In-band and adjacent bands sharing studies to assess the feasibility of the shared use of the 3.8-4.2 GHz frequency band by terrestrial wireless broadband systems providing local-area (i.e. low/medium power) network connectivity

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ECC Report 358

# Executive summary

This Report supported the work of ECC in response to the Mandate to CEPT on technical conditions regarding the shared use of the 3.8-4.2 GHz frequency band for terrestrial wireless broadband systems providing local-area network connectivity in the Union.

This Report includes in-band and adjacent band studies on the basis of the following scenarios:

1. in-band coexistence:

to ensure protection of fixed satellite service (FSS) and fixed service (FS), including the possibility for their future evolution and development;

for in-band sharing between different WBB LMP networks.

1. adjacent band coexistence:

with Radio altimeters (RA)\* and Wireless Avionics Intra-Communications (WAIC)\*\* on board aircraft in the frequency band 4.2-4.4 GHz;

between MFCN below 3.8 GHz and WBB LMP in 3.8-4.2 GHz band (interference from MFCN to WBB LMP and interference from WBB LMP to MFCN).

\*Studies on RA are provided in a separate ECC Report on [XYZ] [1].

\*\*As parameters for WAIC above 4.2 GHz were not provided, no studies have been performed.

Further, this Report assumes that:

* the locations of WBB LMP base stations are known;
* the locations of FSS receiving Earth stations are known;
* the locations of FS stations are known;
* MFCN below 3.8 GHz is not constrained by WBB LMP above 3.8 GHz.

As FSS below 3.8 GHz is considered to be the same service as above 3.8 GHz, the operation of FSS below 3.8 GHz is covered by the in-band sharing studies in 3.8-4.2 GHz.

This Report includes also a coexistence study between WBB LMP and VLBI Global Observing System (VGOS) stations operating in few CEPT countries, supporting EU interests as part of the European Critical Infrastructure Project Galileo.

Synchronisation of WBB LMP

To note, two WBB LMP technologies have been considered, one based on 3GPP technical specifications and the other based on DECT-2020 NR technical specifications. While both technologies can support unsynchronised operation, synchronisation between different WBB LMP can be only supported for WBB LMP based on 3GPP technical specifications. Synchronised operation of WBB LMP with MFCN below 3800 MHz is only possible for WBB LMP based on 3GPP technical specifications. The study results of these two technologies are presented separately.

Power levels and antenna heights studied for WBB LMP

For the purpose of studies, the following maximum power levels for 3GPP WBB LMP have been defined: low power with 31 dBm/100 MHz EIRP and medium power with up to 49 dBm/100 MHz or up to 51 dBm/100 MHz EIRP. The power level for WBB terminals (Mobile, Nomadic, IoT, Machine, FWA) of 28 dBm EIRP is considered and Power Control activation is obligatory. For DECT-2020 NR the power level is 23 dBm EIRP with a channel bandwidth of 6.912 MHz. For studies involving WBB medium power base stations, a range of antenna heights, up to 30 m above the ground, was studied and for studies involving WBB low power outdoor base stations maximum antenna height of 10 m above ground was studied.

This Report contains studies and relevant analysis on a range of coexistence conditions (including geographical separation frequency separation etc.) depending on a range of agreed WBB LMP parameters (EIRP, antenna height, antenna gain, emission and reception masks, etc.) covering both AAS and non-AAS scenarios for medium power and only non-AAS for low power.

In-band coexistence of WBB LMP with FS and FSS

Regarding FS coexistence, one of the studies shows the importance that real terrain data are taken into account in the coexistence assessments, because real terrain data can not only hinder, but also favour propagation significantly and then affect the maximum separation distances and the excluded areas (exclusion zones) accordingly.

Based on the analyses, it is not possible to define generic technical conditions that guarantee the protection of FS, including its long-term development, but a case-by-case analysis is needed. In addition, due to the large separation distances that may be necessary for coexistence even without considering real terrain data and to the potentially unfavourable impacts of real terrain on separation distances and exclusion areas that are required, coexistence between FS and both low and medium power WBB systems cannot always be managed at national level only but may require cross border coordination on a case-by-case basis and related bilateral or even multilateral agreements among neighbouring countries.

It is also not possible to define generic technical conditions that guarantee the protection of FSS, including its long-term development, but a case-by-case analysis is needed. In addition, due to the large separation distances that may be necessary for coexistence, coexistence between FSS and both low and medium power WBB systems cannot always be managed at national level only but may require cross border coordination on a case-by-case basis and related bilateral or even multilateral agreements among neighbouring countries.

