Developing Organisations.

The power limits are specified as e.i.r.p. for terminal stations designed to be fixed or installed and as TRP for terminal stations designed to be mobile or nomadic.

Administrations may relax the in-block power limit in certain situations, for example fixed TS in rural areas, provided that protection of other services, networks and applications is not compromised and cross-border obligations are fulfilled.

Table 9: TS in-block emission limit

Maximum mean in-block power
23 dBm

Note: It is recognised that this value is subject to a tolerance of up to +2 dB, to take account of operation under extreme environmental conditions and production spread.

Table 10: TS Requirements for guard band (694-703 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
694 – 698 MHz	-7 dBm	4 MHz
698 - 703 MHz	2 dBm	5 MHz

Table 11: TS requirements for duplex gap (733-758 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
733-738 MHz	2 dBm	5 MHz
738 – 753 MHz (not applicable for blocks used by SDL)	-6 dBm	5 MHz
753 – 758 MHz (not applicable for blocks used by SDL)	-18 dBm	5 MHz

The assumptions used in the derivation of the unwanted emission requirements are based on the following objectives:

(i) To manage the risk of interference between mobile use and the broadcasting service below 694 MHz,

(ii) To be technically feasible from the point of view of practical implementation of MFCN terminal, and

(iii) To achieve global harmonization of mobile terminals.

Table 12: shows these unwanted emission requirements for MFCN terminal stations within the spectrum allocated to the broadcasting (DTT) service. The value of -42 dBm/8MHz assuming a 10 MHz channel bandwidth or less and separated from DTT channel 48 with 9 MHz guard band, was chosen because it is a balanced solution to meet all the objectives above.

Table 12: Unwanted emissions requirements for TS over frequencies occupied by broadcasting

Frequency range of unwanted emissions	Maximum mean unwanted power (see Notes)	Measurement Bandwidth
470-694 MHz	-42 dBm	8 MHz

Note 1: Unwanted emission limit was based on broadcasting using DVB-T2 and derived for an MFCN system with a bandwidth of 10 MHz for a DTT-MFCN centre frequency separation of 18 MHz (assuming an 8 MHz TV channel, 9 MHz guard band and a 10 MHz MFCN bandwidth).

If administrations wish to allow the deployment of MFCN on a national basis with a bandwidth greater than 10 MHz and in case an unwanted emission power higher than -42 dBm/8MHz is generated in the band below 694 MHz, they should consider:

- either implementing the greater MFCN bandwidth starting at a frequency higher than 703 MHz so that the required limit of unwanted emission power is still met;
- and/or applying mitigation techniques (see Note 3).

Note 2: This value has been derived with regard to fixed DTT reception. Administrations who wish to consider portable-indoor DTT reception may need, on a case-by-case basis, to implement further measures at a national/local level (see Note 3).

Note 3: Examples of potential mitigation techniques which may be considered by administrations include using additional DTT filtering, reducing the in-block power of the TS, reducing the bandwidth of the TS transmissions, or using techniques contained in the non-exhaustive list of potential mitigation techniques given in CEPT Report 30 [1].

Additional considerations on the coexistence between MFCN and broadcasting below 694 MHz

The impact should be determined on a case-by-case basis at national level. To mitigate DTT receiver blocking due to MFCN BS transmissions, additional external filtering could be required at the input of the DTT receiver chain, in particular to avoid overload saturation in antenna amplifiers.

Interference from broadcasting to MFCN

Interference from broadcasting transmitters to MFCN BS receivers either due to transmitter in-band power or unwanted emissions may arise. In such cases, appropriate mitigation techniques can be applied on a case-by-case basis at national level.

PMSE in 700 MHz

PMSE usage of spectrum in the MFCN duplex gap has been studied. Based on simulations of PMSE interference to MFCN UL and DL, power restrictions have been derived. Note that these power restrictions do not cover PMSE out-of-block emission in the MFCN duplex gap. A spectrum emission mask may be applied for that spectrum on a national basis.

PMSE could be used on a national basis in the lower guard band (694-703 MHz) and in the 25 MHz of the duplex gap of the MFCN 2 X 30 MHz band plan, depending on national situations and possible usage of this duplex gap by other services or applications (e.g., PPDR, SDL).

The compatibility situation at the boundary between PMSE and MFCN around the uplink upper band edge, also applies at the lower band edge of the MFCN uplink, if PMSE is used in the guard band below the MFCN UL (694 -703 MHz), due to the fact that the equipment is the same.

Table 13: Power restrictions for handheld microphone

Frequency Range	e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies	-45 dBm(unwanted emissions)	200 kHz
More than -4.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	19 dBm(in-block power)	200 kHz
-4.2 to - 2.8 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	13 dBm(in-block power)	200 kHz
- 2.8 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)	--	--
MFCN downlink frequencies	-45 dBm(unwanted emissions)	200 kHz

Table 14: Power restrictions for body worn microphone

Frequency Range	e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies	-45 dBm(unwanted emissions)	200 kHz
More than -1.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	19 dBm(in-block power)	200 kHz
- 1.2 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)	--	--
MFCN downlink frequencies	-45 dBm(unwanted emissions)	200 kHz

Table 13-14 are providing power restrictions for PMSE in order to protect MFCN. These power restrictions are based on body loss assumed in CEPT Report 50 [13], applicable to the frequency range 1785-1805 MHz. Some other body loss assumption such as the one in CEPT Report 30 [1] applicable to the frequency range 821-832 MHz would provide less stringent conditions and lower protection to MFCN. This issue will be considered in preparation of the CEPT Report B in response to the EC Mandate.

The ECC Report 221 [8] contains the study of the interference from commercial mobile network to PMSE equipment. The results of the studies indicate that for PMSE operation a frequency separation of approximately 1 MHz from MFCN downlink and 1 to 10 MHz from MFCN uplink (depending on spatial distance between MFCN TS and PMSE receiver) are needed.

It can be concluded that audio PMSE equipment will not be able to operate in the compatibility scenarios that were studied. However PMSE is able to find an operational channel with sufficient Quality of Service with the assumption of certain spatial distances between the PMSE equipment and the MFCN equipment. The most critical case is when the PMSE is close to a MFCN UE but if the separation distance is increased the probability of interference decreases accordingly.

PMSE should be operated only if a check of quality of service in the radio environment is performed before use and results in sufficient quality. The PMSE setup indicates whether enough PMSE channels with no interference are available to guarantee the needed quality of service. This procedure is described in Annex 5 of the ECC Report 191 [9].

Protection of PMSE below 694 MHz

Simulations carried out show that given the requirements on MFCN TSs and BSs to protect broadcasting below 694 MHz, PMSE will also be protected.

Compatibility with harmonised conditions of wireless broadband at 790-862 MHz

The preferred channelling arrangement in the 694-790 MHz band identified by CEPT (see ANNEX 2:) uses a conventional duplex arrangement (uplink in the lower part of the band and downlink in the upper part of the band). The 790-862 MHz band uses a reversed duplex arrangement (downlink in the lower part of the band and uplink in the upper part of the band), starting at 791 MHz.

As a consequence, the 700 MHz base station transmit band is adjacent to the 800 MHz base station transmit band. This avoids adjacency between base stations and terminal stations and therefore provides compatibility between the existing 790-862 MHz channelling arrangement and the MFCN channelling arrangement for the 694-790 MHz band.

To the largest extent possible the BEMs for 694-790 MHz have been aligned with those used for wireless broadband at 790-862 MHz.

Non-radio issues

The Mandate from the European Commission states that CEPT should indicate the potential impact on non-radio end-user equipment for fixed broadcasting and broadband electronic communication services in support of standardisation work relating to interference mitigation.

This CEPT Report in response to the 700 MHz EC Mandate covers radio-communication issues. In accordance with the Terms of Reference of ECC, the assessment of potential impact to non-radio systems have been limited to identification of potential frequency ranges (CEPT is not responsible for addressing the impact on non-radio equipment). CEPT describes the evolution of the spectrum usage in this band and the resulting new radio environment in this Report, and will inform ETSI and CENELEC so that they may take this into account in their work.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
APT	Asia-Pacific Telecommunity
BEM	Block Edge Mask
CENELEC	European Committee for Standardisation/European Committee for Electrotechnical Standardisation
CEPT	European Conference of Postal and Telecommunications Administrations
DL	Downlink
DTT	Digital Terrestrial Television
DVB-T2	Digital Video Broadcasting - Terrestrial second generation
EC	European Commission
ECC	Electronic Communications Committee
ECS	Electronic Communications Service
e.i.r.p.	equivalent isotropically radiated power
ETSI	European Telecommunication Standard Institute
FDD	Frequency Duplex Division
IMT	International Mobile Telecommunications
LRTC	Least Restrictive Technical Conditions
LTE	Long Term Evolution
MFCN	Mobile/Fixed Communication Network
M2M	Machine-to-machine
PMSE	Programme Making and Special Events
PPDR	Public Protection and Disaster Relief
QoS	Quality of Service
SEM	Spectrum Emission Mask
SDL	Supplemental Downlink
TRP	Total Radiated Power
TS	Terminal Station
UE	User Equipment
UL	Uplink
WBB	Wireless broadband
WRC-15	World Radiocommunications Conference 2015

1 INTRODUCTION

This Report has been developed by CEPT and considers the tasks 1 and 2 as described in the EC Mandate on 700 MHz (see ANNEX 1:). The results delivered in this report address the following topics:

- preferred channelling arrangement in the 694-790 MHz band for MFCN;
- options considering PMSE, PPDR and other services on a national basis;
- relevant LRTC (based on the BEM approach) for commercial MFCN, as well as for PPDR if used in the frequency bands identified for MFCN;
- compatibility with harmonised conditions of MFCN in the 790-862 MHz band;
- coexistence between MFCN in the 694-790 MHz band and Broadcasting below 694 MHz;
- coexistence between MFCN in the 694-790 MHz band and PMSE below 694 MHz;
- PMSE in the 700 MHz band;
- considerations on Machine-to-Machine (M2M) communications.

The Mandate from the European Commission states that CEPT should indicate the potential impact on non-radio end-user equipment for fixed broadcasting and broadband electronic communication services in support of standardisation work relating to interference mitigation.

This CEPT Report A in response to tasks 1 and 2 of the EC Mandate covers radio-communication issues. In accordance with the Terms of Reference of ECC, the assessment of potential impact to non-radio systems have been limited to identification of potential frequency ranges (CEPT is not responsible for addressing the impact on non-radio equipment). CEPT describes the evolution of the spectrum usage in this band and the resulting new radio environment in this report, and will inform ETSI and CENELEC so that they may take this into account in their work.

2 PREFERRED CHANNELLING ARRANGEMENT IN 694-790 MHz

In this Report MFCN is understood as a network for Wireless Broadband use for the provision of Electronic Communications Services (WBB/ECS).

CEPT confirmed the lower edge at 694 MHz as the only option to be studied in the WRC-15 preparation and discussed possible channelling arrangements on that basis. CEPT identified one channelling arrangement for MFCN.

Channelling arrangement considering MFCN

Within the band 694-790 MHz the MFCN channelling arrangement shall be as follows:

- The block sizes shall be in multiples of 5 MHz, which does not preclude smaller channel bandwidths within a block.
- Paired frequency arrangement (FDD):
  - terminal station transmitter: 703-733 MHz;
  - base station transmitter: 758-788 MHz;
- Unpaired frequency arrangement:
  - supplemental downlink using 'zero up to four' of the following frequency blocks: 738-743 MHz, 743-748 MHz, 748-753 MHz and 753-758 MHz. This decision on the number of contiguous blocks would be taken at national level. This national approach ensures flexibility for combination with other alternative options described hereafter.

Maximum inter-regional harmonisation is achieved by basing the preferred paired channelling arrangement on the lower duplexer of the APT 700 MHz band plan allowing for economies of scale. As this would only provide for 63% utilisation of the band by MFCN, placing up to 4 blocks of 5 MHz MFCN SDL in the duplex gap would result in a utilisation of 83% by MFCN. This arrangement is described is illustrated in 0 and in ANNEX 2:

694-703	703-708	708-713	713-718	718-723	723-728	728-733	733-738	738-743	743-748	748-753	753-758	758-763	763-768	768-773	773-778	778-783	783-788	788-791
Guard band	Uplink						Gap	SDL (A)				Downlink						Guard band
9 MHz	30 MHz (6 blocks of 5 MHz)						5 MHz	20 MHz (zero up to four blocks of 5 MHz)				30 MHz (6 blocks of 5 MHz)						3 MHz

Figure 1: The channelling arrangement for MFCN in the 700 MHz band FDD 2x30MHz and Supplemental Downlink (SDL) option in the duplex gap

(A) SDL Option: There are alternative options being considered in CEPT (see description below) "The zero up to four blocks of 5 MHz approach" ensures flexibility for combining different options

Alternative options for PMSE, PPDR, M2M and other services on a national basis within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30 MHz)

This section describes options other than MFCN that are being considered within CEPT as an alternative to the SDL option within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30 MHz).

Options under consideration											
Frequency bands (MHz)	694-703		703-733	733-738		738-743	743-748	748-753	753-758	758-788	788-791
	694-698	698-703		733-736	736-738						
PMSE	PMSE		MFCN Uplink (see figure 1)	PMSE						MFCN downlink (see figure 1)	
PPDR (2x5MHz) FDD		PPDR UL							PPDR DL		
PPDR (2x3MHz) FDD				PPDR UL							PPDR DL
M2M (2x3MHz) FDD				M2M							M2M
PPDR (2 (2 X 5 MHz) / 2x10 MHz) FDD				PPDR UL				PPDR DL			
Blocks size (MHz)	4 MHz	5 MHz		3 MHz	2MHz	5 MHz	5 MHz	5 MHz	5 MHz		3 MHz

Figure 2: Alternative options for PMSE, PPDR, M2M within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2 x30 MHz)

The following options shown in figure 2 and bulleted below might be combined with each other and/or with the usage of a number of MFCN SDL blocks in order to provide flexibility for administrations depending on their needs. When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases

- PMSE could use the guard band 694-703 MHz and the unused part of the duplex gap (733-758 MHz) according to the technical conditions developed in this report.

- The implementation of PPDR in the 700 MHz band is a national decision.

The Mandate notes, "that finding enough available spectrum for PPDR and PMSE is also priority of the RSPP [14]. Therefore, the exclusive designation of the 700 MHz band to a single application such as WBB may not appear to be a sustainable approach."

The technical parameters (channelling arrangement and common least restrictive technical conditions (BEM) for MFCN in Annex 2 can also be used for the provision of broad band PPDR services within the paired frequency arrangement (703-733 MHz and 758-788 MHz), provided that the implementation is in line with the assumptions made for MFCN networks (incl. the protection requirements).

