



# ECC Report 218

Harmonised conditions and spectrum bands for the implementation of future European Broadband Public Protection and Disaster Relief (BB-PPDR) systems

**Approved October 2015**

## 0 EXECUTIVE SUMMARY

This ECC Report is focusing on the frequency, technology and implementation related aspects of Broadband Public Protection and Disaster Relief (BB-PPDR) communications, and it describes and evaluates proposed frequency arrangement options for BB-PPDR.

This Report is complementary to ECC Report 199 [1] “User requirements and spectrum needs for future European broadband PPDR systems (Wide Area Networks)” approved in May 2013 and shall be considered as a step towards a possible future CEPT harmonisation measure on spectrum for BB-PPDR.

Conclusions on spectrum compatibility of the options included in this ECC Report are derived from ECC Reports 239 and 240 [2] [3] and are summarised in section 9.1.

### 0.1 CONCEPT OF “FLEXIBLE HARMONISATION” FOR BB-PPDR

This Report proposes the concept of “*flexible harmonisation*” to enable an efficient implementation of Broadband Public Protection and Disaster Relief (BB-PPDR) within CEPT. This includes three major elements:

- common technical standard (i.e. LTE and its evolutions);
- national flexibility to decide how much spectrum and which specific frequency ranges should be designated for BB-PPDR networks within harmonised tuning range(s), according to national needs;
- national choice of the most suitable implementation model (either dedicated, commercial or hybrid).

### 0.2 TECHNOLOGY ASPECTS

The PPDR user community has stated that BB-PPDR, from a technical standard point of view, wants to be part of the global LTE ecosystem because of several advantages including for example, a wider choice of terminals, potentially lower costs for chipsets and duplex filters, benefits derived from economies of scale achieved in commercial networks and the commitment to develop mission critical capabilities into the standard. In addition, other benefits include possible roaming<sup>1</sup> over commercial networks and long term developments. The work on developing the LTE technology to support the BB-PPDR specific functionalities has already started in 3GPP, ETSI and other international organisations with wide support from the mobile industry and involvement of the PPDR stakeholders. It is expected to take several years before those functions that the PPDR community has identified as key features have been fully specified, implemented, tested and integrated into the LTE solutions from most infrastructure and terminal suppliers.

### 0.3 NETWORK IMPLEMENTATION MODELS

The BB-PPDR services could generally be provided by means of three infrastructure implementation models. These models are:

- **Dedicated network infrastructure for BB-PPDR**

A mobile broadband network (either owned by the government or contracted operator) dedicated to providing service to BB-PPDR users to meet their specific requirements (coverage, support of special broadband applications, resilience, security etc.).

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<sup>1</sup> Roaming = End User radio terminal equipment can obtain mobile communication services under coverage of another radio communication network (the “visited network”).

- **Commercial network(s) infrastructure**

A BB-PPDR service provided by one or several commercial mobile network operators over networks carrying both PPDR and commercial traffic. Additional BB-PPDR specific requirements may need to be negotiated.

- **Hybrid solutions with partly dedicated and partly commercial network infrastructure**

There are several possible variants of hybrid models that could be implemented of which some of them are further described in section 5 in this Report.

#### 0.4 INTEROPERABILITY AND CROSS-BORDER COMMUNICATIONS

European countries are to a growing extent experiencing the need to give and receive PPDR assistance within areas of international crime and trafficking, near border accidents, VIP protection during international summits, illegal immigration, natural disasters, terror attacks and similar para-military events.

The following EU deliverables, which are relevant for interoperability and cross-border communications, were considered during the development of this ECC Report:

- The Council of the European Union adopted a Recommendation on improving radio communication between operational units in border areas in 2009 [4];
- The European Union Decision on *Multi-annual Radio Spectrum Policy Programme (RSPP)* (Decision 243/2012/EU [5] of the European Parliament and of the Council) specifically addresses in its article 8.3 the need for interoperable solutions for public safety and disaster relief.

Different national choices within CEPT will require, within an implementable tuning range, multi-band BB-PPDR user equipment that can be used in either dedicated, commercial or hybrid LTE networks.

The required level of interoperability is to be realised on multiple layers through the availability of multi-band PPDR user equipment (UE), the adoption of common technical standards (i.e. LTE and its evolutions), utilising different PPDR network types (dedicated, commercial or hybrid networks), and also by standard conformance and interoperability specifications.

Due to the above, it is not required to designate a single frequency band for BB-PPDR.

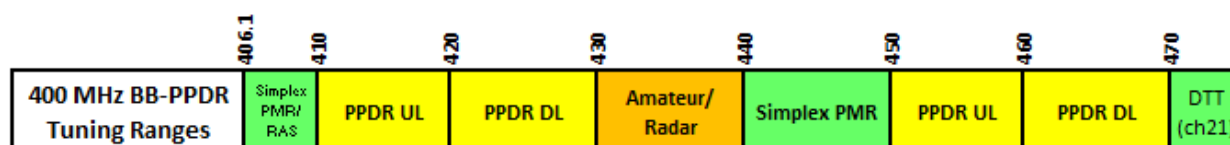
#### 0.5 CANDIDATE BB-PPDR FREQUENCY RANGES FOR HARMONISATION

##### Spectrum options for Wide Area Networks

The following spectrum ranges have been identified for the optional implementation of BB-PPDR services in CEPT countries:

##### 0.5.1 400 MHz (410-430 MHz and 450-470 MHz)

The following tuning ranges for BB-PPDR Uplinks (UL) and Downlinks (DL) have been considered within the 400 MHz range (duplex spacing is always 10 MHz):



**Figure 1: 400 MHz BB-PPDR tuning range and other primary use**

1. The 400 MHz range does not provide enough available spectrum to provide a stand-alone solution in CEPT countries requiring 2x10 MHz for BB-PPDR as calculated in ECC Report 199 [1];
2. The 400 MHz range can offer national flexibility, e.g. in the context of additional spectrum beside the 700 MHz range;
3. Tuning Range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation);
4. 1.4 MHz, 3 MHz, and 5 MHz LTE FDD channelling arrangements could be implemented in the paired frequency arrangements in 410-420/420-430 MHz and/or 450-460/460-470 MHz;
5. The 400 MHz range has the advantage of very good propagation characteristics, potentially reducing the number of sites needed to provide the necessary coverage (rural areas);
6. Cross-border co-ordination guidance is required for the 410-430 MHz and 450-470 MHz bands prior to BB-PPDR deployment;
7. The radio astronomy service in 406.1-410 MHz may require protection zones in some countries, if 410-430 MHz is used by BB-PPDR;
8. In the 410-430 MHz band, there are sharing difficulties with radiolocation systems that are deployed and protected at a national level since the required protection zones can reach hundreds of kilometres;
9. The risk of interference between BB-PPDR and DTT can be reduced by a set of technical measures including a guard band<sup>2</sup> of up to 3 MHz between DTT and BB-PPDR BSs and an appropriate limit of the corresponding PPDR BS out-of-band emissions.

#### 0.5.2 **700 MHz (694-791 MHz)**

1. BB-PPDR can be accommodated within the 700 MHz range by either designating spectrum for dedicated BB-PPDR, use of commercial MFCN<sup>3</sup> or a combination of two (hybrid) as necessary to fulfil national PPDR requirements. Therefore, the 700 MHz range can be considered as a potential stand-alone solution for the BB-PPDR requirements as calculated in ECC Report 199 [1];
2. Tuning range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation). Harmonised technical requirements for the use of MFCN in the 700 MHz range (703-733 MHz and 758-788 MHz) already exist in ECC/DEC/(15)01 [8];
3. Cross-border co-ordination needs to be addressed for the 700 MHz range BB-PPDR options, also with regard to the possible implementation of other use (MFCN and non-MFCN) in neighbouring countries.

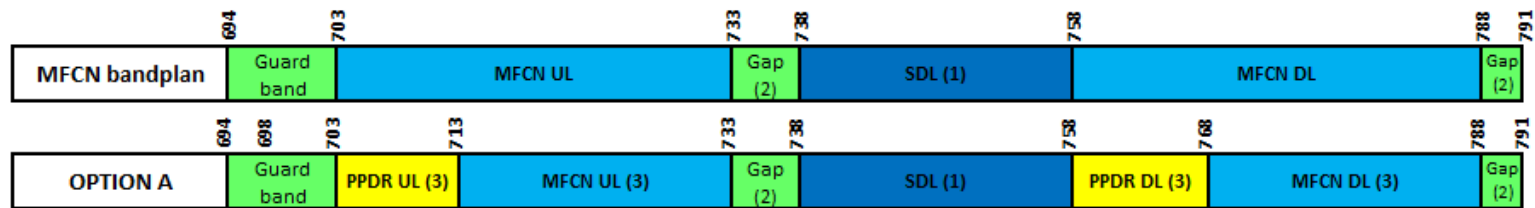
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<sup>2</sup> It should be noted that some administrations apply a smaller guard band for legacy systems.

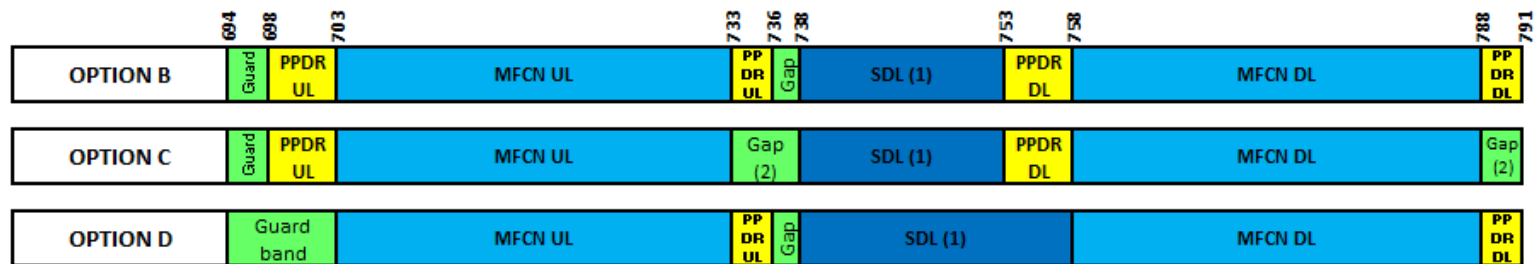
<sup>3</sup> For those countries opting for a commercial or hybrid BB-PPDR solution, any MFCN band harmonised in CEPT may also be used for BB-PPDR meeting the specified requirements (see 5.2.2). Such use is also subject to BB-PPDR equipment roaming capabilities.

The following options have been considered within the 700 MHz range:

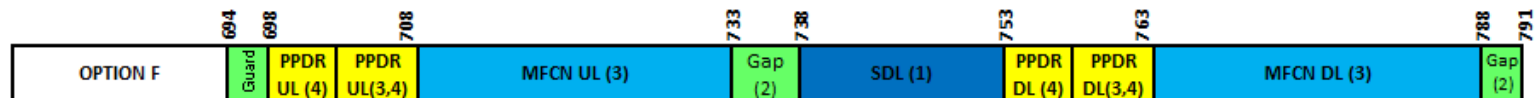
**PPDR in spectrum harmonised for MFCN (ECC/DEC(15)01)**



**PPDR dedicated spectrum:**



**PPDR in a combination of MFCN and dedicated spectrum:**



**Figure 2: 700 MHz Options for BB-PPDR**

Notes in Figure 2:

(1) CEPT Report 53 [9] considers alternative options (M2M, SDL, PMSE, BB-PPDR) for this part of the band and these have been listed in ECC//DEC/(15(01) [8]. The SDL option is one of them and uses zero up to four blocks of 5 MHz. Thus this approach provides flexibility for combining different options.

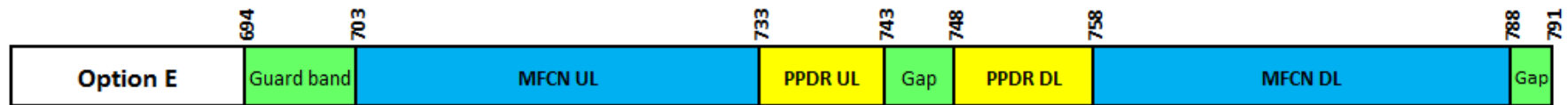
(2) CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with BB-PPDR could be explored in the 733-736 MHz and 788-791 MHz.

(3) BB-PPDR usage could be anywhere within the harmonised MFCN band plan using a 55 MHz duplex spacing.

(4) The use of the 2x2x5 MHz into a combined 10 MHz duplex channel arrangement in 698-708 MHz paired with 753-763 MHz has not been studied.

All the above options use a duplex spacing of 55 MHz.

0.6 DISCARDED 700 MHz OPTION E



**Figure 3: Discarded 700 MHz Option E**

This option uses a 15 MHz duplex spacing (2x10 MHz) and may be divided in to 2x(2x5) MHz. It suffers from technical issues (see section 9.1.7), has received insufficient support (see FM49(15)44 Annex5 [26] summary of cover letter) and is not considered for inclusion in an ECC harmonisation deliverable for BB-PPDR.

## 0.7 CROSS-BORDER FREQUENCY CO-ORDINATION

The current version of ERC/REC T/R 25-08 [12] on the planning criteria and co-ordination of frequencies in the land mobile service in the range 29.7-921 MHz does not address land mobile systems with channel bandwidths greater than 1.25 MHz and therefore does not provide guidance to administrations on frequency co-ordination for BB-PPDR. However, it provides the duplex arrangement for the bands 410-420/420-430 MHz and 450-460/460-470 MHz in its Annex 1.

Cross-border co-ordination guidance is required for BB-PPDR in the 410-430 MHz and 450-470 MHz bands prior to deployment.

At the point of time when the present ECC Report 218 was published a revised draft version of ECC/REC/(15)01 [22], containing also field strength levels for the cross-border co-ordination for the 694-790 MHz frequency band for MFCN, had been in the CEPT public consultation phase. This Recommendation could be used as a basis for deriving field strength levels for the cross-border co-ordination for the 700 MHz range for BB-PPDR.

## 0.8 OTHER USE CASES (CRITICAL VOICE, OFF-NETWORK WORKING, AIR-GROUND-AIR AND AD-HOC NETWORKS)

The main conclusion of ECC Report 199 [1] is that a minimum amount of spectrum in the range of 2x10 MHz is needed for broadband data communications in the future European BB-PPDR wide area networks (WAN). However there could be additional spectrum requirements on a national basis to cater for direct terminal to terminal communications (off-network working), Air-Ground-Air (AGA), ad-hoc networks and critical voice communications over the WAN.

While the same frequencies as for the WAN could be used for direct terminal to terminal communications and ad-hoc networks, ECC Report 199 does neither provide an indication on alternative options nor a solution for future BB-PPDR AGA systems.

The results of the spectrum calculations in ECC Report 199 should be seen as an assessment based on current knowledge. The results should be rather rated as the minimum needed amount of spectrum for future European BB PPDR systems without however excluding any spectrum options to be examined.

If the 700 MHz range is to be used for BB-PPDR direct terminal to terminal communications, it would require further harmonisation and standardisation measures.

The assumption is that mission critical voice will continue to be carried in most CEPT countries by the existing dedicated mission critical voice and narrowband data) TETRA and Tetrapol networks until 2025-2030. The duplex bands 380-385/390-395 MHz have been designated for such PPDR networks in ECC/DEC/(08)05 [7]. However, in some CEPT countries, PPDR agencies could migrate all of their mission critical voice and data services on to network(s) using broadband technology such as LTE in a shorter timescale than those quoted above.

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## LIST OF ABBREVIATIONS

<b>Abbreviation</b>	<b>Explanation</b>
<b>3GPP</b>	Third Generation Partnership Project
<b>A2G</b>	Air to Ground
<b>ACLR</b>	Adjacent Channel Leakage Ratio
<b>AGA</b>	Air-Ground-Air
<b>BB</b>	BroadBand
<b>BBDR</b>	BroadBand Disaster Relief
<b>BS</b>	Base Station
<b>CAPEX</b>	Capital Expenditure
<b>CDMA</b>	Code Division Multiple Access
<b>CEPT</b>	European Conference of Postal and Telecommunications Administrations
<b>D2D</b>	Device to Device
<b>DL</b>	DownLink
<b>DMO</b>	Direct Mode Operation
<b>DMR</b>	Digital Mobile Radio
<b>DTT</b>	Digital terrestrial television
<b>EC</b>	European Commission
<b>ECC</b>	Electronic Communications Committee
<b>EFTA</b>	European Free Trade Association
<b>e.i.r.p.</b>	Equivalent isotropically radiated power
<b>ENISA</b>	European Union Agency for Network and Information Security
<b>ERC</b>	European Radiocommunications Office
<b>ETSI</b>	European Telecommunications Standards Institute
<b>EU</b>	European Union
<b>FCC</b>	Federal Communications Commission
<b>FDD</b>	Frequency Division Duplex
<b>FS</b>	Fixed Service
<b>GCSE</b>	Group Communication Service Enablers
<b>GSM</b>	Global System for Mobile communications
<b>HetNet</b>	Heterogeneous Network
<b>IMT</b>	International Mobile Telecommunication
<b>IOPS</b>	Isolated Operation for Public Safety
<b>ISI</b>	Inter System Interface
<b>ISITEP</b>	Inter System Interoperability for TETRA- Tetrapol Networks
<b>ITU-R</b>	International Telecommunication Union / Radiocommunication Sector
<b>JHA</b>	Justice and Home Affairs
<b>LAES</b>	Location Application for Emergency Services
<b>LEWP-RCEG</b>	Law Enforcement Working Party – Radio Communications Expert Group
<b>LRTC</b>	Least Restrictive Technical Conditions
<b>LTE</b>	Long Term Evolution
<b>M2M</b>	Machine to Machine
<b>MCPTT</b>	Mission Critical Push To Talk

<b>MFCN</b>	Mobile/Fixed Communications Networks
<b>MNO</b>	Mobile Network Operator
<b>MS</b>	Mobile Station
<b>MSS</b>	Mobile-Satellite Service
<b>MVNO</b>	Mobile Virtual Network Operator
<b>NB</b>	NarrowBand
<b>NBC</b>	Nuclear, Biological, and Chemical
<b>OOBE</b>	Out Of Band Emissions
<b>OPEX</b>	Operational Expenditure
<b>QoS</b>	Quality of Service
<b>pf<sub>d</sub></b>	Power Flux Density Level
<b>PAMR</b>	Public Access Mobile Radio
<b>PB</b>	Performance Bond
<b>PCG</b>	Parent Company Guarantee
<b>PMR</b>	Professional Mobile Radio, Private Mobile Radio
<b>PMSE</b>	Programme Making and Special Events
<b>PPDR</b>	Public Protection and Disaster Relief
<b>ProSe</b>	Proximity Services
<b>PTT</b>	Push-To-Talk
<b>PTZ</b>	Pan Tilt Zoom
<b>QoS</b>	Quality of Service
<b>RAN</b>	Radio Access Network
<b>RAS</b>	RadioAstronomy Service
<b>RR</b>	Radio Regulations
<b>RSPG</b>	Radio Spectrum Policy Group
<b>RSPP</b>	Radio Spectrum Policy Programme
<b>Rx</b>	Receiver
<b>SDL</b>	MFCN Supplementary DownLink
<b>TCCA</b>	TETRA and Critical Communications Association
<b>TD</b>	Time Division
<b>TETRA</b>	Terrestrial Trunked Radio
<b>TIP</b>	TETRA Interoperability Profile
<b>TSG</b>	Technical Specifications Group
<b>Tx</b>	Transmitter
<b>UAV</b>	Unmanned Aerial Vehicle
<b>UE</b>	User Equipment
<b>UL</b>	UpLink
<b>UTRA</b>	UMTS Terrestrial Radio Access
<b>VIPs</b>	Very Important Persons
<b>WAN</b>	Wide Area Network
<b>WBB</b>	Wireless broadband
<b>WCDMA</b>	Wideband Code Division Multiple Access
<b>WRC</b>	World Radiocommunication Conference

## 1 BACKGROUND

### 1.1 EUROPEAN HIGH-LEVEL POLICY OBJECTIVES

The Public Protection and Disaster Relief (PPDR) sector is within a vast majority of the nations of the World regarded as vital and of the utmost importance to maintain law and order and to protect the life and values of citizens.

The PPDR sector is for most nations intimately connected to the public sector of society, both directly as part of the governmental structure or as a function which is outsourced under strict rules and intensively monitored by governments contracting ministry or department. These activities are state funded and normally found as one or more line items on the annual state budget.

With this in mind it becomes easier to understand that requirements (operational as well as technical) for establishing an effective PPDR preparedness vary substantially from country to country, even from municipality to municipality, in countries where local preparedness is under the auspices of local public authorities. Consequently the market for PPDR equipment and services can be highly fragmented with high cost as a heavy burden on the national bill unless an overall European common policy is not agreed and implemented according to national requirements.

It is therefore a key high level policy objective in Europe to support to establish as much as possible a large market for BB-PPDR communication equipment, and particularly for terminals, whilst at the same time ensuring that BB-PPDR services can be established according to national circumstances.

There are several EU high-level policy documents (e.g. Decision 243/2012/EU [5]) adopted within recent years by different European policy institutions which address different dimensions of harmonised implementation of advanced solutions for the PPDR sector, many focusing on using wireless broadband (WBB) technologies for satisfying the communication needs of PPDR organisations.