Nevertheless, appropriate mitigation techniques can facilitate coexistence between WBB and FS/FSS systems, both at national level and with the neighbouring countries.

Studies on WBB LMP networks with no synchronisation to other WBB LMP nor to MFCN

For the various type of use-cases there may be various needs of UL/DL resources and different technologies. The studies are mainly based on the following assumptions:

* no synchronisation between WBB LMP local networks in the frequency band 3.8-4.2 GHz;
* no synchronisation between WBB LMP local networks in the frequency band 3.8-4.2 GHz and MFCN networks below 3.8 GHz.

Indoor-only, outdoor-only and outdoor/indoor deployment scenarios have been considered. The analysis of in-band and adjacent band operation demonstrate the feasibility of unsynchronised WBB LMP operation in the frequency band 3.8-4.2 GHz.

Some studies show that for the unsynchronised operation between 3GPP WBB LMP and MFCN (below 3.8 GHz) out of band emission and receiver blocking levels and frequency separation will reduce the need for coordination between WBB LMP and MFCN. The following were investigated:

* 60 MHz frequency separation for WBB MP to accommodate MFCN blocking;
* out of band emission level of -45 dBm/MHz conducted per BS (sector) below 3800 MHz for LP and MP non-AAS BS (sector) and -45 dBm/MHz TRP per BS for MP AAS BS (sector);
* WBB LMP receiver blocking level of -15 dBm below 3800 MHz for wanted signal level: P\_ref\_sens +6 dB.

In addition to the above technical conditions, studies identified possible components for coordination process to ensure co-existence between WBB LMP and MFCN (below 3.8 GHz) e.g.:

* Pfd or field strength values at the WBB LMP local area network coverage border;
* separation distance between WBB LMP and MFCN Macro BSs;
* synchronisation or semi-synchronisation between MFCN and WBB LMP networks.

Adjacent channel coexistence for WBB LMP networks with synchronisation to other WBB LMP and MFCN

Adjacent channel coexistence between synchronized WBB LMPs networks, when operating based on 3GPP technical specifications, is considered covered by 3GPP/ETSI standardisation and thus is not studied in this Report. This assumption also accounts for adjacent channel operation of these WBB LMP networks in the frequency band 3.8-4.2 GHz synchronised with MFCN below 3.8 GHz. Such synchronized coexistence scenarios across the frequency band 3.4-4.2 GHz for non-AAS scenario takes part of possible coordination solutions for WBB LMP based on 3GPP technical specifications.

Semi-synchronised operation of WBB LMP

Studies were also performed for semi-synchronised operation with DL to UL modifications for WBB LMP operating based on 3GPP technical specifications, showing that it can ensure the same protection of MFCN base stations below 3.8 GHz as synchronised operation. This approach could be considered on a case-by-case basis. It could better facilitate coexistence with some limitations on UL/DL sequences on WBB LMP frame structure providing higher uplink capacity but with possible constraints on WBB LMP uplink performance.

Other aspects regarding the shared use of the frequency band 3.8-4.2 GHz for WBB LMP

There is a balance to be struck on how much coordination an Administration is able to carry out at a local level between WBB LMP networks and incumbent services, and how restrictive harmonised technical conditions on WBB LMP need to be. Some of the technical conditions that were studied in this report would reduce to a certain extent the amount of coordination needed when assigning frequencies to WBB LMP installations.

In order to facilitate the deployment of terrestrial wireless broadband systems providing local-area network connectivity and when implementing harmonised technical conditions, administrations may want to be able to complement certain aspects of their use of the band 3.8-4.2 GHz to national circumstances, in order to manage remaining coordination cases not addressed by the harmonised technical conditions (for example on synchronisation and/or frequency separation requirements). CEPT is developing a toolbox for administrations to provide guidance on the approach to coexistence in the band. There may be also a need to further develop relevant cross border recommendations.

Finally, the relevant study results in this Report could be used for developing guidelines to ensure protection and future evolution on a case-by-case basis of FSS receiving earth stations and of terrestrial fixed links sharing the band 3.8-4.2 GHz with WBB LMP, for managing co-existence between WBB LMPs and between WBB LMP and MFCN (below 3.8 GHz).