A set of options for broadband PPDR are currently studied by CEPT. These options may be considered for implementation by administrations to respond to spectrum demand for PPDR on a national level, and include solutions outside the 700 MHz band (e.g. 400 MHz) and/or the possible use of guard band and duplex gap of the 700 MHz with a conventional duplex: for example, the following options are under study 2 x 5 MHz (698-703 / 753-758 MHz), 2x 3 MHz (733-736 / 788-791 MHz), 2 X 10 MHz (733-743 / 748-758 MHz), 2 X 2 X 5 MHz (733-738 / 748-753 MHz and 738-743/ 753-758 MHz). Different possible PPDR combinations will be evaluated. Direct Mode Operation may be also foreseen.

- Other services could use parts of the duplex gap with the same BEM as for MFCN SDL (see section 3.2 of this report).

- Machine-to-Machine communications are being considered in the 733-736 MHz and 788-791 MHz spectrum blocks. The usage of the spectrum blocks for special applications, including M2M, as well as the associated technical conditions has not been studied in detail in this report. In particular, the protection of DTT below 694 MHz needs to be carefully studied.

These national options may result in several scenarios of cross-border coexistence between CEPT administrations. A conventional duplex approach ensures that cross border coordination between PPDR networks and MFCN SDL systems would be manageable with appropriate field-strength levels to be defined later by CEPT.

Additional considerations for PPDR

CEPT noted that LTE technology is expected to form the future platform to meet broadband PPDR needs. The work is in progress with standardization organisations defining functionality enhancements for PPDR operators. The CEPT is considering the options for accommodating broadband PPDR communications requirements, subject to national decision at a later stage. The CEPT also assumes that any decision on the allocation of either dedicated or shared with commercial MFCN operators spectrum to PPDR users will be taken at a national level.

3 LEAST RESTRICTIVE TECHNICAL CONDITIONS/ BEM

3.1 METHOD FOR DEFINING LEAST RESTRICTIVE TECHNICAL CONDITIONS

The definition of the least restrictive technical conditions is based on the block edge mask (BEM) approach, in line with previous work in CEPT, e.g. on the 790-862 MHz [1] the 2.5-2.69 GHz [2] [3] the 2 GHz [4] and the 3.4-3.8 GHz bands [5].

A BEM is an emission mask that is defined as a limit on the average e.i.r.p. or TRP (total radiated power)[8] inside and outside of the block of spectrum licensed to an operator, and is defined for a certain measurement bandwidth. The out-of-block component of the BEM may consist of a baseline level and intermediate (transition) levels which describe the transition from the in-block level to the baseline level as a function of off-set from the block edge.

The BEMs are presented as upper limits on the mean e.i.r.p. or TRP over an averaging time interval and over a measurement frequency bandwidth. In the time domain, the e.i.r.p. or TRP is averaged over the active portions of signal bursts. In the frequency domain, the e.i.r.p. or TRP is determined over the measurement bandwidth (e.g. MFCN block or TV channel) specified in the tables below. It should be noted that the actual measurement bandwidth of the measurement equipment used for purposes of compliance testing may be smaller than the measurement bandwidth provided in the tables. For requirements with a measurement bandwidth of 5 MHz, the measurement bandwidth is aligned within the block structure of the frequency arrangement. The BEM elements are defined on a per cell or per antenna basis, depending on the co-existence scenario from which they have been derived.

Figure 3 describe a general BEM.

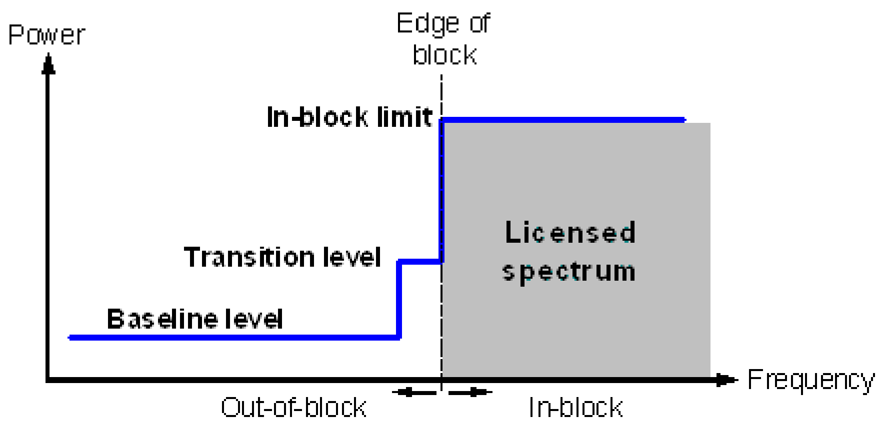

Figure 3: Illustration of a general block-edge mask

BEM elements may also be defined in order to protect the radio systems in adjacent bands. It is also possible to define technical conditions for such protection, which are not in the form of a BEM.

The BEM is a ‘regulatory mask’ and should not be confused with Spectrum Emission Masks (SEM) for base stations and user equipment.

The BEM concept does not in itself define the means by which the equipment in an operator’s network meets the BEM. This may be achieved in different ways such as by employing equipment inherently meeting the

[8] TRP is a measure of how much power the antenna actually radiates. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere. For an isotropic antenna radiation pattern, e.i.r.p. and TRP are equivalent. For a directional antenna radiation pattern, e.i.r.p. in the direction of the main beam is (by definition) greater than the TRP.

requirements, by adding filters, by creating an internal (in-block) guard band or by decreasing the in-block power.

BEMs shall be applied as an essential component of the technical conditions necessary to ensure coexistence between services at a national level. However it should be understood that the derived BEMs do not always provide the required level of protection of victim services and additional mitigation techniques would need to be applied in order to resolve any remaining cases of interference. Possible mitigation techniques are described in Annex 4 of CEPT Report 30 [1].

The technical conditions derived below for the frequency range 694-790 MHz are optimised for, but not limited to, mobile/fixed communications networks (two-way) derived both for base stations (BS) and terminal stations (TS). In addition appropriate technical conditions have been derived for SDL in the FDD duplex gap.

BEMs for BS and TS are developed for equipment used in commercial mobile networks, as well as for PPDR applications operating in the MFCN spectrum.

Less stringent technical parameters may be agreed on a bilateral or multilateral basis for the operation of MFCN in the 694-790 MHz band, providing that they continue to comply with the technical conditions applicable for the protection of other services, applications or networks and with cross-border obligations.

3.2 CONSIDERATIONS OF COEXISTENCE PARAMETERS FOR BEM DERIVATION

As broadband PPDR will use LTE technology, BS and TS parameters can be assumed to be the same as commercial MFCN in the co-existence analysis.

As indicated in Section 2, some MFCN spectrum may be used for Supplemental DownLink (SDL), i.e. downlink without paired uplink spectrum. Such SDL spectrum would be located just below the paired DL spectrum. In terms of co-existence analysis and derivation of BEM, there is no reason to distinguish between SDL blocks and paired DL blocks since the in-block power and antenna characteristics will be the same and since the SDL and paired DL are surrounded by and need to protect the same services and systems. In particular, SDL equipment will need to protect the FDD UL and thus employ a filter similar to the duplex filter of BSs for paired frequency arrangements. Other services could use parts of the duplex gap with the same BEM as for MFCN SDL.

3.3 TECHNICAL CONDITIONS FOR BASE STATIONS

The BEM elements derived below apply to base stations for MFCN. The BS BEM also applies if the spectrum in the duplex gap is used to provide a supplemental downlink (SDL). When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases. The BEM has been designed to protect the adjacent band services, including MFCN above 791 MHz. Other requirements can be applied subject to bi- or multilateral agreements.

3.3.1 In-block e.i.r.p. limits

Table 15: contains information regarding in-block power. The adoption of in-block power limits is not mandatory. In case an upper bound is desired by an administration, a value of 64 dBm/5 MHz per antenna may be applied. Administrations may consider authorising higher in-block e.i.r.p. in specific circumstances, e.g. in rural deployments.

Table 15: BS In-block power limit

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
Block assigned to the operator	Not mandatory. In case an upper bound is desired by an administration, a value of 64 dBm/5 MHz per antenna may be applied	5 MHz

3.3.2 Out-of-block e.i.r.p. limits

Table 16: defines the out-of-block BEM baseline requirements. The details of calculation and the coexistence parameter used for the BEM element for MFCN uplink spectrum are provided in ANNEX 3:. This analysis leads to a requirement that is defined per cell.

The BEM element for FDD downlink frequencies has been obtained from the Spectrum Emission Mask (SEM) in [6] for frequencies below 1 GHz and carrier bandwidths of 5 MHz and more, for a frequency offset of more than 10 MHz, and by adding an antenna gain of 15 dBi, including feeder loss, to convert it into an e.i.r.p. value. In this case, as a consequence of the co-existence scenario used for derivation of the SEM in [6], the requirement is expressed per antenna. This is the case also for transitional requirements, the guard band 788-791 MHz and the requirements for the duplex gap.

The applicability of the baseline elements to the 800 MHz uplink- and downlink spectrum follows from the fact that the channelling arrangement at 694-790 MHz uses a conventional duplex arrangement (uplink in the lower part of the band and downlink in the upper part of the band), whereas the 790-862 MHz band uses a reverse duplex arrangement (downlink in the lower part of the band, 791-831 MHz, and uplink in the upper part of the band, 832-862 MHz).

As a consequence, the 700 MHz base station transmit (downlink) band is adjacent to the 800 MHz base station transmit (downlink) band. The 800 MHz downlink can thus be seen as an extension of the 700 MHz downlink band, from a co-existence perspective. Applying the BS BEM elements beyond 790 MHz thus guarantees sufficiently low interference to the 800 MHz downlink band, as the interference situation for two adjacent downlinks will be the same regardless if they are in the same band or not. Similarly, applying the BS uplink BEM in the 800 MHz uplink frequency range, guarantees sufficiently low interference on the systems that use the band as well.

In the 800 MHz ECC/DEC/(09)03 [12], the BS maximum mean e.i.r.p in uplink frequencies is -49 dBm per cell while for 700 MHz the calculation leads to -50 dBm per cell. The difference is due to the different propagation loss for different frequencies.

Table 16: BS Baseline requirements

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies (703 – 733 MHz)	-50 dBm per cell (1)	5 MHz
Uplink frequencies of 800 MHz band (832- 862 MHz)	-49 dBm per cell (1)	5 MHz
MFCN downlink frequencies (758 – 788 MHz), SDL blocks in the duplex gap, and downlink frequencies of 800 MHz band (791-821 MHz)	16 dBm per antenna	5 MHz

(1) In a multi sector site, “cell” refers to one of the sectors.

Table 17: shows the requirements in transitional regions below 788 MHz. The transitional regions for some of the DL blocks overlap with the duplex gap, in which case transitional power limits are used.

The levels proposed for the transitional regions have been calculated by integration of the SEM in [6] for frequencies below 1 GHz and carrier bandwidths of 5 MHz and above assuming an antenna gain of 15 dBi including feeder loss.

Table 17: BS transition requirements in range 733-788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
–10 to –5 MHz from lower block edge	18 dBm per antenna	5 MHz
–5 to 0 MHz from lower block edge	22 dBm per antenna	5 MHz
0 to +5 MHz from upper block edge	22 dBm per antenna	5 MHz
+5 to +10 MHz from upper block edge	18 dBm per antenna	5 MHz

Table 18: shows the requirements in transitional regions above 788 MHz. These requirements need to be treated separately due to the frequency separation of 3 MHz between the 700 MHz DL and the 800 MHz DL. The elements in Table 18: resulting in different measurement bandwidth and frequency off-sets than for the transitional elements above. Table 18: have also been obtained by integration of the spectrum mask in [6], and adding antenna gain.

Table 18: BS transition requirements above 788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
788-791 MHz for block with upper edge at 788 MHz	21 dBm per antenna	3 MHz
788-791 MHz for block with upper edge at 783 MHz	16 dBm per antenna	3 MHz
791-796 MHz for block with upper edge at 788 MHz	19 dBm per antenna	5 MHz
791-796 MHz for block with upper edge at 783 MHz	17 dBm per antenna	5 MHz
796-801 MHz for block with upper edge at 788 MHz	17 dBm per antenna	5 MHz

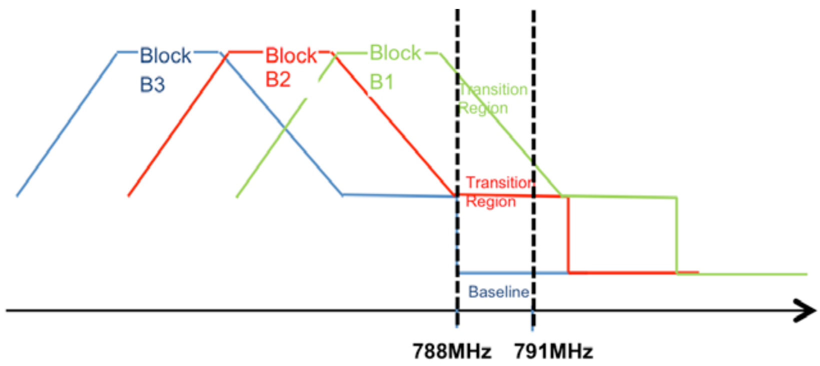

Figure 4: Qualitative description on transitional requirements above the upper downlink band edge for different MFCN blocks

Table 19: contains BEM elements for the spectrum between MFCN uplink and downlink (including possible SDL spectrum). The BEM element in Table 19: for an offset of more than 10 MHz has been derived from the spurious requirement of -36 dBm/100 kHz.

Table 19: BS Requirements for part of duplex gap not used by SDL

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
-10 to 0 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	16 dBm per antenna	5 MHz
More than 10 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	-4 dBm per antenna	5 MHz

Table 20: shows the requirement for base stations over frequencies used as guard band between the MFCN UL and spectrum used for DTT, which has been obtained by converting the baseline for DTT spectrum (see below) from 8 MHz to 1 MHz measurement bandwidth.

Table 20: BS Requirements for guard bands

Frequency range	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
Spectrum between broadcasting band edge and FDD uplink lower band edge (694-703 MHz)	-32 dBm per cell (1)	1 MHz
Spectrum between downlink upper band edge and downlink of 800 MHz MFCN (788-791 MHz)	14 dBm per antenna	3 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

Table 21: shows the BEM baseline requirement for MFCN base stations, within the spectrum used by the broadcasting (DTT) service below 694 MHz. The baseline requirement for broadcasting spectrum is based on the strictest level specified in CEPT Report 30 [1] where it was shown that this level would allow coexistence with broadcasting services. In a typical BS implementation there will be a duplex filter for attenuating the emissions in the receive band and the design of the duplex filters will also result in significant attenuation adjacent to the receive band, e.g. in the broadcasting band. However, it should be noted that these strict limits are feasible due to the special situation of downlink frequencies in this band and may not be feasible in other situations.

Table 21: BS Baseline requirements for DTT spectrum

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
For DTT frequencies below 694 MHz where broadcasting is protected	-23 dBm per cell (1)	8 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

3.4 TECHNICAL CONDITIONS FOR TERMINAL STATIONS

The tables below contain BEM elements for commercial networks as well as for PPDR defining in-block power and for protecting services in adjacent bands and in the duplex gap. As additional requirements on TS are not included in the relevant EC Decisions, any further requirements will have to be taken into account by ETSI in the harmonised standards, which may require close cooperation between ETSI, CEPT and Standard Developing Organisations. CEPT Report 39 [4] contains a more detailed discussion about responsibilities of different organisations regarding TS BEMs.