#### The “Stockholm Programme”

In particular, the *Stockholm Programme “An open and secure Europe serving and protecting the citizen”* which was adopted by the Council of the European Union and planned for the period 2010-2014 called for more close cooperation of European nations’ authorities in, among other areas, border management and disaster relief:

*“An internal security strategy should be developed in order to further improve security in the Union and thus protect the lives and safety of European citizens and tackle organised crime, terrorism and other threats. The strategy should be aimed at strengthening cooperation in law enforcement, border management, civil protection, disaster management as well as criminal judicial cooperation in order to make Europe more secure.”*

#### The European Council Recommendation

The European Council *“Recommendation on improving radio communication between operational units in border areas”* of 2009 stresses the importance of the interoperability between the communication equipment used by PPDR organisations in border areas (“whereas 3”):

*“effective cross-border cooperation requires adequate communication capabilities including interoperable radio communication systems in border areas and between operational services from different Member States;”*

#### LEWP-RCEG statements

The Radio Communications Expert Group of the Law Enforcement Working Party (LEWP-RCEG), which is composed of senior representatives from PPDR agencies and regulatory authorities of EU and EFTA

Members and officials reporting to JHA (Justice and Home Affairs) within the Council of the European Union, has adopted since 2009 a number of statements setting out mid- to long-term spectrum usage related objectives based on the needs of the European PPDR community. These statements have been made available in order to inform CEPT about its work and objectives regarding on harmonisation of PPDR communications.

The LEWP-RCEG stated in October 2012 that: “LEWP-RCEG asks ECC/CEPT WGFM to take into account the PPDR needs for a mission critical Broadband solution and for this purpose to allocate harmonised frequencies”. In 2013 and 2014 additional statements were provided by the LEWP-RCEG that “the only harmonised band for PPDR should be the 700 MHz band; the 400 MHz range may provide national flexibility in rural areas in addition to 700 MHz.” [24]

### Radio Spectrum Policy Programme (RSPP)

The EU Decision on *Multi-annual Radio Spectrum Policy Programme (RSPP)* (Decision 243/2012/EU [5] of the European Parliament and of the Council) specifically addresses in its article 8.3 the spectrum needs for public safety and disaster relief:

*“8.3. The Commission shall, in cooperation with the Member States, seek to ensure that sufficient spectrum is made available under harmonised conditions to support the development of safety services and the free circulation of related devices as well as the development of innovative interoperable solutions for public safety and protection, civil protection and disaster relief.”*

### EC Mandate on 700 MHz

In response to the RSPP Decision, the European Commission issued in February 2013 a mandate to CEPT “to develop harmonised technical conditions for the 694<sup>4</sup>-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”.

As regards the communications requirements for BB-PPDR, the Mandate states the following:

*“Sub-1 GHz 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 protection and disaster relief PPDR**<sup>5</sup>. In particular, BB-PPDR may in the future be deployed based on commercial WBB technology, which could result in synergies inter alia for spectrum designation and use.”*

The EC Mandate further states:

*“In particular, CEPT is mandated to carry out technical studies ..., in fulfilment of the following tasks:*

- (1) Develop a preferred technical (including channelling) arrangement and identify common and minimal (least restrictive) technical conditions<sup>6</sup> for wireless broadband use in the 694<sup>7</sup>-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<sup>7</sup>-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<sup>8</sup>;*
    - (b) to facilitate cross-border co-ordination, including at the EU external borders;**
- ...”*

<sup>4</sup> Provisional lower band edge subject to precise definition within the scope of this Mandate

<sup>5</sup> 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.

<sup>6</sup> Such as the definition of appropriate BEMs (Block Edge Masks)

<sup>7</sup> 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 [21] which is subject to additional refinement at the WRC-15

<sup>8</sup> Subject to Commission Decision 2010/267/EU [15]

The CEPT response to the tasks 1 and 2 of the EC mandate is included in CEPT Report 53 [9] concluding in particular that the harmonised band plan for MFCN in the 700 MHz frequency band shall be used as set out in ECC/DEC/(15)01 [8].

### **The EC study on 'commercial' solutions for BB-PPDR**

Further to the provisions of the EC Mandate on 700 MHz envisaging synergies between spectrum designation and use for commercial and PPDR communications, the European Commission published the results of a study on the *"Use of commercial mobile networks and equipment for "mission-critical" high-speed broadband communications in specific sectors"* (SMART 2013/0016) [17].

### **RSPG Report on Sectoral Needs**

The most recent European level policy related document addressing the needs of European countries for BB-PPDR communications is the Radio Spectrum Policy Group (RSPG) Report [6] on sectoral needs. This Report is focusing on the need for flexibility in the implementation of BB-PPDR solutions in European countries and it in particular states the following:

*"The RSPG recognised that the provision of PPDR services, and the associated radiocommunications infrastructure is a sovereign national matter, and that the BB-PPDR needs of Member States may vary to a significant extent. Therefore, the future harmonisation of the BB-PPDR sector in Europe needs to be flexible enough to respect national sovereignties and different national circumstances such as the amount of required spectrum and the type of network to be deployed (which may be dedicated, commercial or a hybrid solution with a mixture of dedicated and commercial networks). The RSPG also noticed that there are requirements to ensure adequate interoperability between the different countries."*

## **1.2 VARYING NEEDS OF INDIVIDUAL EUROPEAN COUNTRIES FOR BB-PPDR COMMUNICATIONS**

The main conclusion of ECC Report 199 [1] is that an amount of spectrum in the range of 2x10 MHz is needed for future European BB-PPDR Wide Area Networks (WAN). The report further indicates that there could be additional spectrum requirements on a national basis to cater for direct terminal to terminal communications, Air-Ground-Air (AGA), ad-hoc networks and voice communications over the WAN.

At the same time it is recognised that the PPDR sector, including the associated radiocommunications is a sovereign national matter, and that the PPDR needs of European countries may vary to a significant extent. This means that decisions both on the amount of spectrum needed for BB-PPDR and on the most appropriate type of network implementation model will be taken at a national level. Therefore it is not required to designate a single frequency band for BB-PPDR.

## 2 THE CONCEPT OF FLEXIBLE HARMONISATION

### 2.1 HARMONISATION OF FREQUENCY RANGES AND FREQUENCY BANDS

The provisions of ECC/DEC/(08)05 [7] “on the harmonisation of frequency bands for the implementation of digital Public Protection and Disaster Relief (PPDR) radio applications in bands within the 380-470 MHz range” regarding the wide band systems are based on a “*tuning range*” concept which provided a flexibility for the administrations in implementing this Decision. The aim was to make radio spectrum available for wide band PPDR radio applications either in the 385-390/395-399.9 MHz band, in the 410-420/420-430 MHz band or in the 450-460/460-470 MHz band.

ECC Report 199 [1] “User requirements and spectrum needs for future European BB-PPDR systems (Wide Area Networks)” defines the *tuning range* in the following way: “*tuning range is the frequency range over which a receiver, transmitter or other piece of equipment (such as antennas) can be adjusted by means of a tuning control in consideration of a required system performance.*” When BB-PPDR networks use a common technical standard (such as LTE), the tuning range could also be specified as one or several Band Classes.

Resolution 646 (Rev.WRC-12) [10] in resolves 2 identifies “380-470 MHz as the *frequency range* within which the band 380-385/390-395 MHz is a preferred core harmonised band for permanent public protection activities within certain countries of Region 1 which have given their agreement”.

The Resolution 648 (WRC-12) [18] encourages administrations to conduct further studies to support broadband public protection and disaster relief and review Resolution 646 (Rev.WRC-12).

In order to achieve the necessary level of spectrum harmonisation for BB-PPDR systems in Europe a concept of “flexible harmonisation” is proposed in this Report.

### 2.2 THE CONCEPT OF “FLEXIBLE HARMONISATION” FOR WIDE AREA NETWORKS

There are several issues which need to be addressed within the context of this concept in more detail. These include: technology, interoperability, cross-border operations and implementation related issues. All these, as well as some other related points, are discussed in the relevant sections of this Report.

It is assumed in this ECC Report that CEPT administrations have the flexibility to designate specific frequency bands within the European harmonised frequency range(s) for BB-PPDR Wide Area Networks through national measures and subject to national circumstances. It is believed that these requirements could be effectively implemented through the “*flexible harmonisation*” concept. It is also believed to be the most suitable harmonisation model for achieving the goals of harmonisation whilst maintaining each countries’ sovereign right to choose the most suitable solution for BB-PPDR according to national needs.

The “flexible harmonisation” concept for BB-PPDR consists of the following elements:

- common technical standard (i.e. LTE and its evolutions);
- national flexibility to decide how much spectrum and which specific frequency ranges should be designated for BB-PPDR networks within harmonised tuning range(s), according to national needs;
- national choice of the most suitable implementation model (either dedicated, commercial or hybrid).

### 2.3 “FLEXIBLE HARMONISATION” AND INTEROPERABILITY

In order to establish a European family of cross-border functioning BB-PPDR networks it is not required to designate identical (harmonised) frequency bands for this purpose but rather choose suitable harmonised frequency range(s) and the adoption of a common technical standard, in this case LTE. This will allow a border-crossing BB-PPDR UE to operate in the corresponding BB-PPDR network in the visited country within the harmonised frequency range(s). This will also allow roaming agreements between BB-PPDR network operators and reuse of equipment. It should be noted that in case of several harmonised frequency ranges



for BB-PPDR the required level of interoperability will only be realised through the availability of multi-band BB-PPDR UE.

Taking into account that PPDR is an inherent and fragmented niche market, the implementation of the flexible harmonisation concept represents a way to facilitate a large market for the PPDR sector while consequently offering the benefit of enhanced European cooperation, increased competition, enhanced export opportunities for European industry to global markets and last but not least much lower procurement costs. All this can be achieved according to the sovereign needs of individual countries.

This Report will elaborate more on the interoperability and cross-border operations related issues in chapter 6.

### 3 ENVISAGED ROADMAP OF TRANSITION TOWARDS BB-PPDR IN EUROPE

Assuming the “flexible harmonisation” concept as a basis for the evolution of today’s PPDR communications towards a broadband future, a “Transition Roadmap” reflecting the current vision of the future evolution’s milestones mapped onto the timeline up to and beyond year 2025, has been developed. The roadmap may also assist CEPT administrations in national planning of provision of BB-PPDR services.

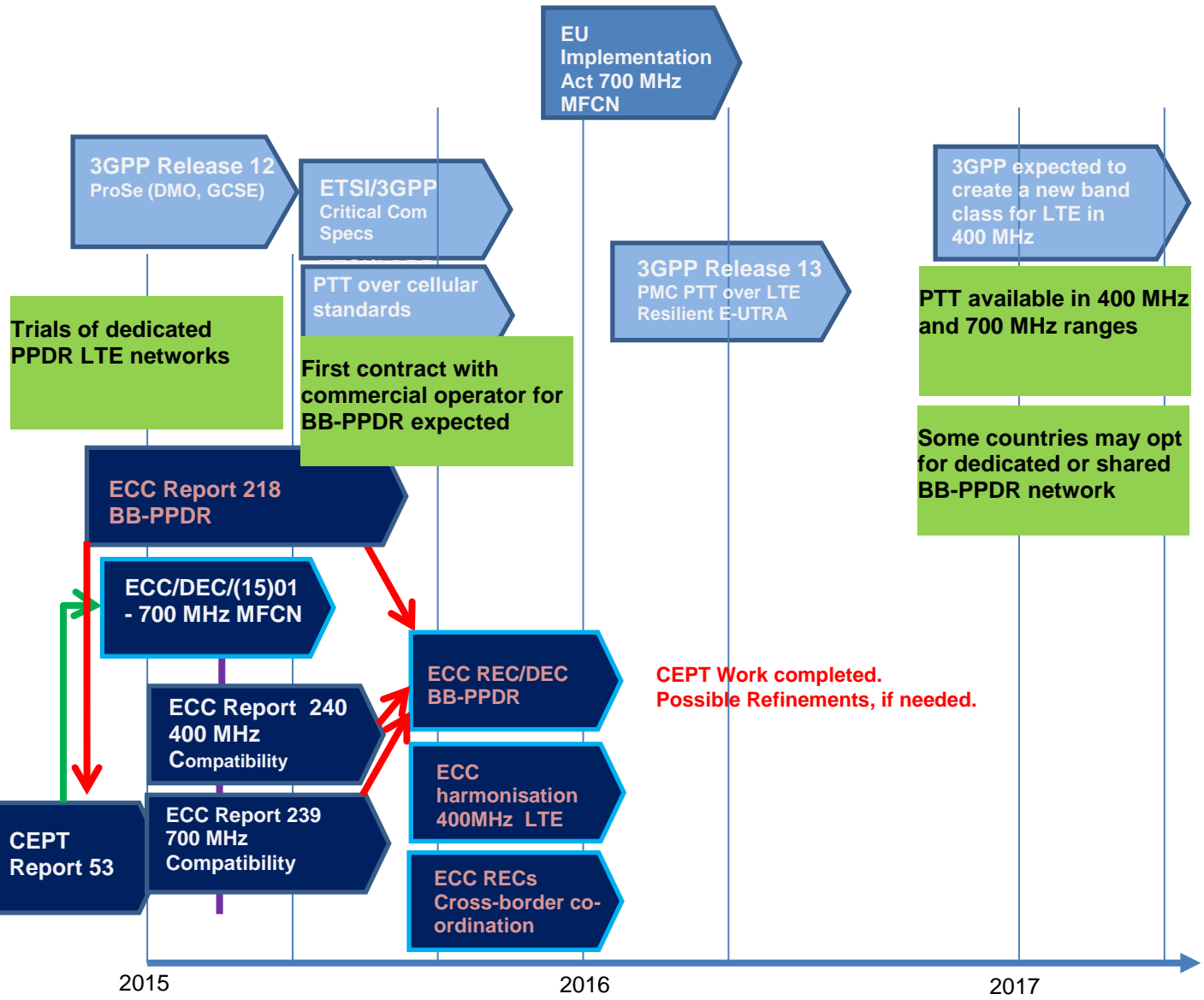
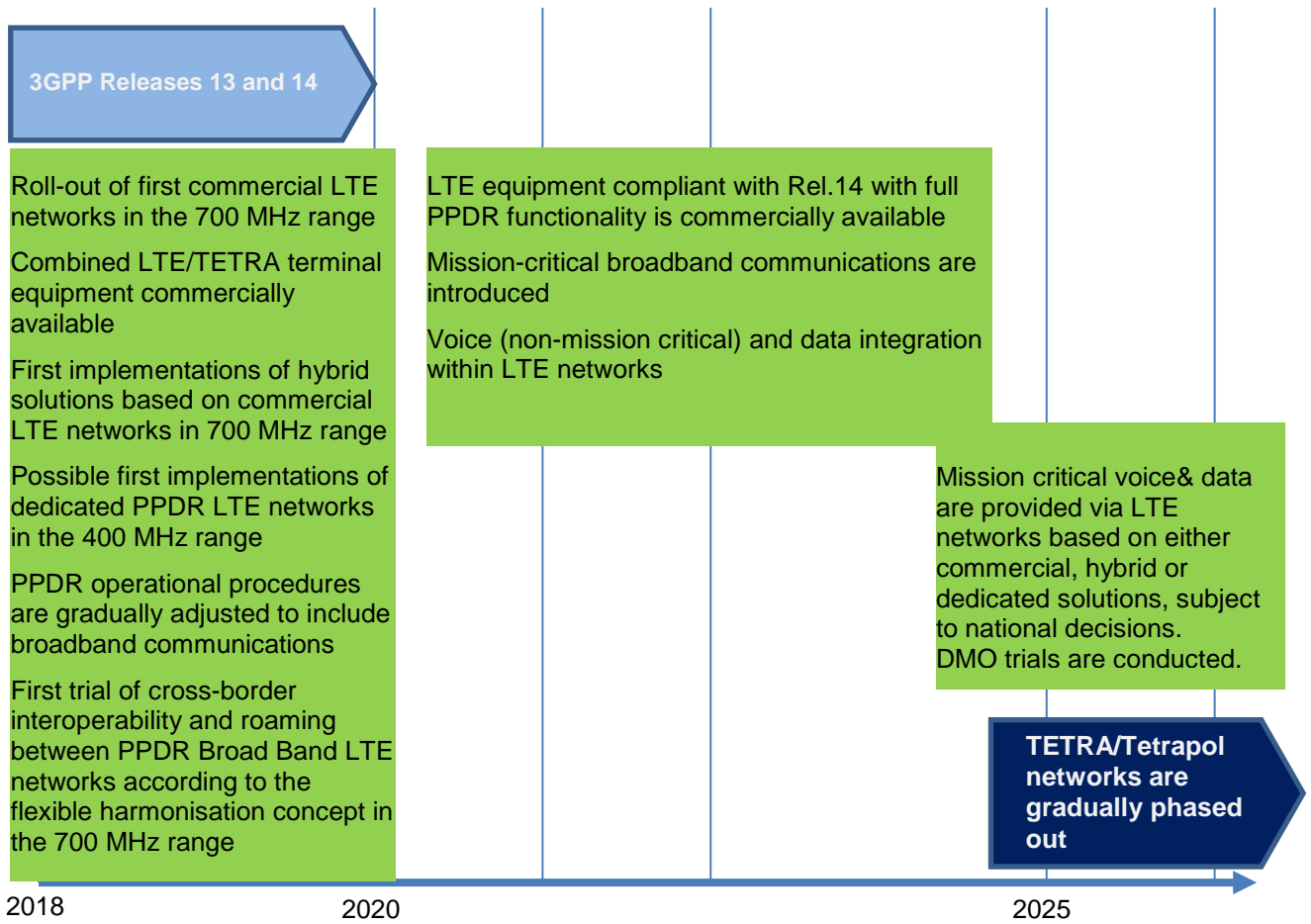


Figure 4: Transition towards BB-PPDR in Europe

Figure 4: Transition towards BB-PPDR in Europe Figure 4 does not contain the following aspects on the long term developments.

The long term developments may be characterised as set out in Figure 5



**Figure 5: Transition towards BB-PPDR in EUROPE - Implementation phase**

## 4 TECHNOLOGY ASPECTS

### 4.1 INTRODUCTION

Developing a completely new mobile broadband communications standard for public safety would require far too much resources and time. This was feasible in mid 1990s but the complexity of modern communication technologies would mean repeating this is not reasonable.

Using common technology platforms shared with the commercial network operators can provide better value for money, i.e. adapting mainstream (mass market) standards and technologies is a more practical approach. This also allows the PPDR community to tap into a much larger and innovative market.

### 4.2 JUSTIFICATION AND RECOMMENDATION ON USAGE OF LTE TECHNOLOGY

Long Term Evolution (LTE and its evolutions) is expected to be the dominant technology for mobile broadband communications for many years ahead. In order for BB-PPDR to benefit from the technical development and economies of scale from the commercial mobile broadband market, there is a common view that LTE will be the technology to meet future BB-PPDR needs. As the future evolution of mobile broadband is assumed to be based on an evolution of the current LTE technology, the adaptation of LTE for BB-PPDR services is seen as a very long term solution.

LTE is already the technology of choice for BB-PPDR in some countries, e.g. the US where the FCC mandated the use of LTE to provide BB-PPDR services in the LTE band 14, 2x10 MHz within the 700 MHz range. Other countries that have made spectrum available for BB-PPDR purposes in LTE compatible bands include Canada (within the 700 MHz LTE band 14) and Australia (from the 800 MHz band).

The RSPG Report on strategic sectoral spectrum needs [6] recognises that a decision on deployment of BB-PPDR networks is a national matter, but expects to see LTE technology to be the future technology to meet BB-PPDR needs.

LEWP-RCEG has concluded that BB-PPDR users want to be part of the global LTE ecosystem as it provides several advantages for the future BB-PPDR including a wider choice of terminals, potentially lower equipment prices, costs for chipsets and duplex filters, roaming with commercial networks and long term developments.

### 4.3 LTE DEVELOPMENT

LTE is a global mobile communications technology specified by 3GPP. 3GPP is a collaboration of several telecommunication standards bodies across the world supported by a wide range of organisations including equipment suppliers, network operators and government departments. In Europe, 3GPP specifications are published by ETSI.

3GPP specifications are developed as Releases. Release 8, the first release of specifications including LTE<sup>9</sup>, was frozen end of 2008 and this was the basis of the first LTE deployments. From Release 10 (specifications frozen in March 2011) the technology family is formally known as LTE-Advanced; however, all releases are referred to as LTE in this document. From 'freezing' no more functions can be added to a release but detailed protocol specifications may still be incomplete for some time.

The main requirements for LTE included high peak data rates, low latency, high spectral efficiency and frequency flexibility, the last one meaning in practice supporting several different frequency bands. In practice, no LTE network can support all bands but most will utilise more than one.

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<sup>9</sup> 3GPP also maintains the specifications for WCDMA, TD-CDMA and GSM, which were included in earlier releases.

Compared to 3G networks, the internal structure of an LTE access network has been simplified, generating a flatter architecture. This speeds up the connection setup and reduces the handover time, both useful for real-time services such as online gaming or video applications.

The possibility to build a network using several frequency bands provides new opportunities for network designers. For example, lower frequencies can be used to provide large area coverage whereas higher bands are better suited for providing high capacity in a relatively small area. Considering BB-PPDR needs, it might be useful to keep members of a group on the same frequency (band) on a base station that supports several bands to avoid setting up the same call on several bands within the base station. By defining which band to use when, the operator may be able to optimise the overall service provided by the network, e.g. to use smaller cells for groups where all members are near the base station or larger cells for fast moving groups.