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LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| Abbreviation | Explanation |
| AAS | Active Antenna Systems |
| BEM | Block Edge Mask |
| BS | Base Station |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| DECT-2020 NR | Digital Enhanced Cordless Telecommunications New Radio + |
| DL | Downlink |
| ECC | Electronic Communications Committee |
| EIRP | Effective Isotropic Radiated Power |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| FS | Fixed Service |
| FSS | Fixed Satellite Service |
| MFCN | Mobile Fixed Communications Network |
| non-AAS | Non Active Antenna Systems |
| PtP | Point to Point |
| PmP | Point to multipoint |
| RA | Radio altimeters |
| Rx | Receiver |
| Tx | Transmitter |
| UL | Uplink |
| UK | United Kingdom |
| VGOS | VLBI Global Observing System |
| VLBI | Very Long Baseline Interferometry |
| WAIC | Wireless Avionics Intra-Communications |
| WBB LMP | Terrestrial wireless broadband systems providing local-area (i.e. low/medium power) network connectivity |

# Introduction

This Report investigates the technical feasibility of the shared use of the 3.8-4.2 GHz frequency band by terrestrial wireless broadband systems (WBB systems) with low/medium power (LMP) providing local-area network connectivity (here and after with abbreviation WBB LMP) with focus on vertical industries and other terrestrial wireless use cases, proving the results of:

* sharing and compatibility studies between WBB LMP networks;
* sharing and compatibility studies between WBB LMP networks and incumbent users in the 3.8-4.2 GHz frequency band, notably receiving satellite earth stations in the fixed satellite service and terrestrial fixed links to ensure the protection and the future evolution and development of incumbent users sharing this band and, sharing and compatibility studies between WBB LMP networks and spectrum users in adjacent bands (such as MFCN below 3.8 GHz).

A separate ECC Report on Radio altimeters [1] studied protection of these systems from WBB LMP.

# Definitions

## Synchronisation

The definitions below may not necessarily apply to an entire network. In particular, there are use cases where different base stations within a network may be unsynchronised or semi-synchronised.

### Synchronised operation

The synchronised operation in the context of this Report means operation of TDD in several different networks, where no simultaneous UL and DL transmissions occur, i.e. at any given moment in time either all networks transmit in DL or all networks transmit in UL. This requires the alignment of all DL and UL transmissions for all TDD networks involved as well as synchronising the beginning of the frame across all networks.

### Unsynchronised operation

The unsynchronised operation in the context of this Report means operation of TDD in several different networks, where at any given moment in time at least one network transmits in DL while at least one network transmits in UL. This might happen if the TDD networks either do not align all DL and UL transmissions or do not synchronise at the beginning of the frame.

### Semi-synchronised operation

The semi-synchronised operation corresponds to the case where a part of the frame is consistent with synchronised operation as described above, while the remaining portion of the frame is consistent with unsynchronised operation as described above. This requires the adoption of a frame structure for all TDD networks involved, including slots where the UL/DL direction is not specified, as well as synchronising the beginning of the frame across all networks.

### Semi-synchronised operation with DL to UL modifications for WBB LMP

In this Report, a specific sub-case of semi-synchronised operation, in which only DL to UL modifications are allowed, is considered. This case is especially interesting for those scenarios where WBB LMP networks require more UL resources than those available in the frame structure of the MFCN network below 3800 MHz. In the case of semi-synchronised operation with DL to UL modifications, only the default DL transmission direction in the default frame structure may be modified into UL. As a result, if DL to UL modifications are only performed by the WBB LMP networks, MFCN below 3800 MHz will not receive additional BS-to-BS cross-interference from the WBB LMP network. However, WBB LMP network will receive additional BS-to-BS cross-interference which might need to be handled. Semi-synchronised operation is also possible employing UL to DL modifications, this case is not considered in this Report since this would cause additional BS-to-BS cross-interference from the WBB LMP network to MFCN below 3800 MHz.

The approach could be implemented with either one of the frame structures recommended in ECC Recommendation (20)03 [2] (referred to as default frame structure hereinafter).

Figure 1 illustrates the concepts via an example of the three different synchronisation options.

A screenshot of a video game

Description automatically generated

Figure 1: Different synchronisation options

From the perspective of flexibility for local network deployments unsynchronised operation is usually the preferred option. However, for some cases, especially if the required separation distance for unsynchronised operation is a challenge, synchronisation is necessary. For those cases, additional frame structure flexibility is achieved by employing semi-synchronised operation.