The power limits are specified as e.i.r.p. for terminal stations designed to be fixed or installed and as TRP for terminal stations designed to be mobile or nomadic.

Table 22: defines the maximum value of the in-block emission level for terminal stations. Administrations may relax this limit in certain situations, for example fixed TS in rural areas, and provided that protection of other services, networks and applications is not compromised and cross-border obligations are fulfilled.

Table 22: TS in-block emission limit

Maximum mean in-block power
23 dBm

Note: It is recognised that this value is subject to a tolerance of up to +2 dB, to take account of operation under extreme environmental conditions and production spread.

Table 23: shows the requirements for terminal stations over frequencies used as guard band. The following BEM have been obtained by integrating the SEM in [7] as reported in ANNEX 4:. BEM values are based on the consideration that support for 1.4 and 3 MHz terminals is not required in this band.

Table 23: TS Requirements for guard band (694-703 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
694-698 MHz	-7 dBm	4 MHz
698-703 MHz	2 dBm	5 MHz

Table 24: TS requirements for duplex gap (733-758 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
733-738 MHz	2 dBm	5 MHz
738-753 MHz (not applicable for blocks used by SDL)	-6 dBm	5 MHz
753-758 MHz (not applicable for blocks used by SDL)	-18 dBm	5 MHz

The assumptions used in the derivation of the unwanted emission requirements are based on the following objectives:

(i) to manage the risk of interference between mobile use and the broadcasting service below 694 MHz,

(ii) to be technically feasible from the point of view of practical implementation of MFCN terminal, and

(iii) to achieve global harmonization of mobile terminals.

Table 25: shows these unwanted emission requirements for MFCN terminal stations within the spectrum allocated to the broadcasting (DTT) service. The value of -42 dBm/8MHz assuming a 10 MHz channel bandwidth or less, and separated from DTT channel 48 with 9 MHz guard band, was chosen because it is a balanced solution to meet all the objectives above.

Table 25: Unwanted requirements for TS over frequencies occupied by broadcasting

Frequency range of unwnated emissions	Maximum mean unwanted power (see Notes)	Measurement bandwidth
470-694 MHz	-42 dBm	8 MHz

Note 1: Unwanted emission limit was based on broadcasting using DVB-T2 and derived for an MFCN system with a bandwidth of 10 MHz for a DTT-MFCN centre frequency separation of 18 MHz (assuming an 8 MHz TV channel, 9 MHz guard band and a 10 MHz MFCN bandwidth).

If administrations wish to allow the deployment of MFCN on a national basis with a bandwidth greater than 10 MHz and in case an unwanted power higher than -42 dBm/8MHz is generated in the band below 694 MHz, they should consider:

- either implementing the greater MFCN bandwidth starting at a frequency higher than 703 MHz so that the required limit of unwanted power is still met;
- and/or applying mitigation techniques (see Note 3).

Note 2: This value has been derived with regard to fixed DTT reception. Administrations who wish to consider portable-indoor DTT reception may need, on a case-by-case basis, to implement further measures at a national/local level (see Note 3).

Note 3: Examples of potential mitigation techniques which may be considered by administrations include using additional DTT filtering, reducing the in-block power of the TS, reducing the bandwidth of the TS transmissions, or using techniques contained in the non-exhaustive list of potential mitigation techniques given in CEPT Report 30 [1].

4 ADDITIONAL CONSIDERATIONS ON THE COEXISTENCE BETWEEN MFCN AND BROADCASTING BELOW 694 MHz - DTT RECEIVER BLOCKING

With regard to blocking[9] of DTT receiver by MFCN BS, additional isolation could be required between the MFCN base station and the DTT Receiver. The actual impact should be determined on a case-by-case basis since this type of interference usually depends on the first component of receiver chain (pre-amplifier of the receiver or amplifier of the antenna assumed to increase the received signal). One way to address this issue would be to improve the DTT adjacent channel rejection capability through enhancing receiving chains (e.g. by adding at the beginning of the receiver system a filter which reduces the unwanted emissions) where needed.

5 INTERFERENCE FROM BROADCASTING TRANSMITTERS TO MFCN BS RECEIVERS

In some cases, interference from broadcasting transmitters to MFCN BS receivers due to DTT transmitter in band power may arise, i.e., blocking. In practice, there are mitigation techniques, which can be applied in such cases. For example, improved receiver performance (receiver blocking levels) of the MFCN BS can be done through better BS design or additional filter.

In some other cases, interference to MFCN BS due to unwanted emissions from high power broadcasting transmitters, transmitting on channel 48, may appear. Other mitigation techniques can be applied. Such mitigation measures could be performed on a case-by-case basis at the national level. It is expected that in real life the number of interference cases would be limited.

A case study reported in ANNEX 6: on the potential interference from broadcasting transmitters to MFCN BS receivers leads to the following conclusions:

- MFCN BS receiver out of band blocking level as defined in 3GPP Specification TS 36.104 [6] may not be sufficient; an additional isolation of up to 40 dB may be required. With the assumptions used in the study of a guard band of 9 MHz, this additional isolation can be achieved with an external filter or improved IMT BS design.
- Non-critical DTT mask may not be sufficient for protecting the MFCN uplink for MFCN BS near the high tower / high power DTT transmitters transmitting on channel 48. Several dB of additional isolation may be needed. Nevertheless, the real DTT transmitter masks are always better than the minimum technical requirement of non-critical mask. Consequently, the interference due to unwanted emissions from high tower / high power DTT transmitters into MFCN spectrum should not be a real problem. If needed, other mitigation techniques may be applied, where appropriate, on MFCN BS.

[9] Blocking interference is generated by a strong interference signal out of the receiver band that makes the receiver work in saturation state and then reduces the gains and generally affects the performance of the receiver chain.

6 SPECIAL APPLICATION / MACHINE-TO-MACHINE COMMUNICATIONS

Machine-to-Machine (M2M) communications domain covers a wide variety of applications, including utility provisioning, transportation, healthcare, energy, retail, public safety, building and many others.

Machine-to-Machine (M2M) communications are being considered in the 733-736 MHz and 788-791 MHz spectrum blocks. The usage of the spectrum blocks for special applications, including M2M, as well as the associated technical conditions has not been studied in detail in this report. In particular, the protection of DTT below 694 MHz needs to be carefully studied.

7 PMSE ISSUES

7.1 TECHNICAL CONDITIONS FOR PMSE

PMSE usage of spectrum in the MFCN duplex gap has been studied. Based on simulations of PMSE interference to MFCN UL and DL, power restrictions as presented in Table 26: and Table 27: have been derived. The PMSE unwanted emission has been derived from PMSE emission mask defined in [8]. Note that these power restrictions do not cover PMSE out-of-block emission in the MFCN duplex gap. A spectrum emission mask may be applied for that spectrum on a national basis. For additional details, see [8].

The compatibility situation at the boundary between PMSE and MFCN around the uplink upper band edge, also applies at the lower band edge of the MFCN uplink, if PMSE is used in the guard band below the MFCN UL (694-703 MHz), due to the fact that the equipment is the same.

Table 26: Power restrictions for handheld microphone

<table>
<tr><th>Frequency Range</th><th>e.i.r.p.</th><th>Measurement bandwidth</th><th>Reasoning</th></tr>
<tr><td>MFCN uplink frequencies</td><td>-45 dBm(unwanted emissions)</td><td>200 kHz</td><td>ETSI EN 300 422</td></tr>
<tr><td>More than -4.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block</td><td>19 dBm(in-block power)</td><td>200 kHz</td><td rowspan="3">Annex 2 of ECC Report 221 [8]</td></tr>
<tr><td>-4.2 to - 2.8 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block</td><td>13 dBm(in-block power)</td><td>200 kHz</td></tr>
<tr><td>- 2.8 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)</td><td>--</td><td>--</td></tr>
<tr><td>MFCN downlink frequencies</td><td>-45 dBm(unwanted emissions)</td><td>200 kHz</td><td>ETSI EN 300 422</td></tr>
</table>

Table 27: Power restrictions for body worn microphone

<table>
<tr><th>Frequency Range</th><th>e.i.r.p.</th><th>Measurement bandwidth</th><th>Reasoning</th></tr>
<tr><td>MFCN uplink frequencies</td><td>-45 dBm(unwanted emissions)</td><td>200 kHz</td><td>ETSI EN 300 422</td></tr>
<tr><td>More than -1.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block</td><td>19 dBm(in-block power)</td><td>200 kHz</td><td rowspan="2">Annex 2 of ECC Report 221 [8]</td></tr>
<tr><td>- 1.2 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)</td><td>--</td><td>--</td></tr>
<tr><td>MFCN downlink frequencies</td><td>-45 dBm(unwanted emissions)</td><td>200 kHz</td><td>ETSI EN 300 422</td></tr>
</table>

Table 26-27 are providing power restrictions for PMSE in order to protect MFCN. These power restrictions are based on body loss assumed in CEPT Report 50 [13], applicable to the frequency range 1785-1805

MHz. Some other body loss assumption such as the one in CEPT Report 30 [1] applicable to the frequency range 821-832 MHz would provide less stringent conditions and lower protection to MFCN. This issue will be considered in preparation of the CEPT Report B in response to the EC Mandate.

According to ECC Report 221 [8], for the scenarios corresponding to audio PMSE equipment interfering with the MFCN UE, a better blocking rejection of 8 dB at 2 MHz offset was assumed. In addition, it is assumed that the duplex filter in the user equipment provides an additional rejection of 2 dB at 2 MHz offset from the channel-edge for narrow band signals. With the proposed power restrictions for PMSE, the compatibility studies show that sharing between PMSE equipment and MFCN BS is feasible. The critical case is when the PMSE equipment is close to the MFCN UE. The simulations show that for Scenario 1 (Outdoor) with a separation distance between 15-100 meters, there will be no compatibility issues for the hand held PMSE device. For the body worn PMSE device, there is no compatibility issue for the 10 MHz band width, but a potential narrow band blocking issue for the 3 MHz LTE UE. The simulations show that for Scenario 3 (Outdoor) with a separation distance between 100-350 meters, there will be no compatibility issues. The simulations show that for Scenario 6 (Indoor) with a separation distance between 5-50 meters, both hand held and body worn PMSE devices have a potential compatibility issues. In this case, both unwanted emissions and blocking cause degradation of the MFCN performance. If this separation distance is increased, the probability of interference decreases accordingly.

The ECC Report 221 [8] also considers interference from commercial mobile network to PMSE equipment. The results of the studies are illustrated in Table 28:. These results indicate that for PMSE operation a frequency separation of approximately 1 MHz from MFCN downlink and 1 to 10 MHz from MFCN uplink (depending on spatial distance between MFCN TS and PMSE receiver) are needed.

It can be concluded that audio PMSE equipment will not be able to operate in the compatibility scenarios that were studied. However PMSE is able to find an operational channel with sufficient Quality of Service with the assumption of certain spatial distances between the PMSE equipment and the MFCN equipment. The most critical case is when the PMSE is close to a MFCN UE but if the separation distance is increased the probability of interference decreases accordingly.

PMSE should be operated only if a check of quality of service in the radio environment is performed before use and results in sufficient quality. The PMSE setup indicates whether enough PMSE channels with no interference are available to guarantee the needed quality of service. This procedure is described in Annex 5 of the ECC Report 191 [9].

Table 28: SEAMCAT simulation results: MFCN interfering PMSE receiver

Scenario	Separation Distance	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.2	756.9	757.9
2:Outdoor	15 – 100m	LTE UE	6.87 / 0	3.06 / 0	0 / 0	0 / 0	0 / 0			
4:Outdoor	100 – 350m	LTE BS	0 / 0.12	0 / 0.12	0 / 0.12	0 / 0.10	4.80 / 0.13			18.35 / 0.13
5:Mixed	100 - 350 m	LTE BS	0 / 0.03	0 / 0.03	0 / 0.03	0 / 0.03	1.73 / 0.03			8.11 / 0.04
7:Indoor	5 - 50m	LTE UE	64.25 / 0	47.11 / 0	3.16 / 0	0.35/ 0	0.13 / 0			

7.2 PROTECTION OF PMSE BELOW 694 MHz

The CEPT noted that the 470-694 MHz band is currently available and will continue to be available for PMSE equipment on a sharing basis with the broadcasting service and that it is used on a daily basis.

In order to assess the impact of MFCN UE on PMSE below 694 MHz, two studies have been carried out:

- Monte-Carlo simulation using the SEAMCAT tool. The simulation results show that with a MFCN UE OOB emission level of -28 dBm/MHz, the probability of interference from a MFCN UE to a PMSE receiver is very low.
- a coexistence study based on Monte-Carlo simulation providing the distance separation necessary to ensure the coexistence between PMSE and MFCN UE.

The details of the above studies are available in ANNEX 5:.

Based on those results and also with consideration of requirements on MFCN TS OOB emissions to protect the broadcasting service below 694 MHz as specified in section 3.4, it can be concluded that MFCN TS above 703 MHz and PMSE below 694 MHz can coexist.

8 COMPATIBILITY WITH HARMONISED CONDITIONS OF WIRELESS BROADBAND AT 790-862 MHz

The preferred channelling arrangement in the 694-790 MHz band identified by CEPT (see ANNEX 2:) uses a conventional duplex arrangement (uplink in the lower part of the band and downlink in the upper part of the band). The 790-862 MHz band uses a reversed duplex arrangement (downlink in the lower part of the band and uplink in the upper part of the band), starting at 791 MHz.

As a consequence, the 700 MHz base station transmit band is adjacent to the 800 MHz base station transmit band. This avoids adjacency between base stations and terminal stations and therefore provides compatibility between the existing 790-862 MHz channelling arrangement and the MFCN channelling arrangement for the 694-790 MHz band.

To the largest extent possible the BEMs for 694-790 MHz have been aligned with those used for wireless broadband at 790-862 MHz.

9 CONCLUSIONS

CEPT considered the tasks 1 and 2 as described in the EC Mandate on 700 MHz (see ANNEX 1:) and studied the following issues:

Preferred channelling arrangement in 694-790 MHz

In this Report MFCN is understood as a network for Wireless Broadband use for the provision of Electronic Communications Services (WBB/ECS).

CEPT confirmed the lower edge at 694 MHz as the only option to be studied in the WRC-15 preparation and discussed possible channelling arrangements on that basis. CEPT identified one channelling arrangement for MFCN.

1. **channelling arrangement for MFCN**

Within the band 694-790 MHz the MFCN channelling arrangement shall be as follows:

- The block sizes shall be in multiples of 5 MHz, which does not preclude smaller channel bandwidths within a block

- Paired frequency arrangement (FDD):
  - terminal station transmitter: 703-733 MHz
  - base station transmitter: 758-788 MHz

- Unpaired frequency arrangement:
  - supplemental downlink using ‘zero up to four’ of the following frequency blocks: 738-743 MHz, 743-748 MHz, 748-753 MHz and 753-758 MHz. This decision on the number of contiguous blocks would be taken at national level. This national approach ensures flexibility for combination with other alternative options described hereafter.