The first 3GPP release to truly address BB-PPDR requirements (Release 12) was frozen by the end of 2014. This release should provide basic support for group communications and terminal to terminal (off network) communications. Following releases will add further BB-PPDR related enhancements to LTE.

#### 4.4 ENHANCING STANDARDS TO MEET BB-PPDR NEEDS

3GPP uses a sequence of releases to provide developers a stable platform for implementation, allowing addition of new features as required by the market. Releases are typically separated by 1-2 years.

The 3GPP release cycle comprises of three main standardisation stages; requirements, analysis/architecture and implementation of protocols. This process produces specifications that the industry will later on turn into products.

The PPDR users and PPDR operators have been involved in 3GPP, ETSI and other international organisations to support standardisation of PPDR related functionality for some years. 3GPP has identified five features to be relevant for critical communications, shown in the table below. Work is also ongoing on related fields, e.g. on developing group voice call services and ensuring the new functionalities will meet the required security targets.

**Table 1: System features and radio layer features**

<b>System features</b>	Group communication enablers
	Proximity services
<b>Radio layer features</b>	Frequency band support
	Power level support
	Radio enablers for system features

3GPP Release 11 (frozen end of 2012) introduced a higher terminal power class to LTE band 14 (dedicated to PPDR in North America) to address the US PPDR requirements. As the terminal output power is controlled by the network, additional maximum transmit power mainly provides an extension of coverage, e.g. deep indoors or in rural areas, in networks where the network parameters allow these higher output powers to be used.

Release 12 introduces two PPDR specific functional areas; group communication service enablers (GCSE) and proximity services (ProSe). GCSE is frequency independent, i.e. is not linked to a specific LTE frequency band, while ProSe has a spectrum element.

GCSE will provide the basic platform support for group communications such as multicasting and group management, but not the actual application. This means that group voice calls will require a group call application in the terminals and a respective application server in the network on top of the GCSE support. Similarly, any other group communications will require an application (the same or a different one). Some

further standardisation effort on the application side is needed to ensure interoperability in European standards developing organisations such as ETSI.

ProSe is the LTE version of direct terminal to terminal communications, its public safety version roughly representative of the direct mode in TETRA. A commercial version may follow later on to enable e.g. photo sharing between friends, but work on the required additional functionality has not been started yet. Both 'in-band' and 'out of band' options of ProSe are being studied as part of Release 12 work, referring to operating in the same band as the LTE network (outside the coverage or within coverage requiring some cooperation from the network) or in a separate band. Some of the currently envisaged ProSe functionality will not be included in Release 12.

Release 13 will add further enhancements to GCSE and ProSe and new PPDR related functionality such as Isolated Operation for Public Safety (IOPS) in case of backhaul loss. 3GPP has set up a new working group to work specifically on public safety applications, focusing first on the mission critical push to talk (MCPTT) application, building on work already started in other bodies such as ETSI.

Some PPDR functionality may be left to be covered in later releases like Release 14. For example, discussion on air-ground-air (AGA) has only started in 3GPP in early 2015 making it unlikely for AGA specific features to be fully covered by Release 13.

## 5 DEDICATED, HYBRID AND COMMERCIAL NETWORKS

BB-PPDR services could be provided by means of one of the following infrastructure implementation models:

1. Dedicated network infrastructure for BB-PPDR;
2. Commercial network(s) infrastructure providing broadband services to PPDR users;
3. Hybrid solutions with partly dedicated and partly commercial network infrastructure.

Fully commercial network implementation options will not require any PPDR specific spectrum, but spectrum for the dedicated network option and many of the hybrid network models would be required on a national level.

While these options have their differences, there are some similarities as well.

All mobile networks, private and public, are known to have service outages of varying sizes and impacts. However, many current narrowband PPDR networks have been built with higher resilience and availability in mind than commercial networks, with respectively higher CAPEX and OPEX costs. In order for a public network to provide service of acceptable level to the PPDR community, the impact (severity, duration, extent and frequency) of these outages must be kept low.

No public statistics exist on the availability or resilience of current narrowband PPDR networks. For the public networks, ENISA<sup>10</sup> published in 2012 an annual report about significant incidents in the European electronic communications sector indicating that many current commercial networks may not have the resilience the PPDR community needs.

There are both technical and non-technical (contractual, financial etc.) challenges in achieving the required resilience in public networks, partly due to the number of equipment, connections etc. However, failures would only impact PPDR operations when all services covering an area have been lost, i.e. losing a site from an area covered by several sites may be less of an issue for the limited number of (prioritised) PPDR users. Also, the ramifications of a network malfunction could be minimised by ensuring faults having a major impact on PPDR users are corrected with a higher urgency than other faults.

All options have commercial and financial risks. For example, a supplier of the equipment may not be able to deliver what has been promised within the timescale and to the quality contracted.

Another risk to be taken into account is that the PPDR specific requirements may be too challenging for the market, leading to single supplier solutions if other potential suppliers do not think the value of the contract justifies the cost of meeting those requirements.

For reasons of national security, also the ownership of major suppliers should be considered. For example, a takeover of a dominating supplier, depending on the future owner, might be a concern for some parts of the PPDR community.

As explained in the technology aspects section, the LTE eco-system is the most suitable technology solution for future BB-PPDR.

The following sections provide an analysis of the advantages and limitations of each of the three infrastructure implementation options.

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<sup>10</sup> Link to the ENISA report and other material (<https://www.enisa.europa.eu/activities/Resilience-and-CIIP/Incidents-reporting/annual-reports/annual-incident-reports-2012-1>)

## 5.1 DEDICATED NETWORK INFRASTRUCTURE FOR BB-PPDR

In this model a dedicated mobile broadband network for PPDR will be specifically designed to meet BB-PPDR specified requirements (coverage, support of broadband applications like video streaming, resilience, security etc.).

There are two variants of a dedicated mobile broadband infrastructure for public safety critical communication.

### 5.1.1 Mobile broadband network planned, built, run and owned by the authority

In this variant the authority set the technical requirements to the network infrastructure with respect to service offering, capacity, security, reliability, redundancy and robustness of the network and supporting infrastructure.

The authority finance the equipment and supporting infrastructure, the operation and maintenance support systems and pay the running cost (lease cost, operation and maintenance cost and spare parts). As described earlier, some services like power distribution or core network transmission links may be shared with other users, depending on national rules and local conditions.

An authority project like this might also include end user radio terminals and the public safety agencies control room equipment. This approach was taken e.g. in Norway in the PPDR "Nødnett" project.

### 5.1.2 Mobile broadband service provided through service offering

In this variant the authority buy the mobile broadband services from a commercial company according to technical requirements set to the services offered with respect to service offering, capacity, security, reliability, redundancy and robustness of the network and supporting infrastructure. In this model there is a prerequisite that the service offered is delivered through a dedicated mobile broadband network.

The contracted company finance the equipment and supporting network infrastructure, the operation and maintenance support systems, perform the network and service infrastructure planning, operation and maintenance and technical support to the end user organisation. As described earlier, some services like power distribution or core network transmission links may be shared with other users, depending on national rules and local conditions.

For current PPDR services, this is regulated through a detailed and long term contract between the parties. This model is similar to the model used to provide the Airwave services in the United Kingdom. Depending on the governance model adopted, in such a scenario the company would be operating a BB-PPDR system on behalf of the PPDR authority and awarded licenses and assigned PPDR spectrum directly or through the binding contract with the authority that has been assigned the dedicated spectrum and authorised to offer PPDR services.

### 5.1.3 Advantages and disadvantages

The advantages of a dedicated network infrastructure design are that the dependencies between commercial mobile network infrastructure and PPDR mobile network infrastructure are limited. This has shown to be of critical importance in several PPDR operations during crises or big events.

With a dedicated PPDR network, the operator of the network has more control over the network design and operations which could be an advantage when it comes to for example network integrity, resilience and availability.

- National priorities of traffic in times of crisis: trade-off between public safety and commercial usage;
- Sharing of a common system by different PPDR agencies ensuring the same quality of service and coverage;
- Dedicated networks are, in case correct measures have been taken, assumed to be the most reliable solution for mission critical communications;
- In critical situations such as bomb threats, commercial networks may have to be switched off at a given location. Priority sim cards can sometimes be used to allow PPDR usage to carry on.



The disadvantages of dedicated network infrastructure for PPDR are additional capital costs and the fact that dedicated spectrum is required.

## 5.2 COMMERCIAL NETWORK(S) INFRASTRUCTURE PROVIDING BROADBAND SERVICES TO PPDR USERS

In most cases, a commercial network will have originally been designed to meet the needs of the consumer market, not specifically addressing the full needs of PPDR users.

This model means that the authority will buy mobile broadband services from commercial mobile network operators. The services are delivered through the commercial mobile network operator's public network and no dedicated network infrastructure is involved in the service delivery to the public safety users. In some countries it may be possible to have a national roaming agreement in place, allowing PPDR terminals to get services from other networks if the currently used one fails or if the user moves out of the coverage of the currently used network.

There are two major variants of broadband service deliveries to PPDR users from a commercial network.

### 5.2.1 Same mobile broadband services to PPDR as to public customers

In this variant the PPDR users get the same service as the public, i.e. the other users of the network.

No special requirements to the service offering or to priority of service exist, with the exception of potential national roaming if that has been agreed.

### 5.2.2 Mobile broadband services to PPDR with special requirements

In this variant the authority buys mobile broadband services to PPDR users from one or several commercial mobile network operators. The mobile broadband services are delivered by the same network infrastructure as the commercial operator uses to deliver services to the public, however, the authority have special requirements to both, services delivered and to the QoS<sup>11</sup>.

Depending on the relevant agreement, the commercial operator has to support special services to the PPDR users, e.g. group calls, pre-emption services and priority access, and potentially also extra security facilities and increased levels of availability and resiliency through increased robustness in the network design (benefiting all of the operator's customers).

### 5.2.3 Advantages and disadvantages

It is a reasonable assumption that the commercial solution will satisfy the *non-mission* critical data communication needs of the PPDR users within the coverage area of the commercial network(s) even without any additional resilience, priority or other specific functionality.

A fully commercial solution for mission critical PPDR communications is likely to cost less than solutions with a dedicated element, as all major cost components are shared by the entire user base of which PPDR users are just small minority.

Also, operators may be able to spend more effort on conducting their own terminal and network testing before rolling new functionality or hardware out, reducing the likelihood of seriously flawed solutions being rolled out before spotting the problems.

Not owning the infrastructure is seen by many governments as having a lower ability to influence the network build or other future plans as the public operator will have also other interests in mind than just the PPDR community's needs. Also operational security might be a bigger issue than when the government owns the network. These areas need to be addressed by contractual and/or financial measures.

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<sup>11</sup> QoS = Quality of Service

The standard response times of public operators in case of network disturbance may vary from what PPDR users are used to see from their current narrowband operator. Recognising that some instances will take a long time to fix, operators will have to agree typical response times that match PPDR needs – naturally, this may come with an extra cost.

Where PPDR users require better network coverage than what the current public networks provide, e.g. in rural areas the operators must install new infrastructure to meet the additional coverage requirement or in some other way to extend their current coverage offering, both most likely coming with an extra cost. Some of this extra cost might be met by the public also benefiting from this additional coverage and therefore using the network more providing extra income to the operator.

In addition, BB-PPDR services can be facilitated using available MFCN bands provided that existing networks are able to meet the needs of PPDR users.

When using commercial networks for mission critical purposes, the governments are expected to put specific legal requirements on the operator in a contract. Some examples of such requirements are provided by TCCA in ANNEX 2:

### 5.3 HYBRID SOLUTIONS WITH PARTLY DEDICATED AND PARTLY COMMERCIAL NETWORK INFRASTRUCTURE

In this model the aim is to find a balance between the service offered by a commercial mobile broadband network and the needs the PPDR users have for availability and capacity in daily operation as well as in periods of disaster and/or big planned and unplanned events.

A shared infrastructure solution can be a viable option to deliver mobile BB-PPDR services in the future, especially in countries having large rural areas with only a few inhabitants per km<sup>2</sup>. The cost to build dedicated mobile broadband solutions for PPDR in these low populated areas may be regarded to be too expensive for the society and one way to overcome this is for PPDR users to utilise commercial mobile broadband services in those areas. There are several substantially different ways how the mobile broadband network infrastructure sharing can be done:

- Geographical split between dedicated and commercial network infrastructure;
- MVNO model where PPDR users share RAN with the public users;
- MVNO model combined with a geographical split;
- Extended MVNO model where PPDR have dedicated carriers in the commercial network's radio transmitters / receivers throughout the country.

Note: In all MVNO variants PPDR will have some dedicated core and service network elements.

A **mobile virtual network operator (MVNO)** is a wireless communications services provider that does not have to own radio access network (RAN) to provide services to its customers. Instead, it enters into a business agreement with one or more existing mobile network operators.

In case a (private or public) MVNO is used to provide services to PPDR users, it can use the core network from the commercial operator, control (parts) of the core network or own the PPDR core network.

The PPDR MVNO model allows one party to negotiate and follow up requirements and service commitments with the commercial operator(s) instead of all individual PPDR organisations doing this separately. As a bigger negotiating party than any of the services alone the MVNO may be able to also offer a better value for money. For the users, a MVNO can provide a 'one stop' service for all types of mobile communications (voice + data) for PPDR.

### 5.3.1 Geographical split between dedicated and commercial network infrastructure

In this variant a dedicated mobile broadband network for PPDR is built in some parts of a country, e.g. in the most populated areas and most important roads, while the remaining part of the country is served by one or more commercial mobile operators. This could be done in several ways, for example:

1. Full separation between the dedicated network part and the commercial network part;
2. Shared core network and service node infrastructure with some dedicated elements and dedicated RAN in some parts of a country.

A geographical split will require dedicated spectrum in the network part serving PPDR users only. Also, a roaming agreement between the PPDR network and the relevant commercial network(s) will be required.

### 5.3.2 MVNO model where PPDR share RAN with the public users

In this variant a dedicated core and service node part of the mobile broadband network is built for PPDR. This will enable the PPDR operator to have full control of the PPDR users with respect to their subscriptions, service profiles and service offerings. The RAN is shared with the public users across the country.

This model is used in Belgium by the service provider 'Astrid' to provide mobile broadband to their PPDR users.

This variant requires no additional spectrum for serving the PPDR users.

### 5.3.3 MVNO model combined with a geographical split

Also in this variant a dedicated core and service node part of the mobile broadband network is built for PPDR users. Additionally, in some parts of a country, e.g. in the most populated areas and along the most important roads, PPDR users will have their own RAN infrastructure. Elsewhere, the service is provided by the RAN of one or several commercial operators.

Effectively, this is a combination of the two variants described above bringing the MVNO functionality into the geographical split solution.

This variant requires PPDR spectrum in those areas where the dedicated RAN exists.

### 5.3.4 Extended MVNO model

Again, in this variant a dedicated core and service node part of the mobile broadband network is built for PPDR.

The main difference to the previous variant is that PPDR users will have dedicated carriers (radio transmitters / receivers) in the commercial mobile base stations all over the country. The assumption is that the functionality to have separate controlled radio carriers (from two different core networks) in a base station will be available. This will give the PPDR users dedicated communication capacity throughout the country but they will be dependent of the robustness and coverage of the RAN of the commercial network(s).

This variant requires PPDR spectrum nationwide.

### 5.3.5 Advantages and disadvantages

A hybrid solution is likely to cost less than a fully dedicated solution, as many major cost elements are shared with a much larger user base.

Also, there is the possibility to benefit from the mobile operator(s) conducting their own terminal and network testing before rolling new functionality or hardware out, reducing the likelihood of seriously flawed solutions being rolled out before spotting the problems.

Trials in some European countries are ongoing at the time of writing this Report. These are expected to bring more clarity to the suitability of hybrid networks for PPDR mission critical communications.

It is a reasonable assumption that the commercial solution will satisfy the *non-mission* critical data transmission needs of the PPDR users within the coverage area of the commercial network(s) even without any additional resilience, priority or other specific functionality.

The disadvantages of hybrid solutions include more complex management (including security arrangements) of the total mobile communications solution, for many of the variants needs for some dedicated spectrum and probably a higher total cost than going with a fully commercial option.

The TCCA has made a document on implementation options with a major part on hybrid models.

A table with some hybrid models including their advantages and disadvantages is provided by TCCA in ANNEX 1:

When using commercial networks for mission critical purposes, the governments are expected to put specific legal requirements on the operator in a contract. Some examples of such requirements are provided by TCCA in ANNEX 2:

## 5.4 NETWORK TOPOLOGY ASPECTS

The design parameters of existing narrowband PPDR networks and commercial mobile broadband networks differ clearly and there should be data available on the site densities of both types of solutions. Care should be taken when any figures from the narrowband solutions are used. There are several reasons for different site densities, most important ones being frequencies and user numbers. On the spectrum side, current narrowband PPDR networks tend to use much lower frequencies, meaning fewer cells in areas where cell numbers are driven by coverage rather than capacity demands.

A heterogeneous network (HetNet) is a network structural design aiming to increase the coverage and capacity particularly for the more advanced applications as well as remove blind spots of a radio networks by combining different sizes and types of base stations based in a hierarchical structure in a certain geographical area.

To ensure high quality broadband services for the PPDR users, a radio communication network should be designed for a defined and/or agreed number of user devices per cell and certain capacity requirements. Large macro cells are the most cost-effective way to serve fast-moving users and rural areas, but to meet capacity requirements smaller micro or pico cells may need to be included to meet the assumed and/or agreed number of user devices and capacity requirements in a particular area.

Deploying the larger macro cells results in LTE uplink (UL) power limitation, i.e. data rates are limited by relatively low received power at the base station due to the large attenuation between the user terminal and the base station. This is caused by path loss related to a combination of the distance in the larger macro cells, limitations in user terminal design (e.g. power and antenna gain) and regulation, but also on other challenging radio propagation conditions, such as in indoor locations at the cell edge. Favourable network designs suggest that most usage should normally be as close to the base station as possible to ensure high quality, high bandwidth communications. These aspects require cells of suitable sizes for different circumstances. There are several approaches that can be taken to meet high traffic and data rate demands. On a high level, the key options to expand network capacity include: improving the macro layer, increasing the density of the macro layer and complementing the macro layer with low power micro and pico nodes, thereby creating a heterogeneous network structure.

The best way to meet these differing requirements is to design a heterogeneous network solution, deploying a blend of cell sizes and network architectures to optimally use available radio resources and spectrum.

## 6 INTEROPERABILITY/ CROSS-BORDER COMMUNICATIONS

Interoperability/ Cross-border communications between Public Safety organisations in the European countries have so far been very limited mainly due to incompatible communication systems in the countries with limited ability to control user access rights. This has limited other countries' Public Safety forces to enter into neighbouring countries and gain access to neighbouring countries internal communication systems for Public Safety.

In addition, lack of relevant legal framework and lack of common operational procedures have made cooperation between countries' Public Safety forces difficult and not offered the right support to obtain maximum results from operational cooperation between Public Safety forces in cross-border activities.

However, the subject Public Safety Cross-border communication and cooperation has been on the agenda throughout the world for years and the need is increasing, e.g. due to the following factors;

- International crime – drugs, human trafficking, smuggling etc.;
- Police pursuit of criminals cross-border(s);
- Transport of patients to hospitals between countries;
- Cross-border support during firefighting;
- Cross-border support during natural disasters and accidents close to a border or in coastal areas between countries;
- Cross-border support during / after terror attacks;
- VIP protection (e.g. EU ministry top).

In the current widespread adopted the narrow- and wideband communications standard TETRA, the cross-border functionality was developed (ISI - Inter System Interface) and standardised. What so far has been missing was the commercial driver to implement these products, for networks to interoperate across borders.

Consequently the EU Commission took the initiatives to progress such development by including it under the 7<sup>th</sup> Framework Programme. One of the nominated consortiums to develop a solution is named ISITEP (Inter-System Interface) for the PPDR narrow-and wideband services. The Norwegian and Swedish authorities have decided to implement cross-border functionality in their Public Safety Radio networks and develop legal framework and common operational procedures in the two countries to facilitate cross-border operation and communication for the Public Safety Forces.

This illustrates the significance for interoperability also for BB-PPDR solutions.

Interoperability requires also protocol compliance and interoperability compliance specifications. ETSI has created protocol conformity and interoperability conformity specifications for a number of standardised radio systems (e.g. GSM, UTRA, DMR). These additional specifications identify the requirements set out in the basic radio system specifications and standards from the aspect of complete identification and interpretation of the requirements and also with regard to the needs for interoperability testing. Full interoperability cannot be achieved without such additional protocol performance and interoperability specifications and will remain subject to arrangements outside of public standardisation organisations such as in the case of TETRA where interoperability is only achieved by means of TETRA Interoperability Profiles (TIP) and bilateral/ multilateral agreements amongst manufacturers. The creation of such specifications in support of interoperability could be fostered by a European standardisation mandate.

The 3GPP SA Plenary meeting (TSG SA#65), in Edinburgh in September 2014, approved the creation of WG SA6 [16], to initially focus on the Mission Critical Push to Talk (MCPTT) application in Release 13 while developing in to the generic home for all future 3GPP mission critical application work - as defined by stage 1 service requirements, on top of a common architecture.

These activities are considered to support the future interoperability requirements for BB-PPDR services, though further analysis about the precise work in SA6 might be required to fully understand whether SA6 will also produce protocol conformance and interoperability specifications (interoperability recognised as important feature for BB-PPDR by many stakeholders).