The benefits of semi-synchronised operation with DL to UL modifications compared to unsynchronised operation are as follows:

* The BEM below 3800 MHz will be identical to synchronised operation;
* The separation distance to MFCN can be significantly reduced compared to unsynchronized case.

Compared to synchronised operation the benefit is the possibility to employ more UL resources than provided by the frame structure of the MFCN network below 3800 MHz.

It should be noted that semi-synchronisation is realized on the same way as synchronised operation and simply requires setting the corresponding network parameters related to the DL to UL modifications in the frame structure of the WBB LMP.

## Licensed Area

Licensed area is geographical zone bounded by a pfd/field strength not to be exceeded at the receiving antenna of the Base Station to be protected.

# Allocations and applications in the band 3800-4200 MHz and adjacent bands

Allocation of services and application according to ECO Frequency Information System ([EFIS](https://efis.cept.org/)) for frequency range 3400-4400 MHz are provided in Table 1.

Table 1: Services and systems to be considered for studies

|  |  |  |
| --- | --- | --- |
| Studies | Allocation | Application |
| In-band (sharing):  3800-4200 MHz | FIXED | Fixed link |
| FIXED-SATELLITE (space-to-Earth) | Earth station |
| MOBILE | WBB LMP |
| Adjacent band (compatibility):  3400-3800 MHz and 4200-4400 MHz, as applicable | FIXED | Fixed link |
| FIXED-SATELLITE (space-to-Earth) | Earth station |
| MOBILE | MFCN |
| AERONAUTICAL MOBILE (R) | WAIC |
| AERONAUTICAL RADIONAVIGATION | RA |
| Note: WBB LMP – terrestrial wireless broadband systems providing local-area (i.e. low/medium power) network connectivity; MFCN – mobile/fixed communications networks which includes IMT and other communications networks in the mobile and fixed services" which would include fixed wireless access but not point-to-point links; WAIC – wireless avionics intra-communication; RA – Radio Altimeters. | | |

## Allocations and applications in the band 3800-4200 MHz

### Fixed satellite service

For decades, the FSS has utilized the 3400-4200 MHz and 5850-6725 MHz frequency bands for space-to-Earth (downlink) and Earth-to-space (uplink) links, respectively. FSS earth stations in CEPT countries have mainly used the 3600-3800 MHz and 3800-4200 MHz bands, rather than the lower 3400-3600 MHz band.

With the introduction of 5G in the 3.4-3.8 GHz band in Europe, CEPT has recommended that administrations consider relocating earth stations operating in the 3400-3800 MHz band from areas with foreseen extensive 5G use, and instead consider using higher bands above 3800 MHz for future FSS usage. As a result, many stations have migrated to the 3800-4200 MHz frequency band.

The 3.8-4.2 GHz band is crucial for FSS due to its unique characteristics, including wide geographic coverage over continents and resistance to rain fade. This band is essential for services provided to inter-tropical regions, and many earth stations are located in Europe for inter-continental communications. Applications include connectivity for enterprises and public institutions, mobile backhauling, and video contribution and distribution. The successful operation of this system depends on interference-free reception of the downlink signal.

CEPT is also studying the possibility of exempting small C-band IoT terminals [8] in other frequency bands from individual licensing, which could lead to the need for more gateway earth stations in the 3.8-4.2 GHz band.

Existing FSS Earth stations in the 3800-4200 MHz band are limited in number and well-identified in location. Future new earth station sites can also be expected to be located in well-defined locations. Due to the introduction of 5G below 3800 MHz, in addition to 5G harmonized technical conditions in the 3400-3800 MHz band some administrations have implemented national measures to protect earth stations above 3800 MHz. These national frameworks provide visibility and legal certainty for the future development of earth stations in the 3800-4200 MHz band while also ensuring the development of 5G in the 3400-3800 MHz band.

As the 3800-4200 MHz band is the only remaining part of the C-band for downlink communication, CEPT has assessed and proposed conditions to preserve this band for the long-term development of FSS in accordance with the objectives of the EC mandate.

### Fixed service

Fixed Service (FS) is a primary user of the 3800-4200 MHz frequency range in Europe and includes both military and civil usage.

Military usage includes fixed microwave links that support military communications and surveillance systems. Military entities use these links for command and control, situational awareness, intelligence, surveillance and reconnaissance (ISR), and other applications.