Maximum inter-regional harmonisation is achieved by basing the preferred paired channelling arrangement on the lower duplexer of the APT 700 MHz band plan allowing for economies of scale. As this would only provide for 63% utilisation of the band by MFCN, placing up to 4 blocks of 5 MHz MFCN SDL in the duplex gap would result in a utilisation of 83% by MFCN. This arrangement is illustrated in Figure 5 and described in ANNEX 2:

694-703	703-708	708-713	713-718	718-723	723-728	728-733	733-738	738-743	743-748	748-753	753-758	758-763	763-768	768-773	773-778	778-783	783-788	788-791
Guard band	Uplink						Gap	SDL (A)				Downlink						Guard band

(A) SDL option: There are alternative options being considered in CEPT (see description in 2 below). "The zero up to four blocks of 5 MHz approach" ensures flexibility for combining different options.

Figure 5: The channelling arrangement for MFCN in the 700 MHz band FDD 2x30MHz and Supplemental Downlink (SDL) option in the duplex gap

2. Alternative options considering PMSE, PPDR, M2M and other services on a national basis within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30MHz)

This section describes options other than MFCN that are being considered within CEPT as an alternative to the SDL option within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2x30 MHz).

Options under consideration											
Frequency bands (MHz)	694-703		703-733	733-738		738-743	743-748	748-753	753-758	758-788	788-791
	694-698	698-703		733-736	736-738						
PMSE	PMSE		MFCN Uplink (see figure 1)	PMSE						MFCN downlink (see figure 1)	
PPDR (2x5MHz) FDD		PPDR UL							PPDR DL		
PPDR (2x3MHz) FDD				PPDR UL							PPDR DL
M2M (2x3MHz) FDD				M2M							M2M
PPDR (2 (2 X 5 MHz) / 2x10 MHz) FDD				PPDR UL				PPDR DL			
Blocks size (MHz)	4 MHz	5 MHz		3 MHz	2MHz	5 MHz	5 MHz	5 MHz	5 MHz		3 MHz

Figure 6: Alternative options for PMSE, PPDR and M2M within the given channelling arrangement for MFCN in the 700 MHz band including FDD (2 x30 MHz)

The following options shown in Figure 6 and bulleted below might be combined with each other and/or with the usage of a number of MFCN SDL blocks in order to provide flexibility for administrations depending on their needs. When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases

- PMSE could use the guard band 694-703 MHz and the unused part of the duplex gap (733-758 MHz) according to the technical conditions developed in this report.

- The implementation of PPDR in the 700 MHz band is a national decision.

  The Mandate notes, "that finding enough available spectrum for PPDR and PMSE is also priority of the RSPP [14]. Therefore, the exclusive designation of the 700 MHz band to a single application such as WBB may not appear to be a sustainable approach."

  The technical parameters (channelling arrangement and common least restrictive technical conditions (BEM)) for MFCN in ANNEX 2: can also be used for the provision of broadband PPDR services within the paired frequency arrangement (703-733 MHz and 758-788 MHz), provided that the implementation is in line with the assumptions made for MFCN networks (incl. the protection requirements).

A set of options for broadband PPDR are currently studied by CEPT. These options may be considered for implementation by administrations to respond to spectrum demand for PPDR on a national level, and include solutions outside the 700 MHz band (e.g. 400 MHz) and/or the possible use of guard band and duplex gap of the 700 MHz with a conventional duplex: for example, the following options are under study 2 x 5 MHz (698-703 / 753-758 MHz), 2x 3 MHz (733-736 / 788-791 MHz), 2 X 10 MHz (733-743 / 748-758 MHz), 2 X 2 X 5 MHz (733-738 / 748-753 MHz and 738-743/ 753-758 MHz). Different possible PPDR combinations will be evaluated. Direct Mode Operation may be also foreseen.

- Other services could use parts of the duplex gap with the same BEM as for MFCN SDL (see section 3.2 of this report)
- Machine-to-Machine (M2M) communications are being considered in the 733-736 MHz and 788-791 MHz spectrum blocks. The usage of the spectrum blocks for special applications, including M2M, as well as the associated technical conditions has not been studied in detail in this report. In particular, the protection of DTT below 694 MHz needs to be carefully studied.

These national options may result in several scenarios of cross-border coexistence between two CEPT administrations. A conventional duplex approach ensures that cross border coordination between PPDR networks and MFCN SDL systems would be manageable at the border with appropriate field-strength levels to be defined later by CEPT. Any other options should also facilitate cross-border coordination.

Common least restrictive technical conditions (LRTC)

The technical conditions derived below for the frequency range 694-790 MHz are optimised for, but not limited to, MFCN (two-way) derived both for base stations (BS) and terminal stations (TS). The BEMs have been developed to protect other MFCN blocks (including the option for SDL), as well as other services and applications in adjacent bands. Additional measures may be required at a national level to further facilitate the coexistence with other services and applications using the guard bands or the duplex gap. The same BS BEM is used for SDL blocks in the duplex gap. BEMs for BS and TS are developed for equipment used in commercial mobile networks, as well as for PPDR applications operating in the paired channelling arrangement (703-733 and 758-788 MHz) for MFCN in accordance with task 1 of the Mandate.

The Base Station (BS) BEM consists of several elements. The in-block power limit is applied to a block licensed to an operator. The out-of-block elements consist of a baseline level, designed to protect the spectrum (paired and SDL) of other MFCN operators as well as adjacent services, and transitional levels enabling filter roll-off from in-block to baseline levels. Additionally, elements are provided for guard bands between MFCN and other services as well as for spectrum between 733 and 758 MHz not used by MFCN (including SDL). When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases.

The BEM is based on minimum coupling loss (MCL) analysis and simulations. The BEM elements are defined on a per cell or per antenna basis, depending on the co-existence scenario from which they have been derived.

Table 29: contains the different elements of the BS BEM, and Table 30: to Table 36: contain the power limits for the different BEM elements.

To obtain a BS BEM for a specific block in the paired DL or SDL spectrum, the BEM elements that are defined in Table 29: are used as follows:

- In-block power limit is used for the block assigned to the operator.
- Transitional regions are determined, and corresponding power limits are used. The transitional regions may overlap with guard bands and adjacent bands, in which case transitional power limits are used. Transitional requirements do not apply in MFCN UL spectrum.

- For remaining spectrum assigned to MFCN UL and DL (including SDL spectrum, if applicable), for DTT spectrum below 694 MHz and for spectrum allocated to MFCN above 790 MHz, baseline power limits are used.
- For remaining guard band spectrum (i.e. not covered by transitional regions) guard band power limits are used.
- For spectrum between 733 and 758 MHz not used by MFCN (including SDL), duplex gap requirements apply .

Less stringent technical parameters may be agreed on a bilateral or multilateral basis for the operation of MFCN in the 694-790 MHz band, providing that they comply with the technical conditions applicable for the protection of other services, applications or networks and with cross-border obligations.

Table 29: BS BEM elements

In-block	Block for which the BEM is derived.
Baseline	Spectrum used for MFCN UL and DL (including SDL, if applicable), for DTT and for MFCN above 790 MHz (UL and DL).
Transitional region	The transitional region applies from 0 to 10 MHz below and above the block assigned to the operator, except from in the uplink region of MFCN (703-733 MHz).
Guard bands	▪ Spectrum between the DTT allocation below 694 MHz and the lower edge of the MFCN uplink (694-703 MHz); ▪ Spectrum between the upper edge of MFCN downlink and the lower edge of MFCN downlink above 790 MHz (if applicable) (788-791 MHz). In case of overlap between transitional regions and guard bands, transitional power limits are used.
Duplex Gap	Spectrum in the duplex gap which is not used by SDL. In case of overlap between transitional regions and the part of the duplex gap not used by SDL, transitional power limits are used.

Table 30: BS in-block power limit

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
Block assigned to the operator	Not mandatory. In case an upper bound is desired by an administration, a value of 64 dBm/5 MHz per antenna may be applied.	5 MHz

Table 31: BS baseline requirements

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies (703 – 733 MHz)	-50 dBm per cell (1)	5 MHz
Uplink frequencies of 800 MHz band (832- 862 MHz)	-49 dBm per cell (1)	5 MHz
MFCN downlink frequencies (758 – 788 MHz), SDL blocks in the duplex gap, and downlink	16 dBm per antenna	5 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
frequencies of 800 MHz band (791-821 MHz)		

(1) In a multi sector site “cell” refers to one of the sectors.

Table 32: BS transition requirements in the range 733-788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
–10 to –5 MHz from lower block edge	18 dBm per antenna	5 MHz
–5 to 0 MHz from lower block edge	22 dBm per antenna	5 MHz
0 to +5 MHz from upper block edge	22 dBm per antenna	5 MHz
+5 to +10 MHz from upper block edge	18 dBm per antenna	5 MHz

Table 33: BS transition requirements above 788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
788-791 MHz for block with upper edge at 788 MHz	21 dBm per antenna	3 MHz
788-791 MHz for block with upper edge at 783 MHz	16 dBm per antenna	3 MHz
791-796 MHz for block with upper edge at 788 MHz	19 dBm per antenna	5 MHz
791-796 MHz for block with upper edge at 783 MHz	17 dBm per antenna	5 MHz
796-801 MHz for block with upper edge at 788 MHz	17 dBm per antenna	5 MHz

Table 34: BS Requirements for part of duplex gap not used by SDL

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
-10 to 0 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	16 dBm per antenna	5 MHz
More than 10 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	-4 dBm per antenna	5 MHz

Table 35: BS Requirements for guard bands

Frequency range	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
Spectrum between broadcasting band edge and FDD uplink lower band edge (694-703 MHz)	-32 dBm per cell (1)	1 MHz
Spectrum between downlink upper band edge and downlink of 800 MHz MFCN (788-791 MHz)	14 dBm per antenna	3 MHz

(1) In a multi sector site “cell” refers to one of the sectors.

Table 36: BS Baseline requirements for DTT spectrum

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
For DTT frequencies below 694 MHz where broadcasting is protected	-23 dBm per cell (1)	8 MHz

(1) In a multi sector site “cell” refers to one of the sectors.

The TS BEM consists of an in-block level, elements for the duplex gap not used by SDL(including SDL, if applicable), requirements for the guard band between DTT below 694 MHz and the MFCN UL, and a baseline level for DTT spectrum, see Table 37: to Table 40:. Further requirements will have to be taken into account by ETSI in the harmonised standards, which may require close cooperation between ETSI, CEPT and Standard Developing Organisations.

The power limits are specified as e.i.r.p. for terminal stations designed to be fixed or installed and as TRP for terminal stations designed to be mobile or nomadic.

Administrations may relax the in-block power limit in certain situations, for example fixed TS in rural areas, Provided that protection of other services, networks and applications is not compromised and cross-border obligations are fulfilled.

Table 37: TS in-block emission limit

Maximum mean in-block power
23 dBm

Note: It is recognised that this value is subject to a tolerance of up to +2 dB, to take account of operation under extreme environmental conditions and production spread.

Table 38: TS Requirements for guard band (694-703 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
694 – 698 MHz	-7 dBm	4 MHz
698 - 703 MHz	2 dBm	5 MHz

Table 39: TS requirements for duplex gap (733-758 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
733-738 MHz	2 dBm	5 MHz
738-753 MHz (not applicable for blocks used by SDL)	-6 dBm	5 MHz
753-758 MHz (not applicable for blocks used by SDL)	-18 dBm	5 MHz

The assumptions used in the derivation of the unwanted emission requirements are based on the following objectives:

(i) to manage the risk of interference between mobile use and the broadcasting service below 694 MHz,

(ii) to be technically feasible from the point of view of practical implementation of MFCN terminal, and

(iii) to achieve global harmonization of mobile terminals.

Table 40: shows these unwanted emission requirements for MFCN terminal stations within the spectrum allocated to the broadcasting (DTT) service. The value of -42 dBm/8MHz assuming a 10 MHz channel bandwidth or less, and separated from DTT channel 48 with 9 MHz guard band, was chosen because it is a balanced solution to meet all the objectives above.

Table 40: Unwanted emissions requirements for TS over frequencies occupied by broadcasting

Frequency range of Unwanted emissions	Maximum mean unwanted power (see Notes)	Measurement Bandwidth
470-694 MHz	-42 dBm	8 MHz

Note 1: Unwanted emission limit was based on broadcasting using DVB-T2 and derived for an MFCN system with a bandwidth of 10 MHz for a DTT-MFCN centre frequency separation of 18 MHz (assuming an 8 MHz TV channel, 9 MHz guard band and a 10 MHz MFCN bandwidth).

If administrations wish to allow the deployment of MFCN on a national basis with a bandwidth greater than 10 MHz and in case an unwanted emission power higher than -42 dBm/8MHz is generated in the band below 694 MHz, they should consider:

- either implementing the greater MFCN bandwidth starting at a frequency higher than 703 MHz so that the required limit of unwanted emission power is still met;
- and/or applying mitigation techniques (see Note 3).

Note 2: This value has been derived with regard to fixed DTT reception. Administrations who wish to consider portable-indoor DTT reception may need, on a case-by-case basis, to implement further measures at a national/local level (see Note 3).

Note 3: Examples of potential mitigation techniques which may be considered by administrations include using additional DTT filtering, reducing the in-block power of the TS, reducing the bandwidth of the TS transmissions, or using techniques contained in the non-exhaustive list of potential mitigation techniques given in CEPT Report 30 [1]

Additional considerations on the coexistence between MFCN and broadcasting below 694 MHz

The impact should be determined on a case-by-case basis at national level. To mitigate DTT receiver blocking due to MFCN BS transmissions, additional external filtering could be required at the input of the DTT receiver chain, in particular to avoid overload saturation in antenna amplifiers.

Interference from broadcasting to MFCN

Interference from broadcasting transmitters to MFCN BS receivers either due to transmitter in-band power or unwanted emissions may arise. In such cases, appropriate mitigation techniques can be applied on a case-by-case basis at national level.

PMSE in 700 MHz

PMSE usage of spectrum in the MFCN duplex gap has been studied. Based on simulations of PMSE interference to MFCN UL and DL, power restrictions have been derived. Note that these power restrictions do not cover PMSE out-of-block emission in the MFCN duplex gap. A spectrum emission mask may be applied for that spectrum on a national basis.

PMSE could be used on a national basis in the lower guard band (694-703 MHz) and in the 25 MHz of the duplex gap of the MFCN 2 X 30 MHz band plan, depending on national situations and possible usage of this duplex gap by other services or applications (e.g., PPDR, SDL).The compatibility situation at the boundary between PMSE and MFCN around the uplink upper band edge, also applies at the lower band edge of the MFCN uplink, if PMSE is used in the guard band below the MFCN UL (694 -703 MHz), due to the fact that the equipment is the same.