## 6.1 OBJECTIVES FOR INTEROPERABILITY/ CROSS-BORDER COMMUNICATION

The objective for Public Safety interoperability and cross-border communication can be summarised as follows:

- Reduce consequences, cost and casualties in European disaster events through an improved interoperability of European PPDR organisations;
- Improve effectiveness and reduce cost of regular European collaboration activities (i.e. related to crime countermeasures, natural disasters and terror) through an improved interoperability between European PPDR organisations.

For the next generation communication systems for Public Safety and other critical communication users it is important that authorities try hard to agree the flexible harmonisation concept as described herein to facilitate Public Safety cross-border operation and communication in the future.

## 6.2 REQUIREMENTS FOR MEETING INTEROPERABILITY AND CROSS-BORDER COMMUNICATION

Harmonised conditions for mobile services or sectorial applications such as BB-PPDR is established when Mobile Terminals or UE (User Equipment) seamlessly maintain its connection when moving into a visited network, what is also called “roaming”.

To obtain this technically at least four aspects have to be fulfilled:

- Spectrum requirements have to be aligned so that radio terminals from the European country’s public safety radio networks are able to operate under other countries radio network coverage. Multi-band user equipment has to be used, interoperability can be achieved in case the bands used in each country are supported by the multi-band equipment even when countries choose different bands;
- Standardised network and radio terminal technologies supported by all user equipment without proprietary modifications by different vendors;
- Appropriate roaming agreements and technical interconnections between the connected networks have to be in place,
- The networks and radio terminals have to have (the standardised) appropriate roaming capability implemented.

### 6.2.1 Spectrum requirements

Spectrum requirements have to be carefully recognised in upcoming designations in order to safeguard the BB-PPDR requirements are met and cross-border communication and roaming with relevant functionality, capacity and security is achieved. This implies that in order to establish a European family of cross-border functioning BB-PPDR networks it is not required in all countries to designate identical (harmonised) bands for this purpose. What is required is, that the BB-PPDR networks and related multi-band user equipment are able to operate within the nationally selected bands (in the other country), inside the same “frequency range” as specified by the 3GPP Band Class. This enables a border-crossing UE to find and attach to its corresponding BB-PPDR network in the visited country.

Consequently the establishment of harmonised conditions by way of the flexible harmonisation concept for an inherent niche market such as PPDR represents a very flexible way to the gradual creation of a large market for the sector offering the benefit of enhanced European cooperation, increased competition, enhanced export options to global markets and last but not least much lower procurement costs. All this can be achieved without any “pressure” on CEPT members to implement European wide BB-PPDR before a specific date.

See also section 2.3 on flexible harmonisation and interoperability on this issue.

### 6.2.2 Understanding operational and technical aspects

A key high level policy objective throughout the world is to seek to establish as much as possible a large market for BB-PPDR communication equipment both network and user equipment, while at the same time ensuring that BB-PPDR services can be established according to national circumstances both with respect to

spectrum planning and regulation as well as technology and technology implementation planning on a national level.

The reason for this is that the PPDR sector is for most nations directly a part of the governmental structure. These activities are state funded and found in the annual state budget.

With this in mind it becomes easier to understand that requirements (operational as well as technical) for establishing an effective PPDR preparedness vary substantially from country to country. Consequently the market for BB-PPDR equipment and services may become highly fragmented with high cost as a heavy burden on the national bill if an overall common policy is not agreed and implemented according to national requirements.

### **6.3 PPDR ROAMING CAPABILITY**

Commercial mobile communication technology has for years facilitated cross-border communication and roaming<sup>12</sup>.

The Public Safety communications require high levels of security, confidentiality and availability. Additionally, the users rely on group communications extensively. To satisfy those needs a Public Safety communication system needs to include a complex access control mechanism specifying terminals that can access the system, what communication rights they will have and what communication groups they can use.

To enable roaming between two PPDR networks these networks need to be interconnected taking into account the capacity, security, resilience, requirements etc. Additionally, a roaming agreement needs to be signed to specify e.g. the rights and services the PPDR users will have when visiting the other network.

The support of cross-border communication and end user equipment roaming will put requirements to the technology (UE to cover both ranges) as well as to the frequency range used in countries that would like to develop cross-border cooperation, communication and roaming between their Public Safety authorities.

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<sup>12</sup> Roaming = End user radio terminal equipment can obtain mobile communication services under coverage of another radio communication network (the "visited network").

## 7 CROSS-BORDER FREQUENCY CO-ORDINATION

Current land mobile networks are inter-alia co-ordinated between administrations based on the preferential frequency regime. This regime divides harmonised spectrum into preferential groups of frequencies which are used by national networks for coverage provision up to the border line. Such a regime is not applicable for a non-harmonised approach where networks in neighbouring countries use different systems with different channel bandwidths.

The current version of ERC/REC T/R 25-08 [12] on the planning criteria and co-ordination of frequencies in the land mobile service in the range 29.7-921 MHz does not address land mobile systems with channel bandwidths greater than 1.25 MHz and therefore does not provide guidance to administrations on frequency co-ordination for BB-PPDR. However, it provides the duplex arrangement for the bands 410-420/420-430 MHz and 450-460/460-470 MHz in its Annex 1.

At the point of time when the present ECC Report 218 was published a revised draft version of ECC/REC/(15)01 [22], containing also field strength levels for the cross-border co-ordination for the 694-790 MHz frequency band for MFCN, had been in the CEPT public consultation phase. This Recommendation could be used as a basis for deriving field strength levels for the cross-border co-ordination for the 700 MHz range for BB-PPDR.

Cross-border co-ordination guidance is required for BB-PPDR in the 410-430 MHz and 450-470 MHz bands prior to deployment.

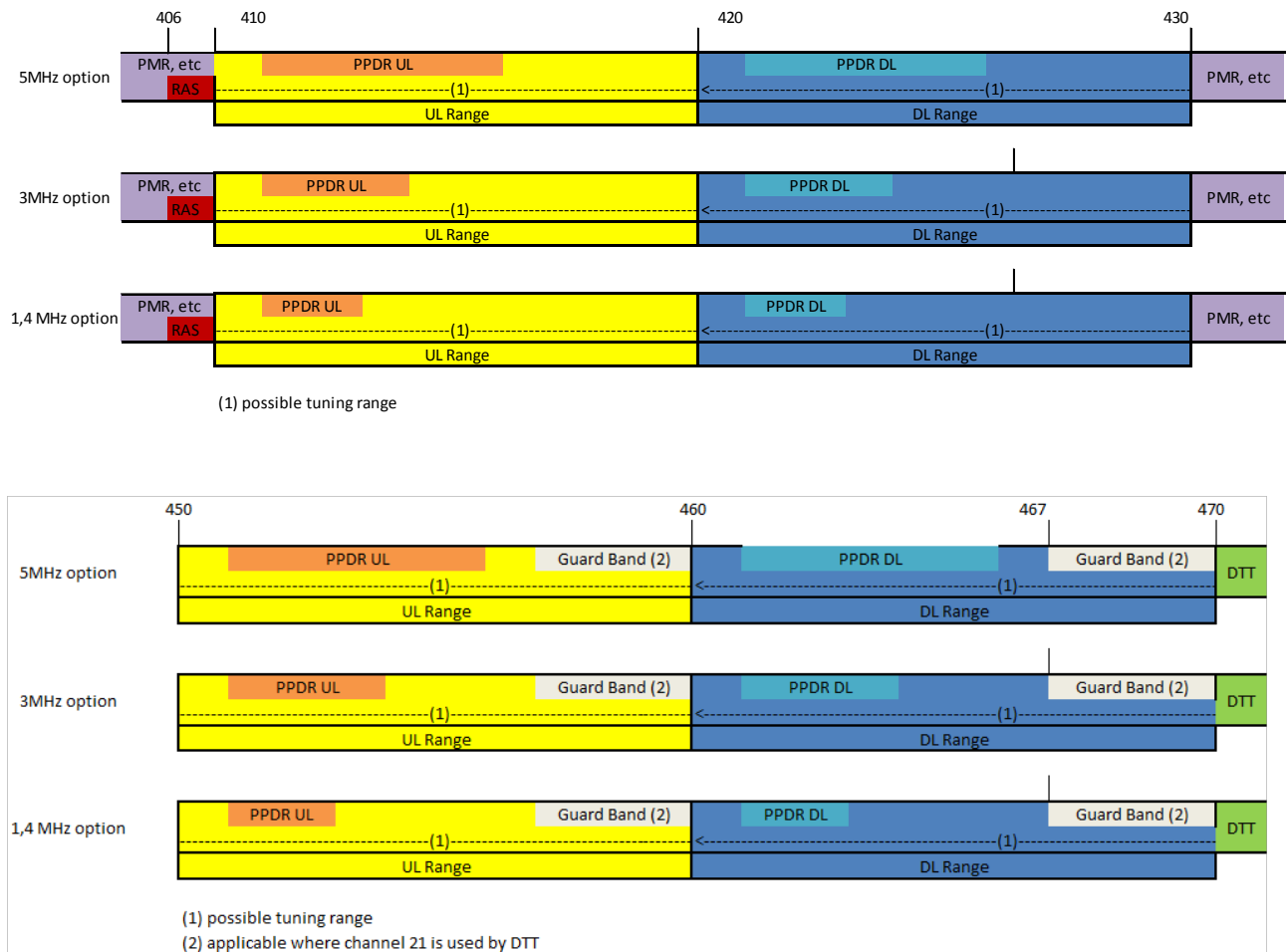


## 8 SPECTRUM OPTIONS FOR WIDE AREA NETWORKS

The following spectrum ranges have been identified for the implementation of BB-PPDR services in CEPT countries.

### 8.1 400 MHz (410-430 MHz AND 450-470 MHz)

The following tuning ranges have been considered within the 400 MHz range and related spectrum compatibility considerations are in ECC Report 240 [3] (the duplex spacing is always 10 MHz):



**Figure 6: 400 MHz BB-PPDR tuning ranges and other primary use**

1. The 400 MHz range does not provide enough available spectrum to provide a stand-alone solution in CEPT countries requiring 2x10 MHz for BB-PPDR as calculated in ECC Report 199 [1];
2. The 400 MHz range can offer national flexibility, e.g. in the context of additional spectrum beside the 700 MHz range;
3. Tuning range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation);
4. 1.4 MHz, 3 MHz, and 5 MHz LTE FDD channelling arrangements could be implemented in the paired frequency arrangements in 410-420/420-430 MHz and/or 450-460/460-470 MHz;
5. The 400 MHz range has the advantage of very good propagation characteristics, potentially reducing the number of sites needed to provide the necessary coverage (rural areas);

6. Cross-border co-ordination guidance is required for the 410-430 MHz and 450-470 MHz bands prior to BB-PPDR deployment;
7. The radio astronomy service in 406.1-410 MHz may require protection zones in some countries, if 410-430 MHz is used by BB-PPDR;
8. In the band 410-430 MHz, there are sharing difficulties with radiolocation systems that are deployed and protected at a national level since the required protection zones can reach hundreds of kilometres;
9. The risk of interference between PPDR and DTT can be reduced by at a set of technical measures including a guard band<sup>13</sup> of up to 3 MHz between DTT and PPDR BSs and an appropriate limit of the corresponding PPDR BS out-of-band emissions.

**8.1.1 Compatibility studies**

Compatibility studies have been performed in the ECC Report 240 [3] on compatibility and sharing studies for the BB-PPDR systems operating in the frequency bands 410-430 MHz and 450-470 MHz. Compatibility was not studied between BB-PPDR and PMSE and scanning telemetry application (point-point and point-multipoint) in the fixed service.

Investigations in ECC Report 240 [3] assumed a maximum e.i.r.p. of 37 dBm for BB-PPDR user equipment within a cell range of about 7.5 km. BB-PPDR requirements in terms of data rate are fulfilled for up to 3 simultaneously transmitting users at cell edge for a 3 MHz system as specified in ECC Report 199 [1].

The 3GPP mobile station spectrum mask (following a ITU-R Recommendation), is used for the compatibility studies between LTE and other systems. An alternative mask is proposed in ECC Report 240 [3] to allow coexistence as shown in Table 2.

**Table 2: Proposed mask for mobile station regulatory framework**

Delta fOOBE (MHz)	Channel width			Measurement bandwidth
	1.4 MHz	3 MHz	5 MHz	
± 0-1	-7 dBm	-7 dBm	-9 dBm	30 kHz
± 1-1.8	-7 dBm	-7 dBm	-7 dBm	1 MHz
± 1.8-2.5	-10 dBm	-7 dBm	-7 dBm	1 MHz
± 2.5-2.8	-25 dBm	-10 dBm	-10 dBm	1 MHz
± 2.8-5		-10 dBm	-10 dBm	1 MHz
± 5-6		-25 dBm	-13 dBm	1 MHz
± 6-10			-25 dBm	1 MHz

**8.1.1.1 Coexistence with PMR/PAMR**

The impact between Narrowband PMR/PAMR (e.g. TETRA, Tetrapol, analogue systems) as well as wideband PMR/PAMR systems (e.g. CDMA PAMR) and BB-PPDR has been studied in the 410-430 MHz and 450-470 MHz sub-bands.

<sup>13</sup> It should be noted that some administrations apply a smaller guard band for legacy systems.

For CDMA-PAMR system, a 1.25 MHz band has been considered. Depending on the results obtained a frequency guard band could be considered between LTE PPDR and the existing CDMA-PAMR allocation.

Due to limited blocking performance of PMR BSs, BB-PPDR BS may cause performance degradation of the PMR BSs over mean distances of 2.3 km. Therefore deployment of nearby sites will require co-ordination.

In addition, OOB of BB-PPDR BSs should not exceed -43 dBm/100kHz in the UL band 450-460 MHz in order to not degrade further the performance of PMR BSs.

Due to limited blocking performance of PMR MSs, BB-PPDR BS may cause performance degradation of the PMR MSs over mean distances of 200 m.

OOB of BB-PPDR BS may also extend the zone up to a mean radius of 2.5 km. In order to ease the co-ordination process and reduce the number of possible interference cases, OOB of PPDR BS should not exceed -43 dBm/100 kHz at frequency offset greater than 1 MHz from BB-PPDR BS band edge. Whenever PPDR and PMR are deployed with smaller offsets, co-ordination may be required.

Coexistence, when operating within these bands, is possible due to the LTE400 base station (BS) and LTE400 user equipment (UE) duplexers in addition to 3GPP requirements to limit the interference to an acceptable level. The duplexers are needed both to fulfil the 3GPP minimum requirements and to ensure the correct behaviour of the LTE400 system itself.

Extremely dense legacy networks may impact the UL capacity of an LTE400 broadband system and may require additional mitigations as specific engineering rules (site co-ordination, additional filtering to improve LTE400 BS adjacent channel selectivity). The LTE duplexers were not considered in the simulations in ECC Report 240 [3].

Finally, the studies also show that the impact of legacy systems on LTE400 is limited.

#### *8.1.1.2 Coexistence with satellite services*

Studies show that coexistence is achieved. The maximum permissible pfd level required for space systems relaying on 406 MHz emergency signals is above the pfd level computed for BB-PPDR systems.

#### *8.1.1.3 Coexistence with the radiolocation service (including defence radar)*

The allocation to the radiolocation service in the band 420-430 MHz is on a secondary basis. Therefore the following considerations apply only to administrations wishing to protect the radiolocation service or for which the allocation to the radiolocation service is on a primary basis.

The conducted study in the ECC Report 240 [3] shows that LTE-based BB-PPDR systems which are in line with 3GPP minimum requirements and operating in the 420-430 MHz band would cause harmful interference to radiolocation systems, in the case of co channel and potentially requires exclusion zones in case of adjacent channel operation:

- Ground radars: separation distances of up to few kilometres may be required in the few countries where radars are deployed. Co-located use may not be possible;
- Airborne radars: separation distances between airborne radars and BB-PPDR (BS or MS) unacceptably degrade any use of aeronautical radiolocation over several hundreds of kilometres wide areas if minimum requirements from LTE specifications are applied to BB-PPDR BSs and UEs.

Additional duplex filtering mitigation is needed to improve the situation and ease the coexistence between BB-PPDR and radiolocation systems.

Coexistence constraints with the radiolocation service may not exist for the 450-470 MHz band when used for BB-PPDR for most administrations.

**8.1.1.4 Coexistence with Digital Terrestrial Television (DTT)**

The results of the theoretical coexistence analyses with DTT demonstrate interferences from the BB-PPDR LTE400 system to DTT reception when the BB-PPDR system is adjacent in the frequency domain to the lower DTT Channel, i.e. Channel 21. Nevertheless, the risk of interference can be reduced by at a set of technical measures including a guard band<sup>14</sup> of up to 3 MHz between DTT and BB-PPDR BSs and an appropriate limit of the corresponding BB-PPDR BS out-of-band emissions. Furthermore additional mitigation measures may be required to solve possible residual interference from PPDR BSs on a case by case basis in a manner similar to the situation between LTE800 and DTT. BB-PPDR LTE400 Base Station OOBE e.i.r.p. levels for protection of DTT above 470 MHz are given in Table 3 below.

**Table 3: BB-PPDR 400 Base Station OOBE e.i.r.p. levels for protection of DTT above 470 MHz**

Frequency range	Condition on Base station in-block e.i.r.p, P (dBm/cell)	Maximum mean OOBE e.i.r.p (dBm/cell)	Measurement bandwidth
For DTT frequencies above 470 MHz where broadcasting is protected	$P \geq 60$	-7	8 MHz
	$P < 60$	$(P - 67)$	8 MHz

The conducted Monte-Carlo simulations in ECC Report 240 [3] have demonstrated limited interferences to DTT for high power UE (37 dBm) with improved ACLR (79 dB, i.e. OOBE of -42 dBm/8 MHz) in Channel 21.

Local interference analyses and field measurements, where PPDR UEs are operating in the vicinity of DTT, have demonstrated that despite the aforementioned measures and because of the limited DTT receiver selectivity UE using higher powers may still interfere a DTT receiver located in regions / countries where DTT Channel 21 is in use, especially when vertically polarised DTT antennas are used (no orthogonal discrimination between PPDR transmitter and DTT receiver antennas). In case interferences are observed or anticipated, they can be solved locally by a power reduction of PPDR UE through signalling or network planning.

Administrations may want to use the power limits as proposed in the following Table 4:

**Table 4: BB-PPDR 400 MHz user equipment in-block emission limits for protection of DTT, fixed roof top reception**

	UE maximum mean in-block power
Power limit 1 (See Note 1)	23 dBm inside the coverage areas of DTT ch 21 and ch 22
	31 dBm outside the coverage areas of DTT ch 21 and ch 22.
Power limit 2 (see Note 2)	37 dBm

Note 1: Assuming -3 dBi antenna gain for devices implementing this Decision, it matches ECC/DEC(15)01 [8].

Note 2: Refer to Monte Carlo simulations. This can be used in case of DTT transmission being horizontally polarised with antenna polarisation discrimination of 16 dB.

Also, BB-PPDR UE blocking capability has to be improved to limit the risk of interference from DTT Channel 21.

Administrations may need to do some further studies to understand the risk of interference for their individual national circumstances. They may also decide that it is appropriate to provide external filters to households in vulnerable DTT areas where there is a risk of interference due to the selectivity of the DTT receivers. This potential solution would not mitigate any risk of interference due to the out-of-band emissions of the handsets.

<sup>14</sup> It should be noted that some administrations apply smaller guard band for legacy systems.

The risk of interference between BB-PPDR and DTT can be reduced by a set of technical measures including a guard band<sup>15</sup> of up to 3 MHz between DTT and PPDR BSs and an appropriate limit of the corresponding PPDR BS out-of-band emissions.

#### 8.1.1.5 Coexistence with radioastronomy

Generic compatibility calculations for BB-PPDR activity in the 410-430 MHz band and radio astronomy operating in the 406.1-410 MHz band have shown that physical separation is required between BB-PPDR BS and RAS to achieve compatibility.

The calculated exclusion zones can reach up to 90 km based on a spurious emission limit of -36dBm/100kHz from LTE400 base stations (BS) and can be reduced to 20 km if the spurious emission into the RAS band is limited to -96 dBm/100kHz according to the 3GPP requirement for protection of the base station's own UL band.

Separation distances between the UEs and the radio astronomy stations are about 50 km. Adding the terrain profile to the analysis showed that the attenuation from the geographical terrain does not reduce the separation distances.

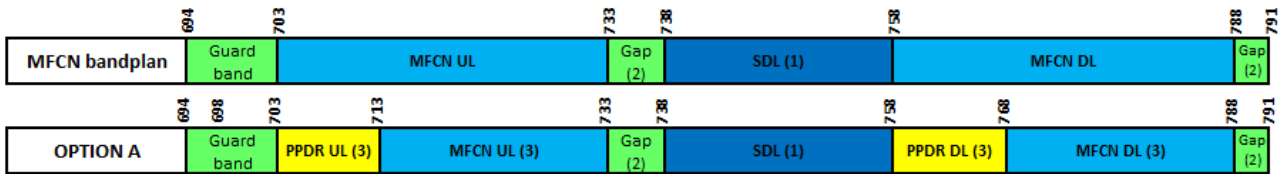
## 8.2 700 MHz (694-791 MHz)

1. BB-PPDR can be accommodated within the 700 MHz range by either designating spectrum for dedicated BB-PPDR, use of commercial MFCN or a combination of two (hybrid) as necessary to fulfil national PPDR requirements. Therefore, the 700 MHz range can be considered as a potential stand-alone solution for the BB-PPDR requirements as calculated in ECC Report 199 [1]<sup>16</sup>;
2. Tuning Range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation). Harmonised technical requirements for the use of MFCN in the 700 MHz range (703-733 MHz and 758-788 MHz) already exist in ECC/DEC/(15)01 [8];
3. Cross-border co-ordination needs to be addressed for the 700 MHz range BB-PPDR options, also with regard to the possible implementation of other use (MFCN and non-MFCN) in neighbouring countries.