Table 41: Power restrictions for handheld microphone

Frequency Range	e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies	-45 dBm(unwanted emissions)	200 kHz
More than -4.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	19 dBm(in-block power)	200 kHz
-4.2 to - 2.8 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	13 dBm(in-block power)	200 kHz
- 2.8 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)	--	--
MFCN downlink frequencies	-45 dBm(unwanted emissions)	200 kHz

Table 42: Power restrictions for body worn microphone

Frequency Range	e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies	-45 dBm(unwanted emissions)	200 kHz
More than -1.2 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block	19 dBm(in-block power)	200 kHz
- 1.2 to 0 MHz offset from MFCN downlink lower band edge or lower edge of the lowest SDL block (guard band)	--	--
MFCN downlink frequencies	-45 dBm(unwanted emissions)	200 kHz

Table 41-42 are providing power restrictions for PMSE in order to protect MFCN. These power restrictions are based on body loss assumed in CEPT Report 50, applicable to the frequency range 1785-1805 MHz. Some other body loss assumption such as the one in CEPT Report 30 [1] applicable to the frequency range 821-832 MHz would provide less stringent conditions and lower protection to MFCN. This issue will be considered in preparation of the CEPT Report B in response to the EC Mandate.

The ECC Report 221 [8] contains the study of the interference from commercial mobile network to PMSE equipment. The results of the studies indicate that for PMSE operation a frequency separation of approximately 1 MHz from MFCN downlink and 1 to 10 MHz from MFCN uplink (depending on spatial distance between MFCN TS and PMSE receiver) are needed.

It can be concluded that audio PMSE equipment will not be able to operate in the compatibility scenarios that were studied. However PMSE is able to find an operational channel with sufficient Quality of Service with the assumption of certain spatial distances between the PMSE equipment and the MFCN equipment. The most critical case is when the PMSE is close to a MFCN UE but if the separation distance is increased the probability of interference decreases accordingly.

PMSE should be operated only if a check of quality of service in the radio environment is performed before use and results in sufficient quality. The PMSE setup indicates whether enough PMSE channels with no interference are available to guarantee the needed quality of service. This procedure is described in Annex 5 of the ECC Report 191 [9].

Protection of PMSE below 694 MHz

Simulations carried out show that given the requirements on MFCN TSs and BSs to protect broadcasting below 694 MHz, PMSE will also be protected.

Compatibility with harmonised conditions of wireless broadband at 790-862 MHz

The preferred channelling arrangement in the 694-790 MHz band identified by CEPT (see ANNEX 2:) uses a conventional duplex arrangement (uplink in the lower part of the band and downlink in the upper part of the band). The 790-862 MHz band uses a reversed duplex arrangement (downlink in the lower part of the band and uplink in the upper part of the band), starting at 791 MHz.

As a consequence, the 700 MHz base station transmit band is adjacent to the 800 MHz base station transmit band. This avoids adjacency between base stations and terminal stations and therefore provides compatibility between the existing 790-862 MHz channelling arrangement and the MFCN channelling arrangement for the 694-790 MHz band.

To the largest extent possible the BEMs for 694-790 MHz have been aligned with those used for wireless broadband at 790-862 MHz.

Non-radio issues

The Mandate from the European Commission states that CEPT should indicate the potential impact on non-radio end-user equipment for fixed broadcasting and broadband electronic communication services in support of standardisation work relating to interference mitigation.

This CEPT Report in response to the 700 MHz EC Mandate covers radio-communication issues. In accordance with the Terms of Reference of ECC, the assessment of potential impact to non-radio systems have been limited to identification of potential frequency ranges (CEPT is not responsible for addressing the impact on non-radio equipment). CEPT describes the evolution of the spectrum usage in this band and the resulting new radio environment in this Report, and will inform ETSI and CENELEC so that they may take this into account in their work.

ANNEX 1: EC MANDATE ON 700 MHZ

EUROPEAN COMMISSION
Directorate-General for Communications Networks, Content and Technology

The Director General

Brussels,
DG CONNECT/B4

MANDATE TO CEPT TO DEVELOP HARMONISED TECHNICAL CONDITIONS FOR THE 694[1]-790 MHZ ('700 MHZ') FREQUENCY BAND IN THE EU FOR THE PROVISION OF WIRELESS BROADBAND ELECTRONIC COMMUNICATIONS SERVICES AND OTHER USES IN SUPPORT OF EU SPECTRUM POLICY PRIORITIES

1. Purpose

The 2012 ITU World Radiocommunication Conference (WRC-12) agreed on an allocation of the 694-790 MHz ('700 MHz') band to the mobile service[2] in ITU Region 1 with immediate effect after WRC-15, alongside broadcasting services., This created the challenge for EU spectrum policy to define a roadmap for a political decision-making process supported by technical specifications for the future use of the 700 MHz band in a coordinated way, in order to shape the ongoing process of international harmonisation of this band[3] while ensuring a balance of interests between incumbent and new users of spectrum and taking into account trends in technology and consumer behaviour.

In order to deal with this challenge in an efficient and forward-looking manner, EU spectrum policy should establish a long-term view of the future use of the whole UHF band currently allocated to terrestrial TV broadcasting in the EU (470-790 MHz[4]) taking into account the long-term developments of digital terrestrial television and their societal value, as well as the possibility of long-term convergence in broadcasting and wireless broadband to deliver voice, data and audio-visual services via a converged platform.

This mandate aims at developing **technical conditions** for the introduction of **wireless broadband** in the 700 MHz band by also studying the possibility of **shared spectrum use** with certain incumbent uses such as PMSE. The technical conditions should ensure the deployment of wireless broadband services while also taking into account **other priority areas of EU spectrum policy** such as public protection and disaster relief (PPDR) and should ensure appropriate protection for incumbent uses, primarily broadcasting services and PMSE, below the 700 MHz band, Appropriate protection of PMSE applications (such as wireless microphones) below the 700 MHz band should take into account the regulatory status of those applications.

The results of this mandate should constitute a **technical input to the EU-level political process** through a timely provision of the technical parameters for any strategic scenarios. The results of this

[1] This provisional lower band edge is subject to a precise definition within the scope of this Mandate. It is identical with the provisional lower limit stipulated in WRC-12 Resolution 232 which is subject to additional refinement at the WRC-15

[2] In ITU terminology

[3] Within the ITU Joint Task Group JTG 4-5-6-7 working on Agenda Items 1.1 (spectrum requirements for wireless broadband) and 1.2 (use of the 700 MHz band for mobile services) for WRC-15

[4] Subject to the release of the 800 MHz band from broadcasting services in all EU Member States in the future

mandate should also complement on high level deliverables of the Radio Spectrum Policy Group (RSPG), in particular the RSPG Opinions on wireless broadband[5] and the definition of common policy objectives for WRC-15[6].

The exploitation of the results of this mandate does not necessarily entail the development of a technical implementation measure under the Radio Spectrum Decision. Any common regulatory action at EU-level should be guided by an EU-level political agreement on the long-term use of the 700 MHz band. In particular, the results of this mandate **do not prejudice the outcome of the inventory process** set up by the Radio Spectrum Policy Programme (RSPP)[7], which has to assist identifying suitable frequency bands in support of specific EU policies. The inventory process, which involves assessment of spectrum supply and demand, will examine the efficiency of spectrum use in WAPECS[8] and other relevant frequency bands and may justify an implementation measure for re-organising the 700 MHz band at an early stage also in view of international developments.

The deliverables on this mandate should contribute to consolidating Member States' positions in the ongoing activities at CEPT and ITU on defining the technical and regulatory conditions for use of the 700 MHz band for wireless broadband alongside broadcasting services[9]. In addition, they should provide a basis for any Member State that may decide to proceed with WBB in the 700 MHz band at an early stage after WRC-15, so as to avoid fragmentation in the internal market. Therefore, the scope and schedule of the mandate reflect the need for a timely and coordinated EU position on harmonised technical conditions in time for WRC-15.

2. EU Policy objectives

The Digital Agenda for Europe (DAE) has set ambitious **broadband targets** by 2020, namely ubiquitous fast broadband coverage in the EU of at least 30 Mb/s as well subscriptions to super-fast broadband of at least 100 Mb/s for 50% of the EU households. WBB is expected to play an important role in achieving these objectives.

Pursuant to the adoption of the revised regulatory framework in electronic communications in 2009, the RSPP gives priority to ensuring sufficient spectrum for the implementation of **specific Union policies**, in particular wireless broadband access, the provision of innovative audio-visual media services (subject to clearly substantiated demand), public safety, civil protection and disaster relief as well as programme making and special events (PMSE)[10].

In its discussion paper on the future use of the 700 MHz band presented to the RSPG[11], the Commission services set out some of the policy considerations and possible options from an EU perspective in order to launch a strategic discussion with Member States on a long-term vision on the future use of this band, including the scenario of **broadband-broadcasting convergence**.
Furthermore, in the course of the **inventory process** established by the RSPP and in light of the objective to identify at least 1200 MHz for wireless broadband by 2015, opportunities are being studied to designate additional spectrum for WBB based on balancing spectrum supply and demand and an evaluation of whether efficiency gains can be envisaged (e.g. via re-allocation, re-farming or sharing).
Therefore, within the tasks of this mandate as specified in the Section "Task order and schedule", the Commission requests CEPT to take into account that use of the 700 MHz band should contribute to several **important EU policy objectives**, namely:

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[5] RSPG12-415 "Request for an Opinion on Strategic Challenges facing Europe in addressing the Growing Spectrum Demand for Wireless Broadband"

[6] RSPG12-422 "Request for an Opinion on the preparation of Common Policy Objectives for WRC-15"

[7] Decision 243/2012/EU of the European Parliament and of the Council of 14 March 2012

[8] Wireless Access Policy for Electronic Communications Services (see COM/2007/0050 final)

[9] In support of the studies at ITU level mandated by ITU Resolutions 232 and 233 (WRC-12)

[10] See Articles 3(b) and 6-8 of the RSPP (Decision 243/2012/EU)

[11] RSPG12-425 "Commission services' discussion paper on the future use of the 700 MHz band in the EU"

- strengthen the Internal Market for potential mass market services and equipment which will operate in the band both for legacy uses and potential new uses;
- contribute to the DAE broadband targets, which rely on a mix of technologies, including wireless broadband;
- support the development of the audio-visual media sector in developing innovative and converging services also by ensuring an appropriate level of protection of media services against interference from other spectrum uses;
- meet spectrum demand in support of specific Union policies, in particular wireless broadband, public safety, civil protection and disaster relief, and PMSE;
- promote innovation and investment through enhanced flexibility in spectrum use;
- foster shared use of spectrum as well as encourage passive infrastructure sharing.

3. Justification

Pursuant to Article 2 of the Radio Spectrum Decision, activities under the Decision must facilitate policy making with regard to the strategic planning and harmonisation of radio spectrum use as well as ensure the effective implementation of radio spectrum policy in the EU. Furthermore, they shall take due account of the work of international organisations related to spectrum management such as the ITU.

Pursuant to Article 4(2) of the Radio Spectrum Decision[12] the Commission may issue mandates to the CEPT for the development of technical implementing measures with a view to ensuring harmonised conditions for the availability and efficient use of radio spectrum necessary for the functioning of the internal market. Such mandates shall set the tasks to be performed and their timetable.

WRC-12 allocated on a co-primary basis the 694-790 MHz band to the mobile service in ITU Region 1 (including all EU Member States) from 2015, and mandated the development of technical and regulatory conditions in time for WRC-15, subject to ongoing studies at ITU level. These studies have the objective to evaluate spectrum requirements, refine the lower edge of the band and define channelling arrangements. They must also take into account the existing EU harmonisation in the 800 MHz band ('digital dividend')[13]. The importance of shaping the international negotiations arises from the unique opportunity offered by the ITU process to promote global technical alignment in a particular spectrum band which potentially translates into economies of scale, lower cost of investment and improved conditions for roaming, thus bringing benefits to EU economy and citizens. Therefore, a coherent EU position in support of the single market should be developed when developing and promoting relevant proposals in international negotiations.

Currently, the 700 MHz band is licensed for terrestrial TV broadcasting in Member States. The Geneva 2006 (GE-06) agreement has laid the framework for cross-border frequency coordination within the broadcasting services as well as between the broadcasting and other services. There is a need to assess the compatibility of any re-allocation of the 700 MHz band affecting broadcasting. While the technical conditions developed through this Mandate inter alia shall ensure coexistence between radio applications, the Mandate shall also indicate the potential impact on non-radio end-user equipment for fixed broadcasting and broadband electronic communications services in support of standardisation work relating to interference mitigation.

Sub-1GHz spectrum is a valuable and scarce frequency resource suitable for ubiquitous wireless coverage. This could make the 700 MHz band suitable not only for electronic communications services or broadcasting delivery services but also for public safety services such as **public**

[12] Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJL 108 of 24.4.2002

[13] Subject to Commission Decision 2010/267/EU

protection and disaster relief (PPDR)[14]. In particular, broadband PPDR may in the future be deployed based on commercial WBB technology, which could result in synergies *inter alia* for spectrum designation and use. Different options for spectrum use are currently under consideration for broadband PPDR, including the 700 MHz band. This Mandate addresses potential PPDR services in the 700 MHz band. Member States should benefit in terms of cost savings and interoperability from harmonised technical conditions for WBB spectrum use, which may also allow the deployment of broadband PPDR applications in the same frequency band already dedicated to WBB. This is without prejudice to national competences regarding the designation and authorisation of spectrum for PPDR and should not limit WBB use in those Member States which make use of the full spectrum range already dedicated to WBB.

Furthermore, the 470-790 MHz band already accommodates other incumbent applications such as PMSE, in particular wireless microphones. It must be noted that finding enough available spectrum for PPDR and PMSE is also priority of the RSPP. Therefore, the exclusive designation of the 700 MHz band to a single application such as WBB may not appear to be a sustainable approach. It is the high socio-economic value of this spectrum that calls for studying sharing opportunities between certain incumbent and potential new uses, either based on traditional frequency separation or on innovative approaches. In this regard, a mandate has already been issued to CEPT[15] to identify suitable frequency bands for wireless microphones and cordless cameras. Another mandate to CEPT to study alternative uses of the unpaired terrestrial 2 GHz band[16] highlights PMSE as one priority application.

Therefore, the Commission considers that international developments set in the context of consistent implementation of the RSPP objectives through the inventory process justify the need for technical studies to identify suitable spectrum in the 700 MHz band for WBB and other specific EU policy areas and harmonised technical conditions of use, in support of the EU-level policy process relating to the future use of this band.

4. Task order and schedule

CEPT is herewith mandated to undertake work to develop technical harmonisation conditions for the use of the 694-790 MHz frequency band for the provision of wireless broadband electronic communications services and shared use with other services or applications in support of EU spectrum policy priorities.

In the work carried out under the Mandate, the general and specific policy objectives of the RSPP, such as effective and efficient spectrum use and the support for specific Union policies shall be given utmost consideration. In implementing this mandate, CEPT shall, where relevant, take utmost account of EU law applicable and support the principles of service and technological neutrality, non-discrimination and proportionality insofar as technically possible.

CEPT is also requested to collaborate actively with the European Telecommunications Standards Institute (ETSI) which develops harmonised standards for conformity under Directive 1999/5/EC. In this regard, CEPT must indicate the potential impact of the deliverables on this Mandate on non-radio end-user equipment for fixed broadcasting and broadband electronic communications services in support of standardisation work relating to interference mitigation.

In particular, CEPT is mandated to carry out technical studies intended to support the policy objectives presented above, in fulfilment of the following <u>tasks</u>:

[14] PPDR as a public service does not represent an electronic communications service in the meaning of the Framework Directive (2002/21/EC) as amended by Directive 2009/140/EC, and thus is not considered as a WBB service. However, it could nevertheless make use of harmonised conditions for WBB use, subject to national demand.

[15] RSCOM11-59 rev1 "Mandate to CEPT on technical conditions regarding spectrum harmonisation options for wireless radio microphones and cordless cameras (PMSE equipment)"

[16] RSCOM12-17 rev3: "Mandate to CEPT to undertake studies on the harmonised technical conditions for the 1900-1920 MHz and 2010-2025 MHz frequency bands in the EU"

(1) Develop a *preferred technical (including channelling) arrangement* and identify *common and minimal (least restrictive) technical conditions*[17] for wireless broadband use in the 694-790 MHz frequency band for the provision of electronic communications services, subject later to a precise definition of the lower band edge under task (3), as well as PPDR services that can make use of such technical conditions. These conditions should be sufficient:

(a) to avoid interference between wireless broadband use and other services in the 694-790 MHz band and in adjacent bands, and in particular to ensure the appropriate protection of broadcasting and PMSE services below the lower band edge, as well as compliance with EU harmonised conditions for the 790-862 MHz band[18];

(b) to facilitate cross-border coordination, including at the EU external borders;

(2) In performing (1), study the possibility of identifying *suitable spectrum to accommodate* incumbent uses in the 694-790 MHz band such as PMSE (in particular wireless microphones)[19], and develop *common technical conditions* for the coexistence of such uses with wireless broadband use in the band, taking into account spectrum sharing requirements and efficient spectrum use;

(3) In addition to and based on (1) and taking utmost account of the possibility of international harmonisation[20], assess the need to refine the conditions developed under (1), in particular *the common and minimal (least restrictive) technical conditions,* in order to ensure that they are sufficiently precise for the development of EU-wide equipment. The overall aim of a coordinated European approach should be considered, as implemented through detailed national decisions on frequency rearrangements in line with international frequency coordination obligations.

The Commission may provide CEPT with further guidance on this mandate depending on future agreements at EU level (which may involve the European Parliament and the Council) concerning spectrum resources to be made available in the context of specific EU policies, as well as relevant impact assessments the Commission may undertake in this context. Also, the impact of spectrum demand assessments for different uses at national level may require to be taken into account during the work on the Mandate.

CEPT should provide deliverables under this Mandate according to the following schedule:

Delivery date	Deliverable	Subject
November 2013	Interim Report from CEPT to the Commission	Description of work undertaken and interim results on tasks (1) and (2)
July 2014[21]	Final Draft Report A from CEPT to the Commission	Description of work undertaken and final results on tasks (1) and (2)
November 2014	Final Report A from CEPT to the Commission, taking into account the outcome of the public consultation	Description of work undertaken and final results taking into account the results of the public consultation on tasks (1) and (2)

[17] Such as the definition of appropriate BEMs (Block Edge Masks)
[18] Subject to Commission Decision 2010/267/EU
[19] For example in unused parts of the band such as a center gap of a potential FDD arrangement
[20] Such as resolutions at the ITU WRC-15
[21] Subject to subsequent public consultation

March 2016	Final Draft Report B from CEPT to the Commission	Considering international developments such as outcomes of the ITU WRC-15 - description of work undertaken and final results of the Mandate on task (3) as well as review of the results of the Final Report on tasks (1) and (2)
July 2016	Final Report B from CEPT to the Commission	Considering international developments such as outcomes of the ITU WRC-15 - description of work undertaken and final results of the Mandate on task (3) as well as review of the results of the Final Report on tasks (1) and (2), taking into account the results of the public consultation.

CEPT is requested to report on the progress of its work pursuant to this Mandate to all meetings of the Radio Spectrum Committee taking place during the course of the Mandate.

The Commission, with the assistance of the Radio Spectrum Committee and pursuant to the Radio Spectrum Decision, may consider applying the results of this mandate in the EU, pursuant to Article 4 of the Radio Spectrum Decision and subject to the results of the inventory process and the guidance of the RSPG.

ANNEX 2: TECHNICAL PARAMETERS FOR ELECTRONIC COMMUNICATIONS SERVICES

In this report MFCN is understood as a network for Wireless Broadband used for the provision of Electronic Communications Services (WBB/ECS).

Based on the result of studies in response to the EC Mandate on the 700 MHz band, the following elements are considered by CEPT to be relevant in the context of potential future EU harmonisation:

- Channelling arrangement in the 694-790 MHz band for MFCN;
- Common least restrictive technical conditions (BEM) for MFCN;
- Coexistence between MFCN in the 694-790 MHz band and Broadcasting below 694 MHz;
- Compatibility with harmonised conditions of MFCN in the 790-862 MHz band;
- Coexistence between MFCN in the 694-790 MHz band and PMSE below 694 MHz.

In response to the task 2 of the EC Mandate, the possible spectrum to accommodate PMSE, on national basis, in the 694-790 MHz band and the relevant common technical conditions (BEM) for PMSE are described in chapter 2 (possible spectrum) and section 7.1 (BEM) of this CEPT Report.

The implementation of PPDR in the 700 MHz band is a national decision and not suitable for the EU harmonisation.

1. Channelling arrangement for electronic communications services

Within the band 694-790 MHz the channelling arrangement shall be as follows:

- The block sizes shall be in multiples of 5 MHz, which does not preclude smaller channel bandwidths within a block;
- Paired frequency arrangement (FDD):
  - terminal station transmitter: 703-733 MHz;
  - base station transmitter: 758-788 MHz.
- Unpaired frequency arrangement:
  - supplemental downlink using ‘zero up to four’ of the following frequency blocks: 738-743 MHz, 743-748 MHz, 748-753 MHz and 753-758 MHz. The decision on the number of contiguous blocks would be taken at national level. This national approach ensures flexibility for combination with other alternative options described hereafter.

In the guard bands and duplex gap, CEPT also identified alternative options, which may or may not include an SDL option, for implementation on national basis of PMSE, PPDR, M2M, and other services. These options may offer some flexibility according to the needs of administrations/EU member states.

2. Common least restrictive technical conditions for electronic communications services

The technical conditions presented in this section are in the form of block edge masks (BEMs).

A BEM is an emission mask that is defined as a limit on the average e.i.r.p. inside and outside of the block of spectrum licensed to an operator.

A BEM consists of several elements which are defined for certain measurement bandwidths. The in-block power limit may be applied to a block licensed to an operator. The out-of-block elements consist of a baseline level, designed to protect the spectrum (paired or SDL) of other MFCN operators as well as services in adjacent spectrum, and transitional levels enabling filter roll-off from in-block to baseline levels.

BEMs shall be applied as an essential component of the technical conditions necessary to ensure coexistence between services at a national level. However, it should be understood that the derived BEMs do not always provide the required level of protection of victim services and additional mitigation techniques may need to be applied in order to resolve remaining cases of interference.

Less stringent technical parameters may be agreed on a national, bilateral or multilateral basis for the operation of mobile/fixed communications networks (MFCN) in the 694-790 MHz band, providing that they continue to comply with the technical conditions applicable for the protection of other services, applications or networks and with cross-border obligations.

The term block edge refers to the frequency boundary of an authorised right of use. The term band edge refers to the boundary of a range of frequencies designated for a certain use.

A2.1 TECHNICAL CONDITIONS FOR BASE STATIONS (BS)

Table 43: contains the different elements of the BS BEM, and Table 44: to Table 49: contain the power limits for the different BEM elements.. When combining SDL and alternative use options there may have to be different technical conditions for SDL. Further studies are underway within CEPT to determine the appropriate least restrictive technical conditions in these cases

To obtain a BS BEM for a specific block in the paired DL or SDL spectrum, the BEM elements that are defined in Table 43: are used as follows:

- In-block power limit is used for the block assigned to the operator.
- Transitional regions are determined, and corresponding power limits are used. The transitional regions may overlap with guard bands and adjacent bands, in which case transitional power limits are used. Transitional requirements do not apply in MFCN UL spectrum.
- For remaining spectrum assigned to MFCN UL and DL (including SDL spectrum, if applicable), for DTT spectrum below 694 MHz and for spectrum allocated to MFCN above 790 MHz, baseline power limits are used.
- For remaining guard band spectrum (i.e. not covered by transitional regions) guard band power limits are used.
- For spectrum between 733 and 758 MHz not used by MFCN (including SDL), duplex gap requirements apply.

Table 43: BS BEM elements

In-block	Block for which the BEM is derived.
Baseline	Spectrum used for MFCN UL and DL (including SDL, if applicable), for DTT and for MFCN above 790 MHz (UL and DL).
Transitional region	The transitional region applies from 0 to 10 MHz below and above the block assigned to the operator, except from in the uplink region of MFCN(703-733 MHz).
Guard bands	- Spectrum between the DTT allocation below 694 MHz and the lower edge of the MFCN uplink (694-703 MHz); - Spectrum between the upper edge of MFCN downlink and the lower edge of MFCN downlink above 790 MHz (if applicable) (788-791 MHz). In case of overlap between transitional regions and guard bands, transitional power limits are used.
Duplex Gap	Spectrum in the duplex gap which is not used by SDL. In case of overlap between transitional regions and the part of the duplex gap not used by SDL, transitional power limits are used.

- In-block limits:
  The adoption of in-block power limits is not mandatory. In case an upper bound is desired by an administration, a value of 64 dBm/5 MHz per antenna may be applied.
- Out-of-block limits:

Table 44: BS baseline requirements

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
MFCN uplink frequencies (703 – 733 MHz)	-50 dBm per cell (1)	5 MHz
Uplink frequencies of 800 MHz band (832- 862 MHz)	-49 dBm per cell (1)	5 MHz
MFCN downlink frequencies (758 – 788 MHz), SDL blocks in the duplex gap, and downlink frequencies of 800 MHz band (791-821 MHz)	16 dBm per antenna	5 MHz

(1) In a multi sector site “cell” refers to one of the sectors.

Table 45: BS transition requirements in the range 733-788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
–10 to –5 MHz from lower block edge	18 dBm per antenna	5 MHz
–5 to 0 MHz from lower block edge	22 dBm per antenna	5 MHz
0 to +5 MHz from upper block edge	22 dBm per antenna	5 MHz
+5 to +10 MHz from upper block edge	18 dBm per antenna	5 MHz

Table 46: BS transition requirements above 788 MHz

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
788-791 MHz for block with upper edge at 788 MHz	21 dBm per antenna	3 MHz
788-791 MHz for block with upper edge at 783 MHz	16 dBm per antenna	3 MHz
791-796 MHz for block with upper edge at 788 MHz	19 dBm per antenna	5 MHz
791-796 MHz for block with upper edge at 783 MHz	17 dBm per antenna	5 MHz
796-801 MHz for block with upper edge at 788 MHz	17 dBm per antenna	5 MHz

Table 47: BS Requirements for part of duplex gap not used by SDL

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
-10 to 0 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	16 dBm per antenna	5 MHz
More than 10 MHz offset from DL lower band edge or lower edge of the lowest SDL block, but above uplink upper band edge	-4 dBm per antenna	5 MHz

Table 48: BS Requirements for guard bands

Frequency range	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
Spectrum between broadcasting band edge and FDD uplink lower band edge (694-703 MHz)	-32 dBm per cell (1)	1 MHz
Spectrum between downlink upper band edge and downlink of 800 MHz MFCN (788-791 MHz)	14 dBm per antenna	3 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

Table 49: BS Baseline requirements for DTT spectrum

Frequency range	Maximum mean e.i.r.p.	Measurement bandwidth
For DTT frequencies below 694 MHz where broadcasting is protected	-23 dBm per cell (1)	8 MHz

(1) In a multi sector site "cell" refers to one of the sectors.

A2.2 TECHNICAL CONDITIONS FOR TERMINAL STATIONS

The power limits are specified as e.i.r.p. for terminal stations designed to be fixed or installed and as TRP for terminal stations designed to be mobile or nomadic.

Table 50: TS in-block emission limit

Maximum mean in-block power
23 dBm

Note: It is recognised that this value is subject to a tolerance of up to +2 dB, to take account of operation under extreme environmental conditions and production spread.

Table 51: TS Requirements for guard band (694-703 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
694 – 698 MHz	-7 dBm	4 MHz
698 - 703 MHz	2 dBm	5 MHz

Table 52: TS requirements for duplex gap (733-758 MHz)

Frequency range of out-of-block emissions	Maximum mean out-of-block e.i.r.p.	Measurement bandwidth
733-738 MHz	2 dBm	5 MHz
738 – 753 MHz (not applicable for blocks used by SDL)	-6 dBm	5 MHz
753 – 758 MHz (not applicable for blocks used by SDL)	-18 dBm	5 MHz

Table 53: Out-of-band requirements for TS over frequencies occupied by broadcasting

Frequency range of out-of-band emissions	Maximum mean out-of-band power (see Notes)	Measurement Bandwidth
470-694 MHz	-42 dBm	8 MHz

Note 1: Out-of-band emission limit was based on broadcasting using DVB-T2 and derived for an MFCN system with a bandwidth of 10 MHz for a DTT-MFCN centre frequency separation of 18 MHz (assuming an 8 MHz TV channel, 9 MHz guard band and a 10 MHz MFCN bandwidth).

If administrations wish to allow the deployment of MFCN on a national basis with a bandwidth greater than 10 MHz and in case an out-of-band power higher than -42 dBm/8MHz is generated in the band below 694 MHz, they should consider:

- either implementing the greater MFCN bandwidth starting at a frequency higher than 703 MHz so that the required limit of out-of-band power is still met;
- and/or applying mitigation techniques (see Note 3).

Note 2: This value has been derived with regard to fixed DTT reception. Administrations who wish to consider portable-indoor DTT reception may need, on a case-by-case basis, to implement further measures at a national/local level (see Note 3).

Note 3: Examples of potential mitigation techniques which may be considered by administrations include using additional DTT filtering, reducing the in-block power of the TS, reducing the bandwidth of the TS transmissions, or using techniques contained in the non-exhaustive list of potential mitigation techniques given in CEPT Report 30 [1].

3. Coexistence with PMSE below 694 MHz

BEM requirements for TSs and BSs to protect broadcasting below 694 MHz are also sufficient for the protection of PMSE.

ANNEX 3: DERIVATION OF BS BASELINE REQUIREMENTS FOR FDD UPLINK FREQUENCIES

In CEPT Report 30 [1] the baseline requirements for FDD uplink frequencies are based on the Minimum Coupling Loss (MCL) approach for a base-to-base line-of-sight interference scenario between a transmitting BS and a receiving BS from another operator separated by 100 m.