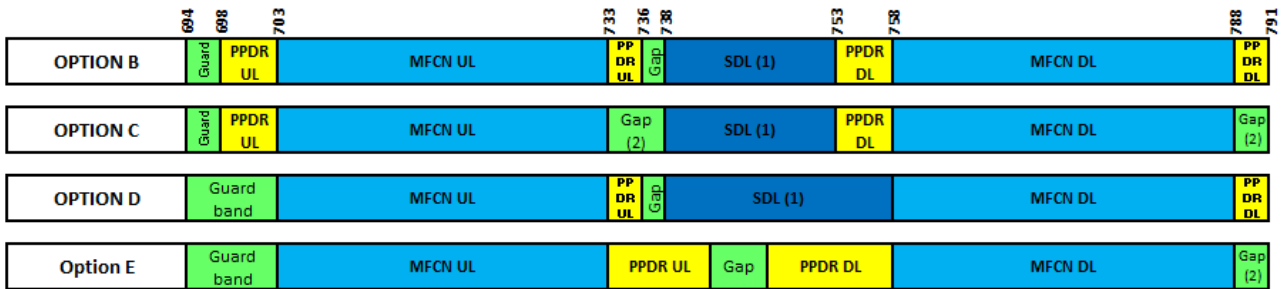
Figure 7: 700 MHz principal options indicates principal options for BB-PPDR which can be considered on national level for the 700 MHz range.

<sup>15</sup> It should be noted that some administrations apply a smaller guard band for legacy systems.

PPDR in spectrum harmonised for MFCN (ECC/DEC(15)01)



PPDR dedicated spectrum:



PPDR in a combination of MFCN and dedicated spectrum:

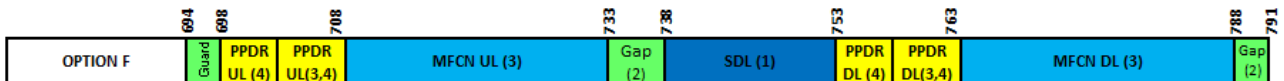


Figure 7: 700 MHz principal options

Notes in Figure 7:

1. CEPT Report 53 [9] considers alternative options (M2M, SDL, PMSE, BB-PPDR) for this part of the band and these have been listed in ECC/DEC/(15)01. The SDL option is one of them and uses zero up to four blocks of 5 MHz. Thus this approach provides flexibility for combining different options.
2. CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with PPDR could be explored in the 733-736 MHz and 788-791 MHz.
3. BB-PPDR usage could be anywhere within the harmonised MFCN band plan using a 55 MHz duplex spacing.
4. The use of the 2x2x5 MHz into a combined 10 MHz duplex channel arrangement in 698-708 MHz paired with 753-763 MHz has not been studied.

All the above options use a duplex spacing of 55 MHz except Option E which uses 15 MHz.

For those countries opting for a commercial or hybrid BB-PPDR solution, any MFCN band harmonised in CEPT may also be used for BB-PPDR meeting the specified requirements (see 5.2.2). Such use is subject to BB-PPDR equipment roaming capabilities. As these bands are already harmonised for Broadband mobile usage then there is no need to specifically harmonise these IMT-bands for BB-PPDR. BB-PPDR terminals capable of using some or all of these bands can provide some flexibility to PPDR organisations wishing to use commercial network resources.

It is shown that BB-PPDR 2x10 MHz in the duplex gap (Option E) is not feasible. Compatibility of PPDR 2x(2x5) MHz in the duplex gap with MFCN may be achieved. However, this option suffers from limitations, such as:

- Severe self-desensitisation of the BB-PPDR UE downlink;
- UE-UE interference;
- Cross-border co-ordination with SDL.

Option E has received insufficient support (see FM49(15)44 Annex 5 [26] summary of cover letter) and is not considered for inclusion in an ECC harmonisation deliverable for BB-PPDR.

### 8.2.1 Compatibility studies

The technical conditions for BB-PPDR services provided by networks in the MFCN channelling arrangement are covered by CEPT Report 53 [9] and ECC/DEC/(15)01 [8].

The compatibility studies in the duplex gap (733-758 MHz) and guard bands (694-703 MHz and 788-791 MHz) have been performed in ECC Report 239 [2].

Investigations in ECC Report 239 [2] assumed a maximum e.i.r.p. of 23 dBm for BB-PPDR user equipment within a cell range of about 845 m. BB-PPDR requirements in terms of data rate, as specified by ECC Report 199 [1], are fulfilled for up to 8 simultaneously transmitting users at cell edge for 2x8(5+3) MHz systems.

#### 8.2.1.1 Coexistence with MFCN

The technical specifications of MFCN Base Station (BS) and User Equipment (UE) do not guarantee interference free operation of concurrent networks in adjacent blocks throughout the coverage area. Increasing BB-PPDR UE adjacent selectivity enables the victim BB-PPDR UE to operate in a sparse network when adjacent in frequency to a dense network. Another phenomenon is the 3<sup>rd</sup> order intermodulation due to DL operations by two different MFCN networks may appear in BB-PPDR band, if this happens, the PPDR operator should accept this type of interference.

Compatibility between BB-PPDR UL and SDL (MFCN Supplemental Downlink) depends on the scenario which is targeted. It is feasible for an SDL BS to fulfil the out-of-block power limit defined in ECC/DEC/(15)01 [8] towards BB-PPDR UL in 733-736 MHz, assuming a 15 dBi antenna gain. There is no blocking requirement for BB-PPDR UL Rx in the ECC Decision and thus the BB-PPDR BS Rx filter was not analysed for this scenario. However, it is recognised that the BB-PPDR BS Rx filter is needed.

If the 3GPP minimum requirements for coexistence are to be fulfilled, it is feasible to create SDL Tx and BB-PPDR BS Rx filters with enough rejection. However, the insertion loss in BB-PPDR UL will be higher than standard. In the case of co-location between BB-PPDR and SDL, then more than 2 MHz separation is needed. The exact level of guard-band beyond 2 MHz for site solutions with external filters has not been investigated in ECC Report 239 [2]. Another way to manage co-location may be to rely on different site solutions, e.g. by using appropriate antenna physical separation.

### 8.2.1.2 Coexistence with DTT

The earlier results of extensive studies on compatibility between MFCN and DTT below 694 MHz are in CEPT Report 53 [9]<sup>17</sup>. As a consequence ECC/DEC/(15)01 [8] indicates that the maximum mean unwanted emission power of MFCN UE should be limited to -42dBm/8 MHz for protection of fixed DTT reception at 470-694 MHz assuming an MFCN channel of 10 MHz or less and a 9 MHz guard band.

This conclusion was based on the results of a number of compatibility studies looking at MFCN UEs operating within the 703-733 MHz band and the technical feasibility of MFCN UEs implementing appropriate filtering to meet this unwanted emission level.

Studies in ECC Report 239 [2] look at the compatibility between BB-PPDR networks using MFCN LTE-based technologies in the 700 MHz range and DTT below 694 MHz. Studies have shown that the most critical compatibility analysis with DTT Networks is for BB-PPDR UE use in the 698-703 MHz band. These studies also looked at a number of different scenarios with different assumptions looking at BB-PPDR UEs operating within the 698-703 MHz band and the technical feasibility of BB-PPDR UEs implementing appropriate filtering to meet the proposed unwanted emission levels.

From the results of the studies presented it appears that a reasonable solution would be to recommend unwanted emission levels for BB-PPDR UE of -42 dBm/8 MHz to manage the risk of interference to DTT below 694 MHz.. This would provide an adequate level of protection for DTT. The cumulative effect of unwanted emission from both BB-PPDR UEs and MFCN UEs was not studied in ECC Report 239 [2].

Some studies have shown the potential for relaxed values of unwanted emission levels for BB-PPDR UEs operating in the 698-703 MHz block.

Simulations have shown that BB-PPDR UEs with 4 MHz guard band, operating at temperatures above +35°C, may have limitations regarding the technical feasibility of implementing appropriate filtering to meet the unwanted emission limit of -42 dBm/8 MHz below 694 MHz.

Taking into account temperature drift and to address the feasibility problems highlighted above for these BB-PPDR UEs to meet the -42 dBm/8 MHz limit a different level can also be considered for such BB-PPDR UEs under extreme environmental conditions for equipment conformance tests. When reviewing these levels the unwanted emission level of a BB-PPDR UE operating in the 698-703 MHz block in extreme environmental conditions for equipment conformance tests should not exceed -30dBm/8MHz. Measured maximum unwanted emission levels of existing MFCN UEs operating in the 700 MHz range in extreme operating conditions are provided in the studies.

The maximum mean in-block power for BB-PPDR terminals is assumed to be 23 dBm to avoid blocking.

The results of coexistence studies when the BB-PPDR system is operating above 733 MHz (in the 700 MHz duplex gap) show that the impact of the BB-PPDR UL would be lower than the level of impact of MFCN LTE UE on DTT channel 48.

The BB-PPDR Base Station receiver may be subject to interference from DTT transmitters using channel 48 and located in the vicinity. Under the GE06 agreement [27] current broadcast networks were not designed to, and may not be able to provide protection for adjacent channel BB-PPDR base station receivers in some cross border situations. The desensitisation of the BB-PPDR base station receiver can be significant depending on the distance between the two sites and on the transmission and receiving characteristics.

In that case BB-PPDR base station receiver should implement appropriate filtering of DTT in-band emissions. Additionally mitigation techniques would reduce the risk of interference from DTT transmitters using channel 48 into BB-PPDR base station receivers on a case by case basis. Possible mitigation techniques include: down tilting the BB-PPDR antenna, fine-tuning antenna orientation and implementing link budget margins by increasing the BB-PPDR network density.

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<sup>17</sup> Additional results for threshold levels for MFCN UEs are in the CPM report for AI 1.2 WRC-15



Compatibility between DTT channel 47 and BB-PPDR UL in the band 698-703 MHz was also considered and it was concluded that the situation is comparable (or better) than the situation considered in CEPT Report 53 [9] between DTT channel 48 and MFCN UL in the band 703-733 MHz.

### 8.3 PPDR USAGE ACTIVITIES STATISTICS

Statistics show the relatively low spatial density of BB-PPDR UEs and therefore the difference in PPDR usage compared with the traditional consumer usage. An example of such PPDR usage statistics is provided by the Police of the Netherlands in ANNEX 3:

### 8.4 OTHER SPECTRUM OPTIONS

It is important to note that the provisioning of BB-PPDR needs not be constrained to the 400 MHz or 700 MHz. Indeed operationally, BB-PPDR capability will be enhanced by allowing BB-PPDR services to be delivered across different bands and networks, either dedicated or commercial. It is important that manufacturers will produce multiple band integrated chipsets, including the designated BB-PPDR ranges, using a common technology for BB-PPDR user terminals ideally on a global or regional basis.

Although currently there are no licences suitable for BB-PPDR wide area coverage (below 1 GHz), for those countries opting for a commercial or hybrid BB-PPDR solution, any MFCN band harmonised in CEPT may also be used for BB-PPDR meeting the specified requirements (see 5.2.2). Such use is also subject to BB-PPDR equipment roaming capabilities. Such a use may already be possible on a national basis (depending on commercial agreements) and subject to the availability of appropriate BB-PPDR terminal equipment. As these bands are already harmonised for Broadband mobile usage then there is no need to specifically harmonise these IMT-bands for BB-PPDR. BB-PPDR terminals capable of using some or all of these bands can provide flexibility to PPDR organisations wishing to use commercial network resources.

#### 8.4.1 Frequency ranges for BB Disaster Relief (BBDR) systems

The following ECC deliverables address spectrum issues for Broad-Band Disaster Relief (BBDR) systems:

- ECC Report 110 “Compatibility studies between Broad-Band Disaster Relief (BBDR) and other systems” (September 2007) [14];
- ECC/REC/(08)04 “The identification of frequency bands for the implementation of broad band disaster relief (BBDR) radio applications in the 5 GHz range” (October 2008) [13].

ECC/REC/(08)04 [13] has been implemented by 16 CEPT countries so far of which:

- Both bands implemented (4940-4990 and 5150-5250 MHz): 5 countries;
- Only 4940-4990 MHz implemented: 1 country;
- Only 5150-5250 MHz (so-called preferred option) implemented: 10 countries.

Spain has implemented the frequency range 5725-5775 MHz. Several other CEPT countries consider implementation in the future, also subject to market demand. So far, there is only a limited number of equipment on the market in compliance with the ETSI Harmonised Standard EN 302 625 [20] for BBDR applications.

The compatibility investigations in ECC Report 110 [14] led to the conclusion that BBDR devices are not compatible with FS links and RA stations in the frequency band 4940-4990 MHz. It is therefore not recommended to use BBDR devices in this band in a country where FS links and/or RAS sites use this frequency band but this is subject to discretion of individual national administrations who may wish to make specific provision to allow the use of BBDR for occasional/minimal use during disaster operation. On the other side, the band 4940-4990 MHz is implemented in many countries in ITU-R regions 2 and 3 for PPDR (not only for disaster relief) in line with Resolution 646 [10].

Regarding the band 5150-5250 MHz, It should be noted that ECC Report 110 differentiates between the number of BBDR systems forecasted to be deployed and the number of active networks transmitting simultaneously being not the same. A wider use of the band by BB-PPDR instead of BBDR alone would lead to increased levels of interference from BB-PPDR devices into MSS Feeder links.

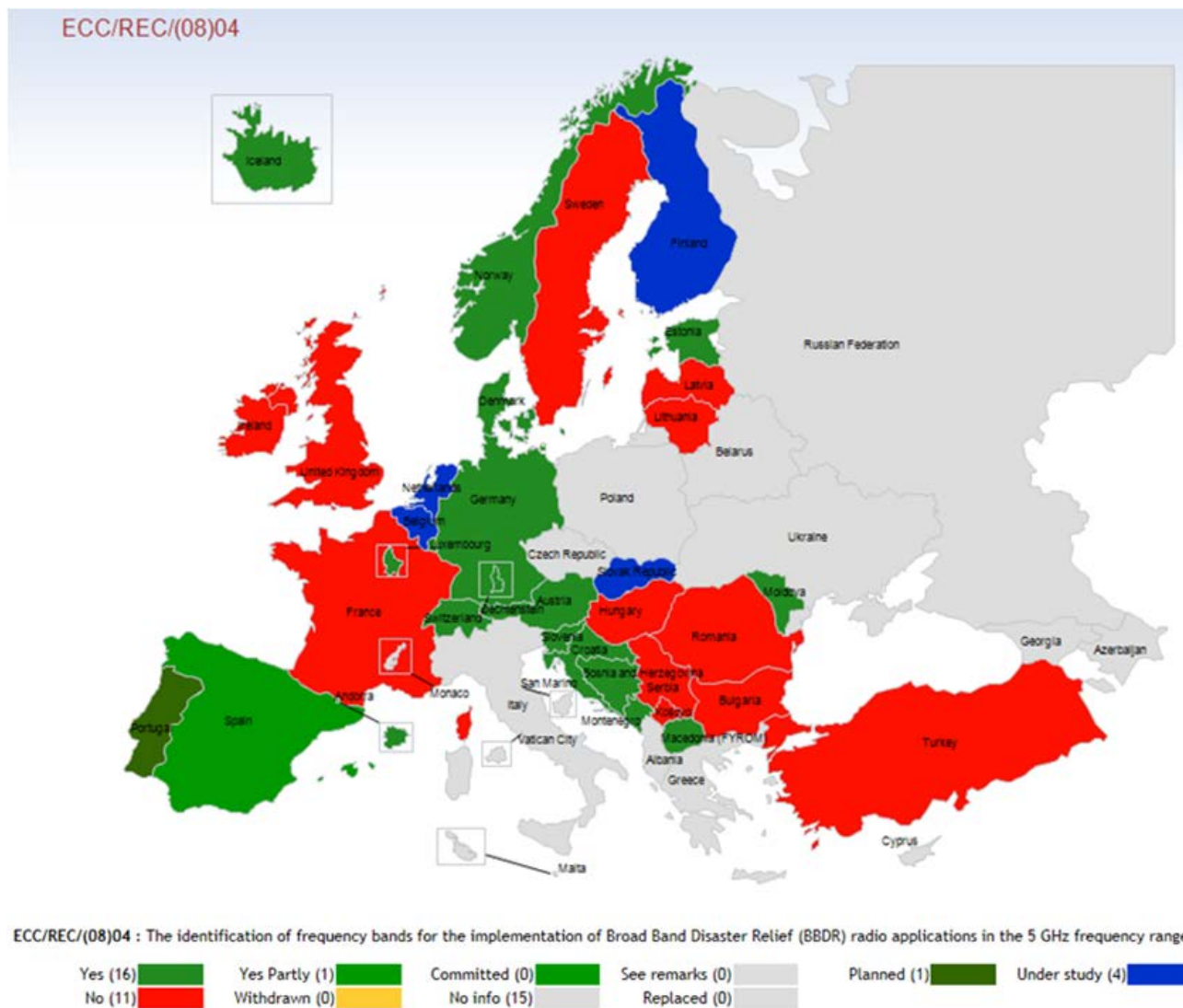


Figure 8: Implementation ECC/REC/(08)04 [13] (September 2015)

#### 8.4.2 Ad-hoc networks

It is often not possible to design and implement cost effective and resilient BB-PPDR networks that could provide service covering every potential incident anywhere in the country. In reality, there are often areas of poorer coverage, e.g. indoors or in rural areas, areas with capacity limitations, e.g. at the edge of the radio cells, and areas where a single failure can severely impact the WAN service.

Sometimes there is a need to deploy temporarily additional Base Stations to provide an ad-hoc enhancement to the service provided by the WAN. There are two typical use cases for these ad-hoc networks:

- Additional capacity: Deployment of one or more Base Stations in an area where a planned or unplanned big/mass event will take place or a natural or major disaster has occurred to increase the capacity in an area where the normal WAN capacity is fully used. Backhaul connectivity to the WAN is required to integrate the additional capacity to the already existing service offering.

- Additional coverage: Deployment of one or more Base Stations in an area where a planned or unplanned big/mass event will take place or a natural or major disaster has occurred to provide service (coverage and capacity) to an area where there is no coverage from WAN either due to lack of planned coverage or an infrastructure failure. Backhaul connectivity to the rest of the WAN is often required but in case of a planned 'no coverage' area a local operation mode without wider connectivity might be acceptable.

The use cases differ also by the type of the event:

- Mass events: Some are predictable as they happen in the same location time after time, e.g. football games, carnivals and many mass demonstrations. When the time and location of an event is known in advance, the infrastructure can be deployed beforehand avoiding a potential loss of communications at the start of the event. Commercial mobile networks are typically operational, possibly even providing extra capacity, and they can make use of additional base stations for such events to avoid overload.
- Disasters: Unlikely to happen time after time in the same location. Infrastructure cannot be deployed beforehand due to the unpredictability of the event. Typical commercial mobile networks, if not completely destroyed by the disaster, are often operational but heavily loaded and may in some cases stop providing services to the public due to overload.

In all of these events the concentration of PPDR personnel is high, capacity demands are likely to be high and there is a great need for interoperability for effective cooperation. These cases were not studied in the compatibility studies in ECC Reports 239 and 240 [2] [3].

For coverage driven events the ad-hoc solutions should aim to use the same frequencies as the WAN to ensure maximum terminal compatibility.

For cases requiring ad-hoc solutions to boost the capacity additional frequencies might be required. Where additional but rarely used frequencies are used this should be done accepting that some users might not be able to directly benefit from this additional capacity due to lack of terminal support.

#### 8.4.3 Air-Ground-air

Air-Ground-Air (AGA)<sup>18</sup> operation is a radio service designed to provide communication between radio users operating from airborne assets and ground based operatives including radio users and dispatchers. The airborne assets typically will be comparatively small in number operating comparatively infrequently. However once they are operational their effectiveness is highly valued.

User needs for AGA communications include voice communications, location services and increasingly video streaming from the camera mounted on the aircraft. Use cases include e.g. search of a missing person, observation at a mass event and investigation of traffic incidents. Air ambulances might additionally have other data needs, e.g. remote medical monitoring,

Current air to ground video solutions utilise special equipment on dedicated frequencies. A typical high quality video stream of today carrying some additional data like telemetry or voice commentary will require a channel bandwidth of several MHz depending on parameters such as which video codec in what mode is being used.

For areas that may require simultaneous video streams from several aircraft the spectrum requirement multiplies rapidly. This is true even if the transmissions are slightly geographically separated as the range of radio interference at typical public safety aircraft flying heights is measured in tens of km or even more.

Simply integrating existing video solutions to the BB-PPDR solution by moving the services to a new band would not change the spectrum demand driven by the need of simultaneous transmissions and the bandwidth requirement of a single video stream. However, if the radio technology platform could be changed to one that allows better spectrum re-use than the current solutions that would have a big effect on the overall spectrum need. Also, work on more effective video codecs is ongoing worldwide and may provide opportunities to reduce the spectrum requirement significantly in the future.

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<sup>18</sup> AGA is sometimes also called Air to Ground (A2G)

AGA video systems are often unidirectional and the need to receive video in an aircraft (from a camera on the ground or in another aircraft) is currently far less common than to receive video on the ground from an aircraft. Depending on national circumstances, it may be that the best solution is to implement lower bit rate bidirectional AGA applications such as voice, location services or other type of M2M on a different technology platform and frequency band also in the future.

#### 8.4.4 AGA frequencies

One significant difference between the WAN and an AGA overlay is the number of site needed as the operating height of aircraft will typically mean they have line-of-sight with the overlay base stations. Consequently AGA overlay networks lend themselves to being implemented at higher frequencies.

It is likely that aircraft users will need the same capability as terrestrial users – operationally aircraft will have to be fully integrated with terrestrial users to maximise their effectiveness. Given aircraft are an eye in the sky, one aircraft could possibly generate a number of video feed to help inform and direct operations on the ground. From this view point an AGA overlay network may need access to a similar amount of spectrum to the terrestrial network, assuming the same technology is deployed.

BB-PPDR AGA may in some cases be able to use frequency allocations from within the BB-PPDR WAN spectrum, assuming this is allowed by the licensing rules, that national radio services and radio services in other countries are not affected and that no additional protection is required. However, it is very likely that the overlay BB-PPDR AGA solution will need to use a separate spectrum for capacity, interference or other reasons. In either case new bi- or multilateral frequency agreements should be concluded or existing agreements should be reviewed.

#### 8.4.5 Direct terminal to terminal communications

The operation category *Direct terminal to terminal communications (Direct Mode Operation (DMO) in TETRA standards, Proximity Services (ProSe) or sometimes Device to Device (D2D) in LTE/3GPP standards)*, describes the ability of radio terminals to communicate directly with each other over a limited distance of typically no further than 1000 m (such as PMR446 Walkie-Talkies) whether or not a Wide Area Network (WAN) is available.

This mode can be used to avoid local overload of the WAN in critical situations, to provide communications when WAN is not available and to extend the network services to terminals just beyond the WAN coverage.

LTE standards will support different ProSe modes so that ProSe can be used within the same or a different band than what is used by the network, and use within and outside the network coverage.

Direct terminal to terminal communication applications are mainly seen when wide area network (WAN) coverage is missing or not sufficient. However, additional scenarios might arise when WAN services are simply not needed because communication is from a tactical perspective limited to a restricted area or number of users in close proximity.

In this scenario the main issue is the communication at the operation scene for a direct data exchange between several vehicles or operational spots. The vehicles can either be mobile or stationary. Operational spots can be temporarily established command centres but also stationary installed cameras or sensors.

In the following, some examples for possible services and applications are described:

- The on-site operational users communicate with each other by voice. This application is relevant for e.g. fire brigades if there are several mobile command centres equipped in vehicles participating the operation. But voice communication between different operation vehicles is also necessary for other PPDR agencies, e.g. the police.
- For nuclear, biological, and chemical (NBC) reconnaissance forces a quick analysis of the NBC measurement results is essential to alert or to give the all-clear. For this purpose, a real-time transmission of measurement results from the NBC measurement / reconnaissance vehicles to a vehicle that is responsible for the collection and analysis of the data or to an on-site operation vehicle can be realised.

- Mobile surveillance of objects and persons is necessary for the police special response units. Therefore, video or picture data (e.g. from thermal imaging, night vision, or PTZ cameras) can be transmitted between the operational spots. In the case of a covert surveillance operation a mobile special response unit benefits from the video transmission from cameras that are installed in unmanned vehicles near the object to a manned vehicle that is positioned outside the visual range.
- A video transmission from one or more cameras located directly at the trouble spot to a mobile on-site co-ordination centre could support the fire brigade to get an overview about the current situation. Besides normal cameras here also thermal imaging cameras are important.
- Data transmission between communication partners in difficult environment, e.g. inside tunnels, buildings, or cellars, is affected by the construction of the building (walls, ceilings) etc. that results in an attenuation of the wireless signal. This effect is well-known for both the analogue and digital radio.

It is assumed that rescue operations of the fire brigade or Technical Relief often take place in burning or collapsed buildings or tunnels and that the following applications are required for co-ordination and support.

- Voice communication to exchange news or other messages;
- Transmission of pictures from inside to the outside, e.g. pictures captured by a night vision or thermal imaging camera;
- Video transmission of the indoor operation, e.g. during a fire firemen might carry helmet cameras when entering an object in order to provide on-scene video information to the operation control. Due to missing or insufficient indoor coverage, direct terminal to terminal transmission might remain the only solution to maintain the video capability;
- Transmission of sensor data of a monitoring system for respiratory protection devices from inside to the outside.
- Another scenario is the usage of connected robots in areas that are destroyed by the disaster and thus not accessible anymore, e.g. if buildings are extremely in danger of collapsing or areas are contaminated by radiation as consequence of a nuclear incident.

Police special response units have often the requirement to keep persons or a crime scene (e.g. at a hostage-taking) under surveillance by using video or other sensor data (e.g. acoustics). These transmitted data support assessing the on-site situation. These persons or crime scenes under observation are often located inside buildings, cellars, or tunnels.

One further scenario is the data connection within a mobile convoy to provide escort to very important persons (VIPs) who intend to visit the event. The video transmitted from the leading vehicles to the other vehicles enables a better assessment of the situation by all parties. In addition, also co-ordination or alerting by voice communication could be a reasonable application.

There are several types of terminal to terminal communications:

**Communication one to one** – called 'Direct Call' in TETRA, 'ProSe Communication – one to one' in 3GPP.



**Figure 9: Peer-to-peer direct call**

**Communication one to many** – called 'Group Call' in TETRA, 'ProSe Communication – one to many' in 3GPP.



**Figure 10: Group call**

**Simultaneous connection to the WAN and to direct communications** – called ‘Dual Watch’ in TETRA, 3GPP standards support this sort of operation but do not have a specific term for it.



**Figure 11: Simultaneous connection to the WAN and to direct communications**

**Network range extension for direct communications** – called ‘Repeater’ in TETRA, ‘UE to UE relay’ in 3GPP.



**Figure 12: Network range extension for direct communications**

**WAN network range extension** – called ‘Gateway’ in TETRA, ‘UE to Network relay’ in 3GPP.



**Figure 13: WAN network range extension**

In current public safety scenarios equipment fitted to vehicles or backpack type equipment is often used to extend the WAN network coverage either into a rural area not covered by the network or into a building. The coverage extension works because the relay will be better located to receive a signal and typically these relays are able to transmit at a higher power than handheld radios enabling a longer operational range. From a radio point of view the vehicle can play three radio roles:

- 1 that of a pure RF repeater: the signal is amplified and retransmitted;
- 2 that of a radio relay (defined by 3GPP because of air interface impacts), the signal is received decoded, re-encoded and retransmitted, usually on a different time slot on the same frequency;
- 3 that of a communication node whereby the traffic is received and decoded, resulting IP datagrams are routed to the WAN, through a dedicated modem, or to other terminals, through a dedicated Base Station.

Inband relaying (same spectrum) is applicable to the RF repeater and radio relay cases, whereas outband relaying is applicable to the RF repeater and communication node cases. Inband and outband relaying do not offer the same performance nor have the same spectrum cost. Outband relaying makes it possible to receive in 700 MHz and repeating e.g. in 2 GHz or vice versa. This enables to make an efficient use of the 700 MHz range, as part of the traffic is off-loaded from this band to the 2 GHz band.

**Nearby terminal discovery** – not supported by TETRA, ‘ProSe Discovery’ in 3GPP

The 3GPP standards recognise a function where a terminal (UE) can discover other terminals nearby. This function is called ProSe Discovery and is currently under development. It is expected to use the network to identify nearby terminals when possible but also be able to operate without network support. TETRA does not support this functionality.

#### 8.4.6 Voice communications

Voice, especially group (one to many) calls, is clearly the most used communication method over existing PPDR networks. While data is increasingly used, the fall back solution especially in emergencies is practically always voice.

While effectively implementing group call functionality into broadband systems will help to keep the related capacity needs low compared to e.g. video services, carrying a similar amount of voice calls over broadband networks as the narrowband PPDR networks support today will pose additional capacity requirements.

Where the national BB-PPDR solution will be designed to support voice calls, the users will expect fully functioning voice communications wherever they have access to mobile broadband (data) services. This may pose additional network planning challenges to ensure a reliable radio connection throughout the call.

## 8.5 CANDIDATE HARMONISED FREQUENCY RANGES FOR BB-PPDR OTHER USE CASES

The main conclusion of ECC Report 199 [1] is that an amount of spectrum in the range of 2x10 MHz is needed for the future European BB-PPDR wide area network (WAN). However there could be additional spectrum requirements to cater for direct terminal to terminal communications, Air-Ground-Air (AGA), ad-hoc networks and voice communications over the WAN.

Please note that other ad-hoc communication solutions (e.g. for BBDR, LAES, video PMSE) are not considered here since they are not solutions for which a LTE-based implementation could be foreseen at the current stage.

### 8.5.1 AGA

BB-PPDR AGA can include different types of airborne use such as onboard helicopters, unmanned systems, or balloons.

The spectrum requirements for BB-PPDR airborne communications have not been calculated within ECC Report 199 or in this Report. Estimation by a CEPT administration is included in Annex 5 of ECC Report 199 which provides an example of possible spectrum requirements.

Spectrum requirements for the AGA application can be satisfied by using external frequency bands, for example, the frequency bands harmonised for PMSE. Regulatory and technical conditions of such a use are subject to national decisions.

The frequency range 410-430 MHz and the 700 MHz range options set out in this Report for BB-PPDR are not possible for AGA because of its radio service allocation status.

450-470 MHz has no allocation restriction. However, existing studies assumed the use of base station heights up to 30 m and not AGA-like applications.

It is necessary to have a good understanding of the technical characteristics of BB-PPDR AGA with regards to the involved antennas (antenna gains, beamforming or sectorisation used). A precise request could be defined in ETSI using the ETSI-ECC co-ordination process by creating an ETSI system reference document.

However, BB-PPDR AGA could be potentially integrated in a terrestrial BB-PPDR network using the same frequencies and be solved within the network planning and dimensioning work.

### 8.5.2 Direct Terminal to Terminal Communications

This communication mode is within the scope of the 3GPP work on terminal to terminal communications standardisation. LTE's Proximity Services may be supported in the same frequency blocks as the network, in another frequency block, or in another band which could provide for an LTE provision.

No compatibility studies were carried out for this communication mode. On the other hand, interference scenarios would differ substantially from what has been studied.

### 8.5.3 Ad-hoc networks

Spectrum requirements for PPDR ad-hoc networks could be satisfied:

- from within the spectrum used for WAN (by means of deploying temporary base stations/ repeaters), or
- in another band which could provide for an LTE implementation, or
- from 'external' frequency bands such as 5150-5250 MHz in the ITU-Region 1 and 4940-4990 MHz<sup>19</sup> for some countries (also used for PPDR in both the ITU-R Region 2 and Region 3). ECC/REC/(08)04 [13] states "that spectrum within the frequency band 5150-5250 MHz should be the preferred option for the deployment of BBDR radio applications."

<sup>19</sup> NATO usage still maintained in some countries.



For specific indoor precise location tracking applications, ECC/REC/(11)10 [19] for LAES (Location tracking Application for Emergency Services) is published.

#### 8.5.4 **Mission critical voice communications**

The assumption is that mission critical voice will be carried in most countries by the existing dedicated mission critical voice (and narrowband data) TETRA and Tetrapol networks for many years (until 2025-2030). At the moment for mission critical voice there is a harmonised European NB-PPDR allocation of 2x5 MHz in the 380-400 MHz band.

The calculation in ECC Report 199 [1] shows that the future BB technology could provide the voice capacity with a comparable (or better) efficiency to current NB-PPDR technologies. According to the calculation, it is estimated that 2x3.2 MHz would be needed for voice traffic including group calls.

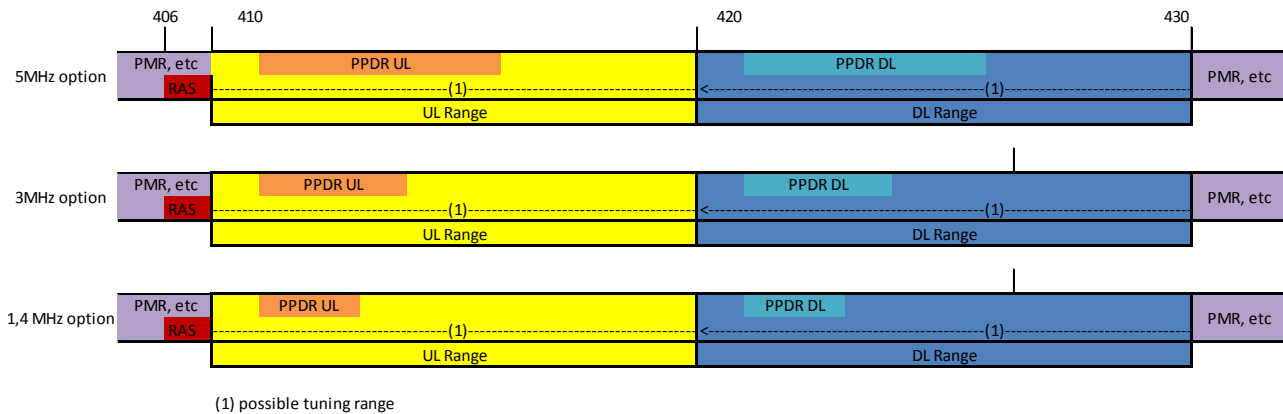
Mission critical voice communications is expected to migrate in the medium/long future to the BB-PPDR networks and be based on LTE solutions.

Hence, additional spectrum for BB-PPDR of up to 2x3 MHz will be required to cover also mission critical voice applications in the medium and long-term future.

## 9 CONCLUSIONS

### 9.1 CONCLUSIONS ON COMPATIBILITY ON BB-PPDR WIDE AREA NETWORK SPECTRUM OPTIONS

#### 9.1.1 410–430 MHz



**Figure 14: 410-430 MHz range**

This band is suitable for the deployment of BB-PPDR services although limitations apply to ensure protection of military radars and radio astronomy where relevant. The band is not identified in ITU-R for IMT/LTE<sup>20</sup>

##### 9.1.1.1 Summary compatibility studies

The studies show that a BB-PPDR system could be operating in the 410-430 MHz band together with other existing services such as TETRA, Tetrapol, analogue systems and wideband PMR/PAMR, and e.i.r.p. of up to 37 dBm (5 Watts) under certain circumstances (see section 8.1.1.1).

For CDMA-PAMR systems, a frequency guard band could be considered between BB-PPDR and the existing CDMA-PAMR allocation.

Due to limited blocking performance of PMR BSs, BB-PPDR BS may cause performance degradation of the PMR BSs over mean distances of 2.3 km. Therefore deployment of nearby sites will require co-ordination.

In addition, OOB of BB-PPDR BSs should not exceed -43 dBm/100 kHz in the UL band 410-420 MHz in order to not degrade further the performance of PMR BSs.

Due to limited blocking performance of PMR MSs, BB-PPDR BS may cause performance degradation of the PMR MSs over mean distances of 200 m.

OOBE of BB-PPDR BS may also extend the zone up to a mean radius of 2.5 km. In order to ease the co-ordination process and reduce the number of possible interference cases, OOB of PPDR BS should not exceed -43 dBm/100 kHz at frequency offset greater than 1 MHz from BB-PPDR BS band edge. Whenever PPDR and PMR are deployed with smaller offsets, co-ordination may be required.

Coexistence, when operating within the 410-430 MHz band, is possible due to the LTE400 base station (BS) and LTE400 user equipment (UE) duplexers in addition to 3GPP requirements to limit the interference to an

<sup>20</sup> Recommendation ITU-R M.1036-4: Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR) [23]

acceptable level. The duplexers are needed both to fulfil the 3GPP minimum requirements and to ensure the correct behaviour of the LTE400 system itself.

Extremely dense legacy networks may impact the UL capacity of an LTE400 broadband system and may require additional mitigations as specific engineering rules (site co-ordination, additional filtering to improve LTE400 BS adjacent channel selectivity). The LTE duplexers were not considered in the simulations in ECC Report 240 [3].

Finally, the studies also show that the impact of legacy systems on LTE400 is limited.

In the 410-430 MHz band, there are sharing difficulties with radiolocation systems that are deployed and protected at a national level since the required protection zones can reach hundreds of kilometres. The studies indicate that exclusion zones more than 400 km would be required in order to ensure compatibility with radar systems operating in the 420-430 MHz.

Generic compatibility calculations for BB-PPDR activity in the 410-430 MHz band and radio astronomy operating in the 406.1-410 MHz band have shown that physical separation is required between BB-PPDR BS and RAS to achieve compatibility.

The calculated exclusion zones can reach up to 90 km based on a spurious emission limit of -36dBm/100kHz from LTE400 base stations (BS) and can be reduced to 20 km if the spurious emission into the RAS band is limited to -96 dBm/100kHz according to the 3GPP requirement for protection of the base station's own UL band.

Separation distances between the UEs and the radio astronomy stations are about 50 km. Adding the terrain profile to the analysis showed that the attenuation from the geographical terrain does not reduce the separation distances.

#### *9.1.1.2 Impact on other services*

This band is in many countries heavily used by existing licensed services. BB-PPDR in the band 410-430 MHz reduces the amount of spectrum available for other services (e.g. PMR, TETRA or Tetrapol) within this frequency range.

BB-PPDR BS may cause performance degradation of the PMR BSs over mean distances of 2.3 km. Therefore deployment of nearby sites will require co-ordination. In addition, OOB of BB-PPDR BSs should not exceed -43 dBm/100kHz in the UL band 410-420 MHz in order to not degrade further the performance of PMR BSs.

In the 410-430 MHz band, there are sharing difficulties with radiolocation systems that are deployed and protected at a national level since the required protection zones can reach hundreds of kilometres. The studies indicate that exclusion zones more than 400 km would be required in order to ensure compatibility with radar systems operating in the 420-430 MHz. Co-channel operation between BB-PPDR and military radars is not possible, while exclusion zones may be needed for adjacent channels operation. Additional PPDR filtering may help to reduce the exclusion zones.

RAS stations operating in the band 406.1-410 MHz can also not co-exist without having large exclusion zones for PPDR (see section 9.1.1.1 above).

#### *9.1.1.3 Impact of national choices*

The frequency cross-border exercise co-ordination is simplified by the fact that BB-PPDR and PMR will use the same direction of transmission (i.e. no base station to base station interference). Examples of successful co-ordination between wideband and narrowband networks exist for this frequency range. Note that not all CEPT countries are aligned in their band plans in this frequency range.

Harmonisation of the BB-PPDR spectrum would allow easier cross-border co-ordination where neighbouring countries are using the same portion of the band. It is therefore proposed to aim to identify preferred portion (e.g. a 5 MHz duplex block).

9.1.2 450-470 MHz

This band is suitable for the deployment of BB-PPDR services.

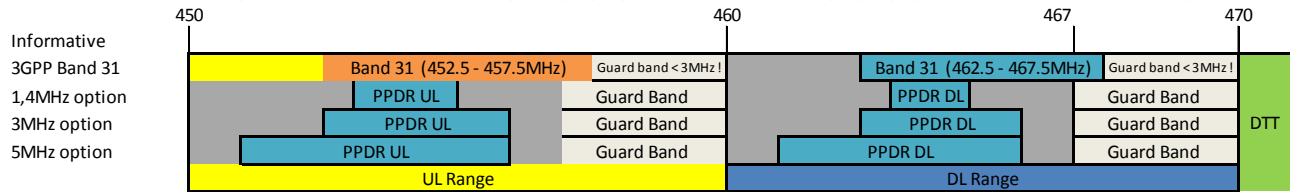


Figure 15: 450-470 MHz range examples

The centre frequencies of the above may be shifted within the band based on national circumstances. BB-PPDR within the 452.5-457.5/462.5-467.5MHz can be used to benefit from existing conditions of 3GPP band 31 however it should be noted that this has not been studied and may cause interference for countries where channel 21 is used for DTT. Therefore the spectrum range 450-457/460-467MHz should be given high priority in the forthcoming work on the ECC harmonisation deliverable for BB-PPDR.

9.1.2.1 Summary compatibility studies

As for the 410-430 MHz band, the studies show that compatibility with existing services (TETRA, Tetrapol, Analogue FM, CDMA-PAMR) can be achieved under certain circumstances (see section 8.1.1.1) including high power UEs.

The results of the theoretical coexistence analyses with DTT demonstrate interferences from the BB-PPDR LTE400 system to DTT reception when the BB-PPDR system is adjacent in the frequency domain to the lower DTT Channel, i.e. Channel 21. Nevertheless, the risk of interference can be reduced by at a set of technical measures including a guard band<sup>21</sup> of up to 3 MHz between DTT and BB-PPDR BSs and an appropriate limit of the corresponding BB-PPDR BS out-of-band emissions. Furthermore additional mitigation measures may be required to solve possible residual interference from PPDR BSs on a case by case basis in a manner similar to the situation between LTE800 and DTT. BB-PPDR LTE400 Base Station OOB e.i.r.p. levels for protection of DTT above 470 MHz are given in Table 3 in section 8.1.1.4 of the present report.

The conducted Monte-Carlo simulations in ECC Report 240 [3] have demonstrated limited interferences to DTT for high power UE (37 dBm) with improved ACLR (79 dB, i.e. OOB of -42 dBm/8 MHz) in Channel 21.