Table 54: summarises the MCL calculation based on the principles in CEPT Report 30 [1], where the 800 MHz BEMs are derived, although the frequency is changed here to reflect the studied band. The main difference with CEPT Report 30 is the propagation loss which is 69.9 dB (instead of 71 dB); the feeder link loss it is not considered as measurements are made at the antenna connector.

Table 54: Parameters for MCL calculation of BS to BS interference

Parameters	Value
Receiver bandwidth (nominal for 5 MHz channel BW)	4.5 MHz
Receiver noise figure	5 dB
Receiver noise floor	-102.5 dBm/5 MHz
Protection ratio (INR)	-5.8 dB
Maximum received interference	-108.3 dBm
Pathloss (freespace, 750 MHz, 100m)	69.9 dB
Receiver antenna gain [including feeder loss]	15 dBi
Receiver tilt loss	3 dB
Transmitter tilt loss	3 dB

The BS baseline requirements for uplink frequencies is obtained with the assumptions in Table 54:.
Considering the following notations:

ACIR	Adjacent Channel Interference Ratio
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
e.i.r.p.tx	Base station in-block e.i.r.p.
GArx	Receiver Antenna Gain
Gtxtilt	Tilting Gain of the TX antenna
Rtxtilt	Tilting Gain of the RX antenna
PL	Path-Loss
NF	Noise Floor
INR	Interference over Noise Ratio

It is obtained:

ACIR = e.i.r.p.tx +Gtxtilt -PL+GArx+ Grxtilt – (NF+ INR)

ACIR= e.i.r.p.tx -3 -69.9+15 -3 – (-102.5 –5.8) = e.i.r.p.tx + 47.4 dB

Considering ACS=ACLR, then ACLR = ACIR+3 = e.i.r.p.tx + 47.4 +3 = e.i.r.p.tx + 50.4 dB

The BS baseline requirements can be therefore derived as:

BS baseline requirement = e.i.r.p.tx – ACLR = e.i.r.p.tx – (e.i.r.p.tx + 50.4) = **-50.4 dBm/ 5MHz**

ANNEX 4: DERIVATION OF THE REQUIREMENTS FOR TERMINAL STATIONS OVER FREQUENCIES USED AS GUARD BAND

To meet the coexistence requirements between MFCN and DTT in terms of OOBE limits for terminal stations, the optimisation of duplexers is needed.

To this aim, in the frequencies used as guard band, emission limits in line with the LTE standards have been considered, in particular Table 6.6.2.1.1-1 of 3GPP 36.101 [7](see Table 55:).

Table 55: General E-UTRA spectrum emission mask [7]

Spectrum emission limit (dBm) / Channel bandwidth							
Δf_{OOB} (MHz)	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	Measurement bandwidth
± 0-1	-10	-13	-15	-18	-20	-21	30 kHz
± 1-2.5	-10	-10	-10	-10	-10	-10	1 MHz
± 2.5-2.8	-25	-10	-10	-10	-10	-10	1 MHz
± 2.8-5		-10	-10	-10	-10	-10	1 MHz
± 5-6		-25	-13	-13	-13	-13	1 MHz
± 6-10			-25	-13	-13	-13	1 MHz
± 10-15				-25	-13	-13	1 MHz
± 15-20					-25	-13	1 MHz
± 20-25						-25	1 MHz

Considering the frequency ranges 703-733 MHz and 758-788 MHz as uplink and downlink respectively, values in the table above correspond to the following emission levels over larger bandwidth:

Table 56: Derived emission levels

Frequency range	LTE BW					
	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz
694-698 MHz	-19.0 dBm	-19.0 dBm	-12.2 dBm	-7.0 dBm	-7.0 dBm	-7.0 dBm
698-703 MHz	5.4 dBm	3.2 dBm	1.6 dBm	-0.3 dBm	-1.3 dBm	-1.8 dBm
733-738 MHz	5.4 dBm	3.2 dBm	1.6 dBm	-0.3 dBm	-1.3 dBm	-1.8 dBm
738-743 MHz	-18.0 dBm	-18.0 dBm	-12.0 dBm	-6.0 dBm	-6.0 dBm	-6.0 dBm
743-748 MHz	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm	-6.0 dBm	-6.0 dBm
748-753 MHz	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm	-6.0 dBm
753-758 MHz	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm	-18.0 dBm

In order for a range of terminals to be supported in the band, it is necessary to adopt emission requirements as the envelope of the terminals emissions. Assuming that support for 1.4 and 3 MHz terminals is not required in this band, the requirements for terminal stations in the table below can be derived.

Table 57: Requirements over frequencies used as guard band

Frequency range	Requirement	Measurement Bandwidth
694-698 MHz	-7.0 dBm	4 MHz
698-703 MHz	1.6 dBm	5 MHz
733-738 MHz	1.6 dBm	5 MHz
738-753 MHz	-6.0 dBm	5 MHz
753-758 MHz	-18 dBm	5 MHz

ANNEX 5: IMPACT OF THE INTRODUCTION OF MFCN IN THE 700 MHz ON PMSE

A5.1 MONTE-CARLO SIMULATION WITH SEAMCAT

In order to assess the impact of MFCN terminal on PMSE receiver below 694 MHz, a Monte-Carlo simulation has been performed. The scenario and parameters are taken from ECC Report 191 [9]

In ECC Report 191, several scenarios are considered, but the most critical and relevant in this study is Scenario 12 (see Table 58:).

Table 58: Coexistence scenario between PMSE and LTE UE [9]

Outdoor/ Indoor	Interferer	Victim	Distance (MCL)	Distance range (Monte-Carlo Simulations)	Propagation model
Indoor	LTE UE	PMSE	5 m	5…50 m	IEEE 802.11 Model C, break-point at 5m

Simulation parameters are summarised in Table 59:

Table 59: Parameters for MFCN UE

Parameter	Unit	Value	Comment
Channel bandwidth	MHz	10	
Transmission bandwidth (BW)	MHz	9	ETSI TS 136 101, Table 7.3.1-2
Antenna height	m	1.5	
Body loss	dB	3	
Antenna gain	dBi	-4	Average value Omni directional
Maximum transmit power	dBm	23	ETSI TS 136 101, Table 6.2.2-1
Cell size	m	350	Urban environment is considered.

In this simulation MFCN UE power control is considered and the values in Table 60: below are used.

Table 60: MFCN UE power control values

Parameter	Unit	Value	Comment
Power control step size	dB	1	
Minimum threshold	dBm	-101.5	Sensitivity of the MFCN BS
Dynamic range	dB	63	

This means that if the received power at the base station is higher than the minimum threshold, the UE will reduce the transmitted power in 1 dBm steps, until the minimum threshold is reached. Depending on the frequency separation between block edge of the MFCN UE and PMSE channel edge, and the filter characteristics of the UE in questions. PMSE can experience different levels of MFCN UE OOB emissions as illustrated in Table 61:. These values correspond to a maximum Transmit power of 23 dBm and for lower transmitted power due to power control the OOB emission will be lower as well.

The results of the simulation are illustrated in Table 61:.

Table 61: Monte-Carlo Simulation Results

Interference probability: Unwanted [%]						
Maximum MFCN UE OOB emission level [dBm/MHz]	-13	-25	-28	-30	-35	-37
% interference unwanted	17.6	5.95	4.06	3.35	1.35	0.85

The simulation results indicate that with a MFCN UE OOB emission level lower than -28 dBm/MHz, the probability of interference from MFCN UE to PMSE receiver is below 4%, which is in line with protection criteria used in ECC Report 191 [9].

A5.2 COEXISTENCE STUDY BASED ON “SCENARIO 12” FROM ECC REPORT 191

In this study, we consider MFCN UE randomly dispatched (uniform distribution) from 0 to 10 metres around the PMSE receiver.

The different parameters used in the simulations are taken from ECC Report 191 [9].

Table 62: MFCN UE parameters

Parameter	Unit	Value
Channel bandwidth	MHz	10
Antenna height	m	1.5
Body loss	dB	3
Antenna gain	dBi	-2
Maximum transmit power	dBm	23

Table 63: PMSE receiver parameters

Parameter	Unit	Value
Bandwidth (BW)	MHz	0.2
Reference sensitivity	dBm	-90
Noise figure (NF)	dB	6
Noise floor (N)	dBm	-115
Standard desensitization $D_{STANDARD}$	dB	3
Antenna height	m	3
Antenna gain	dBi	0
C/(N+I)	dB	25

In the simulation the minimum required signal of -90 dBm (sensitivity) with a location probability of 95% has been used. The fading conditions on a stage are simulated with a Gaussian distribution with a standard deviation of 12 dB. The distribution of the wanted signal is described in Annex 1, section A1.3.1, of ECC Report 191 [9].

Free space loss was used as propagation model.

We then look at the probability of interference depending on the distance for an OOBE of -51 dBm/MHz (corresponding to -42 dBm/8MHz), in Figure 7.

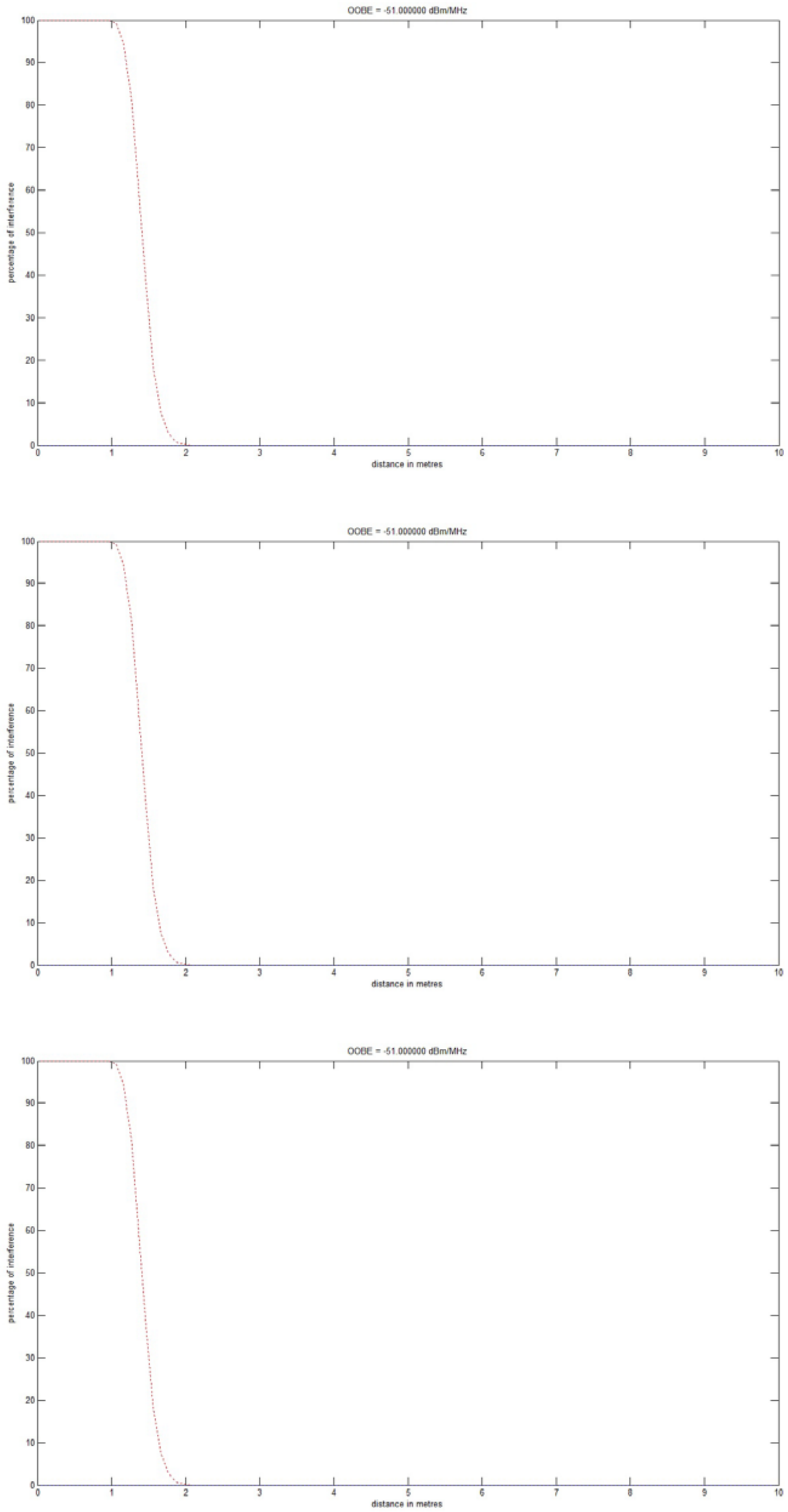

Figure 7: Probability of Interference as a function of the distance

It can be concluded that for a distance separation above 3 metres, the probability of interference is negligible for a OOBE of -51 dBm/MHz (corresponding to -42 dBm/8MHz), even though power control was not implemented and the signal strength of the PMSE link was very low.

A5.3 CONCLUSION

Considering the results of the presented studies it can be concluded that MFCN TS and PMSE below 694 MHz can coexist.

ANNEX 6: ANALYSIS OF POTENTIAL INTERFERENCE FROM BROADCASTING TRANSMITTERS TO MFCN BS RECEIVERS

A6.1 CO-EXISTENCE SCENARIO AND SIMULATION ASSUMPTIONS

The frequency arrangement considered in the simulation of potential interference from DTT to MFCN uplink is plotted in Figure 8. It can be seen that the analysis and simulations are focused on the potential interference from DTT channel 48 (686-694 MHz) to MFCN UL lower block (703-713 MHz).

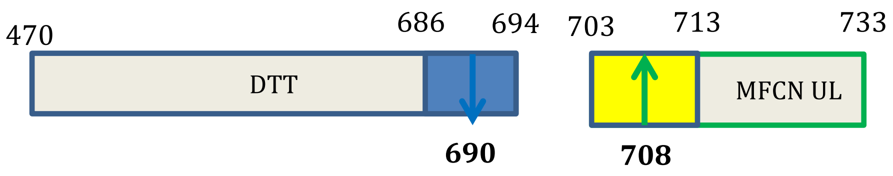

Figure 8: Frequency arrangement considered in the analysis of interference from DTT to MFCN Uplink

The coexistence scenario for the analysis of potential interference from DTT transmitter to MFCN uplink is illustrated in Figure 9.

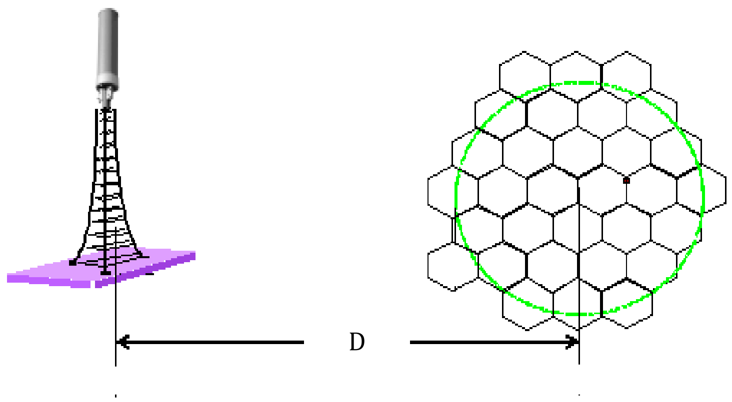

Figure 9: Co-existence scenario

As shown in Figure 9, a LTE network clutter (7 tri-sector sites composed of 21 cells) is placed at separation distance D (between the DTT transmitter and LTE cluster centre reference cell site). The DTT parameters and LTE network parameters are summarised in the following tables. In particular DTT parameters are given in Table 64:, DTT transmitter non critical mask and critical mask are given in Table 65:, and MFCN UL system parameters are summarised in Table 66:.