Local interference analyses and field measurements, where BB-PPDR UEs are operating in the vicinity of DTT, have demonstrated that despite the aforementioned measures and because of the limited DTT receiver selectivity UE using higher powers may still interfere a DTT receiver located in regions / countries where DTT Channel 21 is in use, especially when vertically polarised DTT antennas are used (no orthogonal discrimination between BB-PPDR transmitter and DTT receiver antennas). In case interferences are observed or anticipated, they can be solved locally by a power reduction of BB-PPDR UE through signalling or network planning.

Also, BB-PPDR UE blocking capability has to be improved to limit the risk of interference from DTT Channel 21.

Administrations may need to do some further studies to understand the risk of interference for their individual national circumstances. They may also decide that it is appropriate to provide external filters to households in vulnerable DTT areas where there is a risk of interference due to the selectivity of the DTT receivers. This potential solution would not mitigate any risk of interference due to the out-of-band emissions of the handsets.

<sup>21</sup> It should be noted that some administrations apply smaller guard band for legacy systems.

### 9.1.2.2 Impact on other services

This band is in many countries heavily used by existing licensed services. An introduction of BB-PPDR in 450-470 MHz band would reduce the amount of spectrum available for these services (e.g. PMR, TETRA or Tetrapol) within this frequency range.

BB-PPDR BS may cause performance degradation of the PMR BSs over mean distances of 2.3 km. Therefore deployment of nearby sites will require co-ordination. In addition, OOB of BB-PPDR BSs should not exceed -43 dBm/100kHz in the UL band 450-460 MHz in order to not degrade further the performance of PMR BSs.

OOB of BB-PPDR BS may also extend the zone up to a mean radius of 2.5 km. In order to ease the co-ordination process and reduce the number of possible interference cases, OOB of PPDR BS should not exceed -43 dBm/100kHz at frequency offset greater than 1 MHz from BB-PPDR BS band edge. Whenever PPDR and PMR are deployed with smaller offsets, co-ordination may be required.

Depending on where in the band BB-PPDR is located, the required minimum guard band towards DTT may introduce restrictions on the usage of Channel 21 for DTT. Some countries also use this frequency band, or parts of it, for commercial mobile broadband using CDMA2000 or LTE technology. The maximum output power of BB-PPDR terminals has to be limited in order to limit the interference to DTT.

### 9.1.2.3 Impact of national choices

The frequency cross-border exercise co-ordination is simplified by the fact that BB-PPDR and PMR will use the same direction of transmission (i.e. no base station to base station interference). Examples of successful co-ordination between wideband and narrowband networks exist for this frequency range. Note that not all CEPT countries are aligned in their band plans in this frequency range.

Harmonisation of the BB-PPDR spectrum would allow easier cross-border co-ordination where neighbouring countries are using the same portion of the band. It is therefore proposed to aim to identify preferred portion (e.g. a 5 MHz duplex block).

For the PPDR vehicular UEs, additional conditions may be required (e.g. improvement of RF filtering or reduction of the transmit power).

### 9.1.3 MFCN band plan (700 MHz Option A)

Note: PPDR usage could be anywhere within the harmonised MFCN band plan using a 55 MHz duplex spacing.

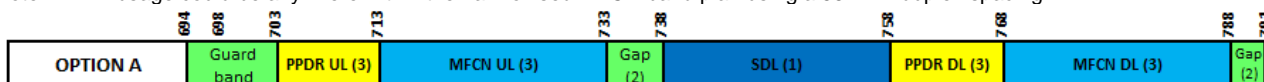


Figure 16: Option A

#### Notes in Figure 16:

- (1) CEPT Report 53 considers alternative options (M2M, SDL, PMSE, BB-PPDR) for this part of the band and these have been listed in ECC/DEC/(15)01. The SDL option is one of them and uses zero up to four blocks of 5 MHz. Thus this approach provides flexibility for combining different options.
- (2) CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with PPDR could be explored in the 733-736 MHz and 788-791 MHz.
- (3) BB-PPDR usage could be anywhere within the harmonised MFCN band plan using a 55 MHz duplex spacing.

Technical conditions for the use of BB-PPDR in the MFCN band shall be in line with ECC/DEC/(15)01 [8] and CEPT Report 53 [9].

### 9.1.3.1 Summary compatibility studies

The compatibility between MFCN and PPDR networks is as between two MFCN networks under the assumption that the BB-PPDR network has same performance requirements and similar topology as a commercial network. BB-PPDR UE radio modules proving sufficient receiver performance, e.g. through the

introduction of improved RF filtering compared to 3GPP requirements, would ensure operation in a sparse network when adjacent in frequency to a dense commercial network.

Another phenomenon is the 3<sup>rd</sup> order intermodulation due to DL operations by two different MFCN networks may appear in BB-PPDR band, if this happens, the PPDR operator should accept this type of interference.

**9.1.3.2 Impact on other services**

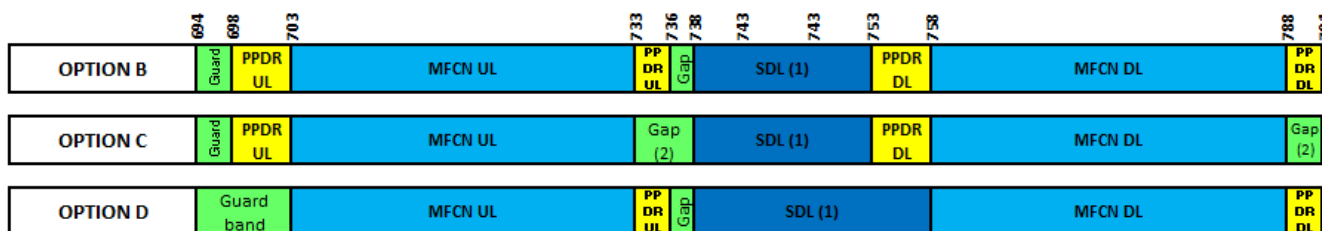
By using parts of the harmonised MFCN spectrum for BB-PPDR services, the amount of spectrum available for commercial mobile broadband is reduced correspondingly or capacity on the given MFCN network reduced for public services.

BB-PPDR within the MFCN band has existing regulation in place (ECC/DEC/(15)01 [8]). CEPT Report 53 [9] in response to the 700 MHz mandate [11] sets out the preferred technical arrangement and LRTC for MFCN used by BB-PPDR services that can make use of such technical conditions provided that the implementation is in line with the assumptions made for MFCN networks

**9.1.4 Combination of 2x3 MHz and 2x5 MHz (700 MHz Option B)**

The Option B is the combination of Option C (2x5 MHz in 698-703/753-758 MHz) and Option D (2x3 MHz in 733-736/788-791 MHz) as described in the following sections 9.1.5 and 9.1.6 respectively, and resulting to a combined bandwidth of 2x8 MHz.

By designating the 2 x 5 MHz for PPDR, the total frequency spectrum that could be used for SDL is reduced from 4 to 3 blocks in a given area. By allocating in addition 2x3 MHz for PPDR, M2M would not be possible nationally.



**Figure 17: Options B, C and D**

**Notes in Figure 17:**

(1) CEPT Report 53 [9] considers alternative options (M2M, SDL, PMSE, BB-PPDR) for this part of the band and these have been listed in ECC/DEC/(15)01 [8]. The SDL option is one of them and uses zero up to four blocks of 5 MHz. Thus this approach provides flexibility for combining different options.

(2) CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with PPDR could be explored in the 733-736 and 788-791 MHz.

Dedicated BB-PPDR spectrum included in Option B should be given high priority in the forthcoming work on the ECC harmonisation deliverable for BB-PPDR.

**9.1.5 2x5 MHz (700 MHz Option C)**

**9.1.5.1 Summary compatibility studies**

The compatibility between MFCN and BB-PPDR networks is as between two MFCN networks under the assumption that the BB-PPDR network has same performance requirements and similar topology as a commercial network. BB-PPDR UE radio modules proving sufficient receiver performance, e.g. through the introduction of improved RF filtering compared to 3GPP requirements, increasing BB-PPDR UE adjacent selectivity (from 33 to 41 dB), would ensure operation in a sparse network when adjacent in frequency to a dense commercial network.

Another phenomenon is the 3<sup>rd</sup> order intermodulation due to DL operations by two different MFCN networks may appear in BB-PPDR band, if this happens, the PPDR operator should accept this type of interference.

Studies in ECC Report 239 [2] look at the compatibility between PPDR networks using MFCN LTE-based technologies in the 700 MHz range and DTT below 694 MHz. Studies have shown that the most critical compatibility analysis with DTT Networks is for PPDR UE use in the 698-703 MHz band. These studies also looked at a number of different scenarios with different assumptions looking at PPDR UEs operating within the 698-703 MHz band and the technical feasibility of PPDR UEs implementing appropriate filtering to meet the proposed unwanted emission levels.

From the results of the studies presented it appears that a reasonable solution would be to recommend unwanted emission levels for BB-PPDR UE of -42 dBm/8 MHz for the protection of DTT below 694 MHz. This would provide an adequate level of protection for DTT. The cumulative effect of unwanted emission from both BB-PPDR UEs and MFCN UEs was not studied in ECC Report 239 [2].

Some studies show the potential for relaxed values of unwanted emission levels for BB-PPDR UEs operating in the 698-703 MHz block.

Simulations have shown that UEs with 4 MHz guard band, operating at temperatures above +35°C, may have limitations regarding the technical feasibility of implementing appropriate filtering to meet the unwanted emission limit of -42 dBm/8 MHz below 694 MHz.

Taking into account temperature drift and to address the feasibility problems highlighted above for these BB-PPDR UEs to meet the -42 dBm/8 MHz limit a different level is considered for such BB-PPDR UEs under extreme environmental conditions for equipment conformance tests. When reviewing these levels the unwanted emission level of a BB-PPDR UE operating in the 698-703 MHz block in extreme environmental conditions for equipment conformance tests should not exceed -30 dBm/8 MHz. Measured maximum unwanted emission levels of existing MFCN UEs operating in the 700 MHz range in extreme operating conditions are provided in the studies.

The maximum mean in-block power for BB-PPDR terminals is assumed to be 23 dBm to avoid blocking.

The BB-PPDR Base Station receiver may be subject to interference from DTT transmitters using channel 48 and located in the vicinity. Under the GE06 agreement [27] current broadcast networks were not designed to, and may not be able to provide protection for adjacent channel BB-PPDR base station receivers in some cross border situations. The desensitisation of the BB-PPDR base station receiver can be significant depending on the distance between the two sites and on the transmission and receiving characteristics.

In that case BB-PPDR base station receiver should implement appropriate filtering of DTT in-band emissions. Additionally mitigation techniques would reduce the risk of interference from DTT transmitters using channel 48 into BB-PPDR base station receivers on a case by case basis. Possible mitigation techniques include: down tilting the BB-PPDR antenna, fine-tuning antenna orientation and implementing link budget margins by increasing the BB-PPDR network density.

#### *9.1.5.2 Impact on possible future services*

CEPT Report 53 [9] and ECC/DEC/(15)01 [8] contain information on other possible use (SDL, M2M, PMSE, PPDR) in the band 738-758 MHz. Administrations are therefore invited to consider the impact to and from PPDR services. This option would allow 1 block for BB-PPDR and up to 3 blocks for SDL.

By allocating the 2x5 MHz for BB-PPDR, the total frequency spectrum that could be licensed for SDL is reduced from 4 to 3 blocks in a given area.

### **9.1.6 2x3 MHz (700 MHz Option D)**

#### *9.1.6.1 Summary compatibility studies*

Compatibility between BB-PPDR UL and SDL (MFCN Supplemental Downlink) depends on the scenario which is targeted. It is feasible for an SDL BS to fulfil the out-of-block power limit defined in ECC/DEC/(15)01

[8] towards BB-PPDR UL in 733-736 MHz, assuming a 15 dBi antenna gain. There is no blocking requirement for BB-PPDR UL Rx in the ECC Decision and thus the BB-PPDR BS Rx filter was not analysed for this scenario. However, it is recognised that the BB-PPDR BS Rx filter is needed.

If the 3GPP minimum requirements for coexistence are to be fulfilled, it is feasible to create SDL Tx and BB-PPDR BS Rx filters with enough rejection. However, the insertion loss in BB-PPDR UL will be higher than standard. In the case of co-location between PPDR and SDL, then more than 2 MHz separation is needed. The exact level of guard-band beyond 2 MHz for site solutions with external filters has not been investigated in ECC Report 239 [2]. Another way to manage co-location may be to rely on different site solutions, e.g. by using appropriate antenna physical separation.

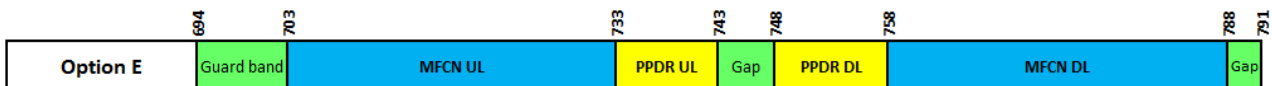
The compatibility between MFCN and BB-PPDR networks is as between two MFCN networks under the assumption that the BB-PPDR network has same performance requirements and similar topology as a commercial network. BB-PPDR UE radio modules proving sufficient receiver performance, e.g. through the introduction of improved RF filtering compared to 3GPP requirements, increasing BB-PPDR UE adjacent selectivity (from 33 to 41 dB), would ensure operation in a sparse network when adjacent in frequency to a dense commercial network.

Another phenomenon is the 3<sup>rd</sup> order intermodulation due to DL operations by two different MFCN networks may appear in BB-PPDR band, if this happens, the PPDR operator should accept this type of interference.

**9.1.6.2 Impact on possible future services**

CEPT Report 53 [9] and ECC/DEC/15(01) [8] contain information on other possible use (SDL, M2M, PMSE, BB-PPDR) in the 738-758 MHz band. Administrations are therefore invited to consider the impact to and from BB-PPDR services. This option would allow 1 block for BB-PPDR and up to 3 blocks for SDL in 743-758 MHz. M2M would not be possible nationally according to CEPT Report 53.

**9.1.7 Use of 2x10 MHz for BB-PPDR with 15 MHz duplex spacing in the MFCN duplex gap (Discarded 700 MHz Option E)**



**Figure 18: Discarded Option E**

**9.1.7.1 Summary compatibility studies**

It is shown in ECC Report 239 [2] that BB-PPDR 2x10 MHz in the MFCN duplex gap is not feasible. Compatibility of BB-PPDR 2x(2x5) MHz in the duplex gap with MFCN may be achieved. Compatibility with DTT is insured due to the large frequency separation. However, this option suffers from limitations, such as:

- Severe self-desensitisation of the BB-PPDR UE downlink;
- UE-UE interference;
- Cross-border co-ordination with SDL.

If the same technical conditions as used for MFCN applies then compatibility with other services (e.g DTT) is ensured.

Option E is not considered for inclusion in an ECC harmonisation deliverable for BB-PPDR.

**9.1.7.2 Impact on possible future services**

CEPT Report 53 [9] and ECC/DEC/(15)01 [8] contain information on other possible use (SDL, PMSE, M2M) in the band 733-758 MHz. Administrations are therefore invited to consider the impact to and from BB-PPDR services. This option would allow 4 blocks, which is the required target of 2x10 MHz according to ECC Report 199 [1] for BB-PPDR in the duplex gap. Compared to the 700 MHz Option A, the implementation of other national options such as SDL and M2M would consequently not be possible



Furthermore, cross-border co-ordination will be complex where one country deploys SDL and the other deploys BB-PPDR since the band 738-743 MHz will be used in opposite direction which could lead to interference from SDL base station to BB-PPDR base station over a long distance. Distances of 100 km for land paths and up to 600 km for sea paths are identified in the ECC Report 239 [2].

### 9.1.8 Combination of MFCN and dedicated spectrum band plan (700 MHz Option F)

This option is a combination of Option A (only 2x5 MHz) and Option C.

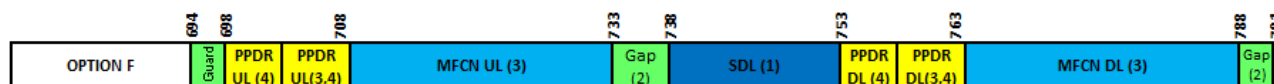


Figure 19: Option F

#### Notes in Figure 19

(2) CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with PPDR could be explored in the 733-736 MHz and 788-791 MHz.

(3) BB-PPDR usage could be anywhere within the harmonised MFCN band plan using a 55 MHz duplex spacing.

(4) The use of the 2x2x5 MHz into a combined 10 MHz duplex channel arrangement in 698-708 MHz paired with 753-763 MHz has not been studied.

## 9.2 CONCEPT OF “FLEXIBLE HARMONISATION” FOR BB-PPDR

This Report proposes the concept of “flexible harmonisation” to enable an efficient implementation of Broadband Public Protection and Disaster Relief (BB-PPDR) within CEPT. This includes three major elements:

- common technical standard (i.e. LTE and its evolutions);
- national flexibility to decide how much spectrum and which specific frequency ranges should be designated for BB-PPDR networks within harmonised tuning range(s), according to national needs;
- national choice of the most suitable implementation model (either dedicated, commercial or hybrid).

## 9.3 TECHNOLOGY ASPECTS

The PPDR user community has stated that BB-PPDR, from a technical standard point of view, wants to be part of the global LTE ecosystem because of several advantages including for example, a wider choice of terminals, potentially lower equipment prices, costs for chipsets and duplex filters, benefits derived from economies of scale achieved in commercial networks and the commitment to develop mission critical capabilities into the standard. In addition, other benefits include possible roaming<sup>22</sup> over commercial networks and long term further developments. The work on developing the LTE technology to support the BB-PPDR specific functionalities has already started in 3GPP, ETSI and other international organisations with wide support from the mobile industry and involvement of the PPDR stakeholders. It is expected to take several years before those functions that the PPDR community has identified as key features have been fully specified, implemented, tested and integrated into the LTE solutions from most infrastructure and terminal suppliers.

## 9.4 NETWORK IMPLEMENTATION MODELS

The BB-PPDR services could generally be provided by means of three infrastructure implementation models. These models are:

- **Dedicated network infrastructure for BB-PPDR**

<sup>22</sup> Roaming = End User radio terminal equipment can obtain mobile communication services under coverage of another radio communication network (the “visited network”).

A mobile broadband network (either owned by the government or contracted operator) dedicated to providing service to BB-PPDR users to meet their specific requirements (coverage, support of special broadband applications, resilience, security etc.).

- **Commercial network(s) infrastructure**

A BB-PPDR service provided by one or several commercial mobile network operators over networks carrying both PPDR and commercial traffic. Additional BB-PPDR specific requirements may need to be negotiated.

- **Hybrid solutions with partly dedicated and partly commercial network infrastructure**

There are several possible variants of hybrid models that could be implemented of which some of them are further described in section 5 in this Report.

## 9.5 INTEROPERABILITY AND CROSS-BORDER COMMUNICATIONS

European countries are to a growing extent experiencing the need to give and receive PPDR assistance within areas of international crime and trafficking, near border accidents, VIP protection during international summits, illegal immigration, natural disasters, terror attacks and similar para-military events.

The following EU deliverables, which are relevant for interoperability and cross-border communications, were considered during the development of this ECC Report:

- a) The Council of the European Union adopted a Recommendation on improving radio communication between operational units in border areas in 2009 [6];
- b) The European Union Decision on *Multi-annual Radio Spectrum Policy Programme (RSPP)* (Decision 243/2012/EU [5] of the European Parliament and of the Council) specifically addresses in its article 8.3 the need for interoperable solutions for public safety and disaster relief.

Different national choices within CEPT will require, within an implementable tuning range, multi-band BB-PPDR user equipment that can be used in either dedicated, commercial or hybrid LTE networks.

The required level of interoperability is to be realised on multiple layers through the availability of multi-band PPDR user equipment (UE), the adoption of common technical standards (i.e. LTE and its evolutions), utilising different PPDR network types (dedicated, commercial or hybrid networks), and also by standard conformance and interoperability specifications.

Due to the above, it is not required to designate a single frequency band for BB-PPDR.

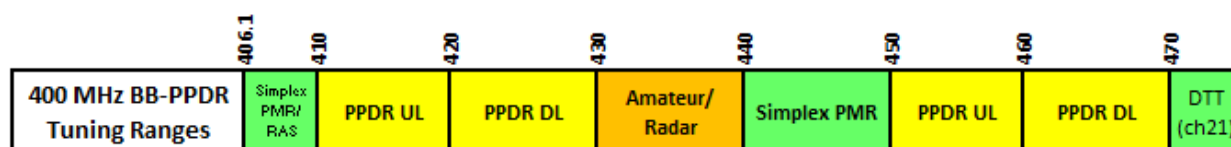
## 9.6 CANDIDATE BB-PPDR FREQUENCY RANGES FOR HARMONISATION

### Spectrum options for Wide Area Networks

The following spectrum ranges have been identified for the optional implementation of BB-PPDR services in CEPT countries:

#### 9.6.1 400 MHz (410-430 MHz and 450-470 MHz)

The following tuning ranges for BB-PPDR Uplinks (UL) and Downlinks (DL) have been considered within the 400 MHz range (duplex spacing is always 10 MHz):



**Figure 20: 400 MHz BB-PPDR tuning range and other primary use**

1. The 400 MHz range does not provide enough available spectrum to provide a stand-alone solution in CEPT countries requiring 2x10 MHz for BB-PPDR as calculated in ECC Report 199 [1];
2. The 400 MHz range can offer national flexibility, e.g. in the context of additional spectrum beside the 700 MHz range;
3. Tuning Range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation);
4. 1.4 MHz, 3 MHz, and 5 MHz LTE FDD channelling arrangements could be implemented in the paired frequency arrangements in 410-420/420-430 MHz and/or 450-460/460-470 MHz;
5. The 400 MHz range has the advantage of very good propagation characteristics, potentially reducing the number of sites needed to provide the necessary coverage (rural areas);
6. Cross-border co-ordination guidance is required for the 410-430 MHz and 450-470 MHz bands prior to BB-PPDR deployment;
7. The radio astronomy service in 406.1-410 MHz may require protection zones in some countries, if 410-430 MHz is used by BB-PPDR;
8. In the 410-430 MHz band, there are sharing difficulties with radiolocation systems that are deployed and protected at a national level since the required protection zones can reach hundreds of kilometres;
9. The risk of interference between BB-PPDR and DTT can be reduced by a set of technical measures including a guard band<sup>23</sup> of up to up to 3 MHz between DTT and BB-PPDR BSs and an appropriate limit of the corresponding PPDR BS out-of-band emissions.