Table 64: DVB-T link budget for fixed roof top reception

DVB-T link budget for fixed roof top reception at 10 m Single transmitter case (Assignments)				
DVB-T parameters		**Downlink all environments (Medium power transmitter)**	**Downlink all environments (High power transmitter)**	**Notes**
Center frequency	MHz	690.00	690.00	Channel 48
Channel BW	MHz	8.00	8.00	
Effective BW	MHz	7.61	7.61	
Noise figure (F)	dB	7	7	
Boltzmann's constant (k)	Ws/K	1.38E-23	1.38E-23	
Absolute temperature (T)	K	290	290	
Noise power (P_n)	dBm	-98.16	-98.16	P_n(dBm) = F+10log(k*T*B*10^6)+30
SNR at cell-edge	dB	21	21	
Receiver sensitivity (P_{min})	dBm	-77.16	-77.16	P_{min} = P_n(dBm) +SNR(dB)
Cell-edge coverage probability	%	95	95	
Gaussian confidence factor for cell-edge coverage probability of 95% ($\mu_{995\%}$)	%	1.645	1.645	
Shadowing loss standard deviation (σ)	dB	5.50	5.50	
Building entry loss standard deviation (σ_w)	dB	0.00	0.00	
Total loss standard deviation (σ_T)	dB	5.50	5.50	s_T = SQRT(σ^2 + $\sigma_w{}^2$)
Loss margin (L_m)	95%	9.05	9.05	L_m = $\mu_{95\%}$* σ_T
P_{mean} (95%)	dBm	-68.11	-68.11	P_{mean} = P_{min} + L_m
Minimum median field strength	dBµV/m	56.72	56.72	
E.i.r.p.	dBm	69.15	85.15	5 and 200 kW ERP respectively.
Antenna height	m	150.00	300.00	
Cable loss (L_{cable})	dB	4.00	4.00	
Antenna gain (G_{iso})	dBi	13.15	13.15	
G_{iso}-L_{cable}	dBi	9.15	9.15	
Average building entry loss (L_{wall})	dB	0.00	0.00	
Max allowed path loss (L_{pmax})	dB	146.42	162.42	L_{pmax} = e.i.r.p. + (G_{iso}-L_{cable}) - L_{wall} -L_{body} -P_{mean}
DVB-T coverage radius calculated by JTG 5-6 model	km	12.62	39.5	Urban
	km	32.11	70.53	Suburban
	km	32.11	70.53	Rural

Table 65: DTT Tx mask (GE06)

DTT Tx mask for 8 MHz Channel		
	Non critical	Critical
Frequency relative (MHz)	Relative level (dB)	Relative level (dB)
–12	–110	–120
–6	–85	–95
–4.2	–73	–83
–3.9	–32.8	–32.8
+3.9	–32.8	–32.8
+4.2	–73	–83
+6	–85	–95
+12	–110	–120

Table 66: MFCN UL system parameters

MFCN UL system parameters	
Channel bandwidth	10 MHz
BS antenna height	30 m
BS antenna gain	15 dBi including feeder loss
BS antenna patterns	ITU-R F1336 with k=0.7
BS antenna downtilt	6° (urban)
UE Tx maximum power	23 dBm
UE antenna gain	-3 dB
Body/hand loss	-4 dB
MCL UE to BS	70 dB
Number of active users per cell	3 UEs/cell
Cell range	1 km (urban)

In the simulation of potential interference from DTT to MFCN UL, DTT transmitter antenna used has an omnidirectional pattern on horizontal plan, and a vertical antenna pattern taken from a real DTT transmitter antenna.

In the simulation, 3 outdoor LTE UEs are generated per cell. LTE network cluster throughput loss due to interference from DTT is simulated. LTE BS receiver mask is taken from 3GPP TS36.104 [6], as given in Table 67:.

Table 67: LTE 10 MHz BS receiver mask [6]

LTE 10 MHz BS receiver mask (5 dB noise figure)	
Frequency offset (MHz)	Rejection (dB)
<-25	79.7
-25 to -10	51.7
-10 to -5	42.7
-4.5 to 4.5	0
5 to 10	42.7
10 to 25	51.7
-25	79.7

In the simulation, a variable additional isolation for LTE700 BS receiver blocking below 694 MHz is assumed; the objective is to find the appropriate LTE700 BS blocking level to keep the throughput loss below 5%.

The propagation models used in the simulations are summarised in Table 68:.

Table 68: Propagation models used in the simulation

Propagation models used in the simulation	
Link	Propagation model
DTT Tx to Rx	ITU-R P.1546
LTE UE to BS	Extended Hata (Urban)
DTT Tx to LTE BS	ITU-R P.1546

A6.2 INTERFERENCE SIMULATION AND ANALYSIS

Urban area DTT high site (H=300 m, Tx e.i.r.p.=85.15 dBm)

The simulation results for DTT transmitter antenna at 300 m and e.i.r.p. 85.15 dBm in urban area with critical DTT Tx mask and non-critical DTT Tx mask are given in Table 69: and Table 70: respectively, for a separation distance between DTT transmitter and LTE cluster reference cell BS of D=300 m.

Table 69: Simulation results for D=300 m (DTT Tx e.i.r.p.=85.15 dBm at H=300 m) (DTT Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted (dBm)	-118.55	-118.96	-118.93	-118.68
iRSS_Blocking (dBm)	-78.82	-98.97	-109.2	-118.95
Ref_Cell TP Loss (%)	94.071	27.846	6.24	1.333
Net average TP Loss (%)	95.324	34.596	9.18	2.32

Table 70: Simulation results for D=300 m (DTT Tx e.i.r.p.=85.15 dBm at H=300 m) (DTT Non Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-108.89	-109.01	-108.81	-108.85
iRSS_Blocking	-79.16	-99.88	-109.08	-119.13
Ref_Cell TP Loss (%)	93.337	26.995	9.658	6.309
Net average TP Loss (%)	95.262	35.668	14.232	9.439

The simulation results in Table 69: and Table 70: show that when the LTE700 network cluster is placed at D=300 m from DTT transmitter:

1. When 40 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the critical mask, LTE700 uplink throughput loss is about 2%, that is well below 5%.
2. When 40 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the non-critical mask, LTE700 uplink throughput loss is about 9%.

The simulation results are given in Table 71: and Table 72: respectively for DTT transmitter with critical Tx mask and non-critical Tx mask for a separation distance between DTT transmitter and LTE cluster reference cell BS of D=19.75 km.

Table 71: Simulation results for D=19.75km (DTT Tx e.i.r.p.=85.15 dBm at H=300m) (DTT Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-126.9	-126.63	-126.43	-126.56
iRSS_Blocking	-87.17	-106.91	-116.7	-126.83
Ref_Cell TP Loss (%)	73.608	8.632	1.378	0.235
Net average TP Loss (%)	57.396	5.078	0.763	0.155

Table 72: Simulation results for D=19.75km (DTT Tx e.i.r.p.=85.15 dBm at H=300m) (DTT Non Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-116.58	-116.55	-117.01	-116.21
iRSS_Blocking	-86.86	-106.82	-117.28	-126.48
Ref_Cell TP Loss (%)	74.619	9.237	2.114	1.511
Net average TP Loss (%)	58.129	5.530	1.333	0.818

The simulation results in Table 71: and Table 72: show that when the LTE700 network cluster is placed at D=19.75 km from DTT transmitter, which is the middle point of the DTT coverage range:

1. When 30 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the critical mask, LTE700 uplink throughput loss is about 1%, that is well below 5%.
2. When 30 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the non-critical mask, LTE700 uplink throughput loss is about 2%, that is below 5%.

Urban area DTT Low site (H=150 m, Tx e.i.r.p.=69.15 dBm)

The simulation results for DTT transmitter at 150 m and e.i.r.p. 69.15 dBm in urban area with critical DTT Tx mask and non-critical DTT Tx mask are given in Table 73: and 0 respectively for aseparation distance between DTT transmitter and LTE cluster reference cell BS of D=300 m.

Table 73: Simulation results for D=300 m (DTT Tx e.i.r.p.=69.15 dBm at H=150 m) (DTT Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted (dBm)	-132.07	-131.78	-131.65	-131.39
iRSS_Blocking (dBm)	-92.34	-112.05	-121.93	-131.66
Ref_Cell TP Loss (%)	54.172	3.257	0.409	0.073
Net average TP Loss (%)	65.206	7.545	1.264	0.254

Table 74: Simulation results for D=300 m (DTT Tx e.i.r.p.=69.15 dBm at H=150 m) (DTT Non Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-121.46	-121.94	-121.9	-121.82
iRSS_Blocking	-91.73	-112.21	-122.18	-132.1
Ref_Cell TP Loss (%)	56.349	3.231	0.666	0.445
Net average TP Loss (%)	65.866	8.224	2.093	1.271

The simulation results given in Table 73: and Table 74: show that:

1. When 30 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the critical mask, LTE700 uplink throughput loss is about 1%, that is well below 5%.
2. When 30 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the non-critical mask, LTE700 uplink throughput loss is about 2%, that is below 5%.

The simulation results for DTT with critical Tx mask and non-critical Tx mask are given in Table 75: and Table 76: respectively for a separation distance between DTT transmitter and LTE cluster reference cell BS of D=6.3 km.

Table 75: Simulation results for D=6.3km (DTT Tx e.i.r.p.=69.15 dBm at H=150m) (DTT Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-132.51	-132.69	-132.87	-132.54
iRSS_Blocking	-92.79	-112.97	-123.15	-132.81
Ref_Cell TP Loss (%)	50.494	2.461	0.364	0.06
Net average TP Loss (%)	36.361	1.745	0.223	0.041

Table 76: Simulation results for D=6.3km (DTT Tx e.i.r.p.=69.15 dBm at H=150m) (DTT Non Critical Tx mask)

Add isolation to LTE BS Rx (dB)	0	20	30	40
iRSS_unwanted	-122.39	-122.64	-122.67	-122.61
iRSS_Blocking	-92.66	-112.91	-122.94	-132.88
Ref_Cell TP Loss (%)	51.984	3.068	0.612	0.356
Net average TP Loss (%)	36.681	1.929	0.403	0.235

The simulation results given in Table 75: and Table 76: for LTE network cluster at D=6.3 km from DTT transmitter show that:

1. When 20 dB of additional isolation is added to LTE700 BS blocking level, with the DTT transmitter using the critical mask, LTE700 uplink throughput loss is about 2.5%, which is below 5%.
2. When 20 dB of additional isolation is added to LTE700 BS blocking level, when the DTT transmitter using the non-critical mask, LTE700 uplink throughput loss is about 3%, which is below 5%.

A6.3 ANALYSIS OF THE SIMULATION RESULTS

The simulation results described above show the LTE700 uplink throughput loss caused by interference from DTT transmitter (DTT channel 48 (686-694 MHz) to LTE700 lower block (703-713 MHz)), due to two mechanisms:

i) out of band emission of DTT transmitter
ii) out of band blocking of LTE700 BS receiver

Based on the 5% throughput loss criterion, the simulation results show that:

1. DTT transmitter non-critical mask is sufficient for protecting the LTE700 uplink when the DTT transmit power (e.i.r.p.) is below 69 dBm.
2. For the DTT transmitter at transmit power of 85 dBm, the non-critical mask may not appear to be sufficient for protecting the LTE700 uplink for LTE700 BS near the DTT transmitter and several dB (<10 dB) additional improvement is needed. Considering that the real DTT transmitter mask is always better than the minimum requirement of the non-critical mask, it may not be a problem in the field.
3. For DTT transmitting power e.i.r.p. of 69 dBm, an additional isolation up to 30 dB is required to improve the LTE700 BS receiver out of band blocking level.
4. For DTT transmitting power e.i.r.p. of 85 dBm, an additional isolation of 40 dB is required to improve the LTE700 BS receiver out of band blocking level.

A6.4 CONCLUSIONS

Based on the simulation results and analysis of the potential interference from DTT transmitter to LTE700 uplink using frequencies above 703 MHz, the following conclusions can be drawn:

i) LTE 10 MHz BS receiver blocking level defined in 3GPP TS36.104 is not sufficient, and an additional isolation of 40 dB is required. With 9 MHz guard band, a filter can be designed with 40 dB rejection and an acceptable insertion loss (<0.5 dB).

ii) DTT non-critical mask is sufficient for protecting LTE700 uplink reception for DTT transmit power e.i.r.p. up to 69 dBm.

iii) For high power (e.i.r.p. 85 dBm) DTT transmitter transmitting on the channel 48, several dB (<10 dB) improvement above the non-critical mask might be needed for protecting LTE700 uplink based on the protection criterion of 5% throughput loss.

Since the situation of high power DTT transmitting on the channel 48 varies country by country, DTT transmitter out of band emissions may be dealt with at national level.

ANNEX 7: LIST OF REFERENCES

[1] CEPT Report 30: The identification of common and minimal (least restrictive) technical conditions for 790-862 MHz for the digital dividend in the European Union
[2] CEPT Report 19: Least restrictive technical conditions for WAPECS frequency bands
[3] ECC Report 131: The derivation of a Block Edge Mask (BEM) for terminal stations in the 2.6 GHz frequency band (2500-2690 MHz)
[4] CEPT Report 39: To develop least restrictive technical conditions for 2 GHz bands
[5] CEPT Report 49: Technical conditions regarding spectrum harmonisation for terrestrial wireless systems in the 3400-3800 MHz frequency band
[6] 3GPP TS 36.104 Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception, § 6.6.3.2.1
[7] 3GPP TS 36.101 Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception
[8] ECC Report 221: Adjacent band compatibility between MFCN and PMSE audio applications in the 700 MHz frequency band
[9] ECC Report 191: Adjacent band compatibility between MFCN and PMSE audio applications in 1785 to 1805 MHz
[10] ETSI EN302 296-2 v1.2.1 Electromagnetic compatibility and Radio spectrum Matters (ERM); Transmitting equipment for the digital television broadcast service, Terrestrial (DVB-T); Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive
[11] ECC Report 199 on the spectrum requirements and technology for broad band PPDR
[12] ECC Decision (09)03 on harmonised conditions for Mobile/Fixed Communications Networks (MFCN) operating in the band 790-862 MHz
[13] CEPT Report 50: Technical conditions for the use of the bands 821-832 MHz and 1785-1805 MHz for wireless radio microphones in the EU
[14] DECISION No 243/2012/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2012 establishing a multiannual radio spectrum policy programme – Article 8.3 and 8.5