#### 9.6.2 700 MHz (694-791 MHz)

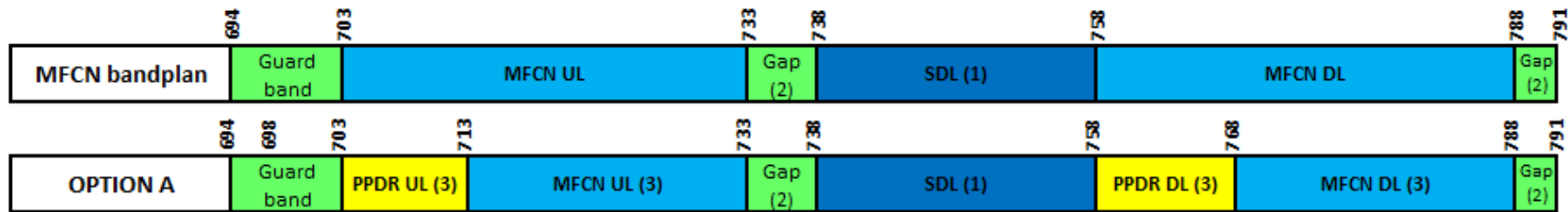
1. BB-PPDR can be accommodated within the 700 MHz range by either designating spectrum for dedicated BB-PPDR, use of commercial MFCN<sup>24</sup> or a combination of two (hybrid) as necessary to fulfil national PPDR requirements. Therefore, the 700 MHz range can be considered as a potential stand-alone solution for the BB-PPDR requirements as calculated in ECC Report 199 [1];
2. Tuning range and associated LRTC should be included in an ECC harmonisation deliverable (ECC Decision or Recommendation). Harmonised technical requirements for the use of MFCN in the 700 MHz range (703-733 and 758-788 MHz) already exist in ECC/DEC/(15)01 [8];
3. Cross-border co-ordination needs to be addressed for the 700 MHz range BB-PPDR options, also with regard to the possible implementation of other use (MFCN and non-MFCN) in neighbouring countries.

<sup>23</sup> It should be noted that some administrations apply a smaller guard band for legacy systems.

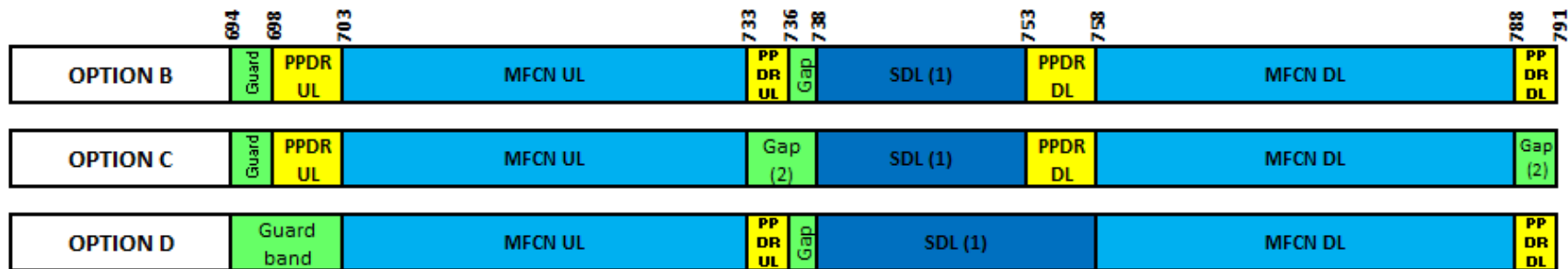
<sup>24</sup> For those countries opting for a commercial or hybrid BB-PPDR solution, any MFCN band harmonised in CEPT may also be used for BB-PPDR meeting the specified requirements (see 5.2.2). Such use is also subject to BB-PPDR equipment roaming capabilities.

The following options have been considered within the 700 MHz range:

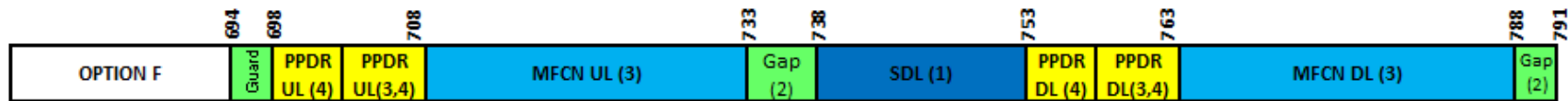
**PPDR in spectrum harmonised for MFCN (ECC/DEC(15)01)**



**PPDR dedicated spectrum:**



**PPDR in a combination of MFCN and dedicated spectrum:**



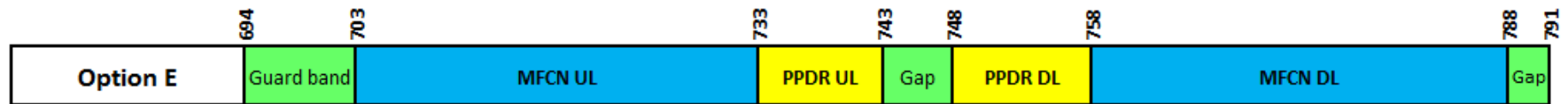
**Figure 21: 700 MHz PPDR Options**

Notes in Figure 21:

- (1) CEPT Report 53 [9] considers alternative options (M2M, SDL, PMSE, BB-PPDR) for this part of the band and these have been listed in ECC//DEC/(15)01 [8]. The SDL option is one of them and uses zero up to four blocks of 5 MHz. Thus this approach provides flexibility for combining different options.
- (2) CEPT Report 53 considers Machine to Machine (M2M) as an alternative national option for 733-736 MHz UL / 788-791 MHz DL. Synergies with PPDR could be explored in the 733-736 and 788-791 MHz.
- (3) BB-PPDR usage could be anywhere within the harmonised MFCN band plan using a 55MHz duplex spacing.
- (4) The use of the 2x2x5 MHz into a combined 10 MHz duplex channel arrangement in 698-708 MHz paired with 753-763 MHz has not been studied.

All the above options use a duplex spacing of 55 MHz.

## 9.7 DISCARDED OPTION E



**Figure 22: Discarded Option E**

This option uses a 15 MHz duplex spacing (2x10 MHz) and may be divided into 2x(2x5) MHz. It suffers from technical issues (see section 9.1.7), has received insufficient support (see FM49(15)44 Annex 5 [26] summary of cover letter) and is not considered for inclusion in an ECC harmonisation deliverable for BB-PPDR.

## **9.8 CROSS-BORDER FREQUENCY CO-ORDINATION**

The current version of ERC/REC T/R 25-08 [12] on the planning criteria and co-ordination of frequencies in the land mobile service in the range 29.7-921 MHz does not address land mobile systems with channel bandwidths greater than 1.25 MHz and therefore does not provide guidance to administrations on frequency co-ordination for BB-PPDR. However, it provides the duplex arrangement for the bands 410-420/420-430 MHz and 450-460/460-470 MHz in its Annex 1.

Cross-border co-ordination guidance is required for BB-PPDR in the 410-430 MHz and 450-470 MHz bands prior to deployment.

At the point of time when the present ECC Report 218 was published a revised draft version of ECC/REC/(15)01 [22], containing also field strength levels for the cross-border co-ordination for the 694-790 MHz frequency band for MFCN, had been in the CEPT public consultation phase. This Recommendation could be used as a basis for deriving field strength levels for the cross-border co-ordination for the 700 MHz range for BB-PPDR.

## **9.9 OTHER USE CASES (CRITICAL VOICE, OFF-NETWORK WORKING, AIR-GROUND-AIR AND AD-HOC NETWORKS)**

The main conclusion of ECC Report 199 [1] is that a minimum amount of spectrum in the range of 2x10 MHz is needed for broadband data communications in the future European BB-PPDR wide area networks (WAN). However there could be additional spectrum requirements on a national basis to cater for direct terminal to terminal communications (off-network working), Air-Ground-Air (AGA), ad-hoc networks and critical voice communications over the WAN.

While the same frequencies as for the WAN could be used for direct terminal to terminal communications and ad-hoc networks. ECC Report 199 does neither provide an indication on alternative options nor a solution for future BB-PPDR AGA systems.

The results of the spectrum calculations in ECC Report 199 should be seen as an assessment based on current knowledge. The results should be rather rated as the minimum needed amount of spectrum for future European BB PPDR systems without however excluding any spectrum options to be examined.

If the 700 MHz range is to be used for BB-PPDR direct terminal to terminal communications, it would require further harmonisation and standardisation measures.

The assumption is that mission critical voice will continue to be carried in most CEPT countries by the existing dedicated mission critical voice (and narrowband data) TETRA and Tetrapol networks until 2025-2030. The duplex bands 380-385/390-395 MHz have been designated for such PPDR networks in ECC/DEC/(08)05 [7]. However, in some CEPT countries, PPDR agencies could migrate all of their mission critical voice and data services on to network(s) using broadband technology such as LTE in a shorter timescale than those quoted above.

## ANNEX 1: EXTRACT FROM A TCCA STUDY [25] “MOBILE BROADBAND FOR CRITICAL COMMUNICATIONS USERS” (2013)

### A1.1 OTHER HYBRID APPROACHES

#### A1.1.1 Introduction

Within the previous approaches there are a number of hybrid approaches. These are illustrated in the following table.

**Table 5: Advantages and disadvantages of hybrid approaches**

Description	Advantages	Disadvantages
<b>Take service from standard commercial networks</b> , but fund network enhancements on coverage and resilience	<ul style="list-style-type: none"> <li>▪ Network can be engineered to meet some of the Critical Communications key requirements.</li> <li>▪ Lower CAPEX and OPEX</li> </ul>	<ul style="list-style-type: none"> <li>▪ May be classified as State Aid.</li> <li>▪ Forces a long term arrangement with one MNO.</li> <li>▪ May need governmental investment in all MNO networks and lost investment if MNOs merge</li> </ul>
<b>Take service from Commercially Owned Dedicated Network</b> , but allow operator to sell excess capacity to commercial users	<ul style="list-style-type: none"> <li>▪ Economies of scale improve for the network operator, with more viable business case</li> <li>▪ Easier for Public Safety users to justify spectrum</li> <li>▪ Attractive high quality network for professional commercial users with premium rate possibility</li> <li>▪ No CAPEX and Lower OPEX</li> </ul>	<ul style="list-style-type: none"> <li>▪ Some loss of control once the network has commercial users</li> <li>▪ Commercial users may be hesitant to move to network, if they know their service may be degraded during an incident</li> <li>▪ May be difficult to control if all resources are available for Critical Communications users</li> </ul>
<b>Build Own Dedicated Network</b> , but outsource operation of the network	<ul style="list-style-type: none"> <li>▪ Allow an external more focussed and capable organisation to operate and manage the network</li> <li>▪ Lower OPEX</li> </ul>	<ul style="list-style-type: none"> <li>▪ Need to form a commercial long term arrangement with a suitable operator</li> <li>▪ Operator will charge for service</li> <li>▪ Higher CAPEX</li> </ul>
<b>Build dedicated network</b> but share network elements with commercial operators. i.e. share towers and backhaul but add own radio access network.	<ul style="list-style-type: none"> <li>▪ Reduces CAPEX requirements</li> <li>▪ Eases planning and site building requirements</li> <li>▪ Reduces network management costs</li> <li>▪ Lower CAPEX and OPEX</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increases reliance on commercial operator</li> <li>▪ Coverage may not be tailored to Critical Comms users' requirements</li> <li>▪ Network resilience may be compromised</li> </ul>

## ANNEX 2: EXAMPLES OF LEGAL REQUIREMENTS IMPOSED ON THE OPERATOR BY THE GOVERNMENTAL AUTHORITY IN THE CONTRACT (SOURCE: TCCA)

### A2.1 MOST STRINGENT

**Parent Company guarantee/Performance Bond:** (i) PCG – The supplier’s parent company agrees to meet the supplier’s financial and/or performance obligations should the supplier fail to do so. (ii) PB – The supplier provides the government customer with a performance bond usually valued at between five and 10 percent of the contract price. The government customer can redeem the bond if the supplier fails to meet its contractual obligations (even if the financial costs of the failure are lower than the value of the bond). Both are standard in government customer contracts.

**Intellectual Property:** The government customer is to own the rights in any new, project-specific intellectual property developed by the supplier. Often a non-negotiable requirement of the customer. This is a standard approach.

**Liability:** Government customer contracts may specifically exclude a waiver of consequential and indirect damages, and the overall liability cap may be in excess of contract value. Losses for breach of the confidentiality provisions may be uncapped altogether. Light breaches will in some countries result in liabilities in the order of 500 M€ and in other cases be fully uncapped. Standard provision in many jurisdictions.

**Open Book Accounting:** The government customer has access to the supplier’s financial records in order to see any reduction in the supplier’s costs in performing the contract. If costs have reduced, the supplier and government customer will split the “profit”. Sometimes the split is 50/50 although it is not uncommon for the government customer to receive the majority of any such profit. Provision is becoming more common.

**Most Favoured Customer:** The government customer must have the best price. The supplier cannot sell the same (or similar) products and services to another customer at prices lower than those paid by the government customer. Reasonably frequent, but not a standard provision.

### A2.2 MODERATELY STRINGENT

**Step-in:** The government customer has the right to take over the performance of the contract in certain circumstances. For example, where the supplier suffers an insolvency event (e.g. insolvency, arrangement with creditors, etc) or commits a material breach of the contract. The supplier is not paid during step-in, and may also have to meet the government customer’s additional costs associated with step-in. The government customer may hand back the services to the supplier, or terminate the contract. Provision is becoming more common.

**Termination:** The government customer has extensive rights to terminate, often including termination for convenience. Whereas the supplier will only be permitted to terminate in very limited circumstances (for example, protracted failure to pay undisputed fees). Standard provision.

**Change of Control:** A change of control of the supplier will be subject to the government customer’s approval, which often may be withheld at the customer’s absolute discretion. In some instances, changes of control are prohibited altogether. Standard provision.

**Financial Strength:** The supplier is required to show financial strength on a regular, ongoing basis. If the supplier’s financial strength diminishes, the government customer may terminate the contract. Provision is becoming more common.

**Control over performance:** This is typically very stringent in government contracts – the government customer takes a more involved role than is usual in other contracts, for example in testing and acceptance procedures. In our experience, government customers are slower and less inclined to approve and accept



elements of a project than commercial customers, resulting in delayed payment to the supplier. Standard approach.

**Liquidated Damages/Service Credits:** Although they can vary from contract to contract, LD/SC regimes are, in our experience, often more onerous with government contracts as the government cannot allow or afford the project to fail or be delayed, or services to be compromised. Also see comments regarding force majeure events. Standard provision.

**Force Majeure:** Force Majeure Events are often defined much more narrowly than in commercial contracts. For example, industrial action is usually excluded from government customer contracts (although sometimes permitted if it is nation- or industry-wide). Force Majeure clauses may also include a proviso that, due to the very purpose of the contract (i.e. public safety), a circumstance will not be considered a Force Majeure event if the party invoking that event reasonably ought to have taken into account when the contract was signed. Standard provision.

**Export Control:** A US company is responsible for ensuring its products are not exported to prohibited countries. This responsibility extends to onward sale by the company's customers. Government customers will not accept such restrictions imposed on it by another government. Accordingly, standard export control provisions are routinely excluded from government customer contracts. Standard provision.

**Source Code Escrow:** The supplier must place the system source code into escrow with a third party, at the supplier's cost. The source code can be released to the government customer in specified events such as insolvency of the supplier, breach of contract by supplier, etc. Standard provision.

### A2.3 LEAST STRINGENT

**Assignment:** The supplier is not usually allowed to assign the contract without the government customer's prior consent, which may be withheld at the customer's discretion. Standard provision.

**Security Clearance:** The government customer may require certain supplier employees (e.g. those who have access to certain customer sites) to undergo national security clearance. Standard provision.

**Data:** Recording and retention obligations for data processed under government customer contracts may be subject to specific data protection legislation, which can be quite burdensome. Provision is becoming more common.

**Continuous Improvement:** The supplier must improve the operation of the system over time at no additional cost to the government customer. Reasonably frequent, but not a standard provision.

**Taxes:** Contractual obligation on the supplier to regularly pay its taxes. Failure to do so would amount to breach of contract by the supplier. Standard provision.

**Confidentiality:** Government customers are usually reluctant to agree to standard confidentiality provision, preferring to use their own. Standard provision.



## ANNEX 4: LIST OF REFERENCE

- [1] ECC Report 199 on User requirements and spectrum needs for future European broadband PPDR systems (Wide Area Networks)
- [2] ECC Report 239 on compatibility and sharing studies for broadband PPDR systems operating in the 700 MHz range
- [3] ECC Report 240 on compatibility and sharing studies for the BB-PPDR (BroadBand Public Protection and Disaster Relief) systems operating in the frequency bands 410-430 and 450-470 MHz
- [4] Council of the European Union, 20 May 2009: Council Recommendation on improving radio communication between operational units in border areas
- [5] Decision 243/2012/EU of the European Parliament and of the Council on establishing a multi-annual radio spectrum policy programme (RSPP)
- [6] RSPG Report on Strategic Sectoral Spectrum Needs (doc Document RSPG13-540 (rev2))
- [7] ECC Decision (08)05 on the harmonisation of frequency bands for the implementation of digital Public Protection and Disaster Relief (PPDR) radio applications in bands within the 380-470 MHz range
- [8] ECC Decision (15)01 of 6 March 2015 on Harmonised technical conditions for mobile/fixed communications networks (MFCN) in the band 694-790 MHz including a paired frequency arrangement (Frequency Division Duplex 2x30 MHz) and an optional unpaired frequency arrangement (Supplemental Downlink)
- [9] CEPT Report 53: Report A from CEPT to the European Commission in response to the Mandate "To develop harmonised technical conditions for the 694 -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"
- [10] ITU-R Resolution 646 (Rev.WRC-12) on Public protection and disaster relief
- [11] Defence Research and Defence Canada - Center for Security and Sciences, February 2011: "700 MHz Spectrum Requirements for Canadian Public Safety Interoperable Mobile Broadband Data Communications"
- [12] CEPT ERC Recommendation T/R 25-08 on the planning criteria and co-ordination of frequencies in the Land Mobile Service in the range 29.7-921 MHz
- [13] ECC Recommendation (08)04 The identification of frequency bands for the implementation of Broad Band Disaster Relief (BBDR) radio applications in the 5 GHz frequency range
- [14] ECC Report 110 on Compatibility studies between Broad-Band Disaster Relief (BBDR) and other systems (September 2007);
- [15] Commission Decision 2010/267/EU of 6 May 2010 on harmonised technical conditions of use in the 790-862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union;
- [16] 3GPP TSG SA Meeting #65 – Liaison Statement TD SP-140640 – on 3GPP work organization for Mission Critical Push to Talk
- [17] EC Study SMART 2013/0016 on Use of commercial mobile networks and equipment for mission-critical high-speed broadband communications in specific sectors
- [18] ITU-R Resolution 648 (WRC-12) on Studies to support broadband public protection and disaster relief
- [19] ECC Recommendation (11)10 on Location Tracking Applications for Emergency Services (LAES)
- [20] ETSI Harmonised European Standard EN 302 625 on BBDR (BroadBand Disaster Relief) radio equipment
- [21] ITU-R Resolution 232 (WRC-12) on Use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and related studies
- [22] Draft amended ECC Recommendation (15)01 on Cross-border co-ordination for mobile / fixed communications networks (MFCN) in the frequency bands: 694-790 MHz, 1452-1492 MHz, 3400-3600 MHz and 3600-3800 MHz
- [23] Recommendation ITU-R M.1036-4 on Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)
- [24] FM49(12)057: Radio Communication Expert Group (RCEG) of the Law Enforcement Working Party (Mixed Committee joined by EU- and EFTA Members) of the Council of the European Union (LEWP-RCEG) Letter to ECC, CEPT-FM + CEPT-FM-PT49
- [25] TETRA and Critical Communications Association – first issued in December 2013: The Strategic Case for Mission Critical Mobile, Broadband, a review of the future needs of the users of critical communications

- [26] FM49(15)44 Annex 5: Summary of the responses received to the Cover Letter accompanying the public consultation for the ECC Report 218
- [27] GE06 Agreement, Geneva 2006: Plan modification and notification procedures, adopted by RRC-06, which governs the use of frequencies by the broadcasting service and other primary terrestrial services in the frequency bands 174-230 MHz and 470-862 MHz.