Civil use is primarily fixed point-to-point microwave links, connecting different points in a network, such as data centres or remote locations. These links are commonly used for various applications such as internet access, broadcasting, public safety and emergency services, and transportation systems.

ERC Recommendation 12-08 [3] provides a channel plan for the 3600-4200 MHz frequency range. In particular its Annex B Part 1 defines a channel arrangement in 3.8-4.2 GHz for Point-to-Point (PtP) and Point-to-multi-Point (PmP) links based on Recommendation ITU-R F.382 [4] with 29 MHz paired channels.

### VLBI (Very Long Baseline Interferometry) stations

There is a globally well-distributed network of VLBI Global Observing System (VGOS) stations, which are highly sensitive passive receivers and are expected eventually to number ~40. Some VGOS observatories are installed around Europe (Wettzell in Germany, Ny-Ålesund in Norway, Flores and Santa Maria in Portugal, Gran Canaria and Yebes in Spain, Onsala in Sweden and Matera in Italy). These are part of the European Critical Infrastructure Project Galileo which has to be supported from all European countries.

The start frequencies of these VGOS stations, like type VGOS-992 A8 is 3960.4 MHz (Block A) (see Report ITU-R RA.2507, page 25 [5]).

It is recognized that for the moment these observations, which are operating in the spectrum bands of the 2-14 GHz range, have no radio astronomy allocation in 3.8-4.2 GHz and therefore cannot claim interference protection on international or European level. Nevertheless, administrations are urged to take all practicable steps to protect these observatory operations from harmful interference.

## Allocations and applications in adjacent bands

### MFCN

The 3400-3800 MHz band has already been harmonised for MFCN in CEPT (and in EU on the basis of a response to an EC mandate) and is recognised to be the 5G primary band in Europe.

The band 3400-3800 MHz has been auctioned in majority of CEPT countries, see ECO Report 03[[1]](#footnote-2) and EU 5G Observatory[[2]](#footnote-3). Under the relevant authorisations and rights of use granted accordingly, mobile operators have invested heavily to roll out 5G and will continue during the next years. Those networks are widely deployed outdoors with AAS Base Stations. Non AAS small cells could be also rolled out indoors.

It is crucial, that the MFCN service is adequately protected.

### Fixed satellite service (Space-to-Earth) below 3.8 GHz

With the introduction of 5G in the 3.4-3.8 GHz band in Europe, CEPT has recommended that administrations consider relocating earth stations operating in the 3400-3800 MHz band from areas with foreseen extensive 5G use. In addition, CEPT recommended administrations to avoid authorising new FSS sites in the 3400-3800 MHz band in areas intended for 5G, and instead consider using higher bands above 3800 MHz for future FSS usage. As a result a limited number of FSS earth stations have been maintained in band bellow 3800 MHz.

As this is the same service as above 3.8 GHz, it is expected that operation of FSS below 3.8 GHz should be covered by the in-band sharing studies.

In case of conducting adjacent band studies the characteristics for FSS earth station remain the same as in section 5.1.2.

### Aeronautical mobile (R) service above 4.2 GHz (WAIC)

The use of the frequency band 4200-4400 MHz by stations in the aeronautical mobile (R) service is reserved exclusively for wireless avionics intra-communication systems that operate in accordance with recognized international aeronautical standards. Such WAIC use shall be in accordance with Resolution 424 (WRC-15).

### Aeronautical radionavigation service in 4.2-4.4 GHz (Radio altimeters)

Within the International Telecommunication Union (ITU) Radio Regulations (RRs) the frequency band 4 200-4 400 MHz is globally allocated to the aeronautical radionavigation service (ARNS) and is reserved exclusively for radio altimeters installed on board aircraft and for the associated transponders on the ground by Radio Regulations Footnote No. 5.438.

In addition, the frequency band is shared with Wireless Avionics Intra-Communications (WAIC) systems.

More detailed information is available in ECC Report [XYZ] [1].

# Terrestrial wireless broadband systems providing local area (i.e. low/medium power) network connectivity in 3800-4200 MHz

This section provides an overview of the WBB LMP use cases and associated parameters. As described in the EC mandate, these WBB LMP application are aimed at providing local area network connectivity in a shared manner. The following sub-sections attempt to capture and address the wide range of use-cases and requirements of potential users, such as enterprises and local communities.

## Use cases

The 400 MHz available in the 3.8-4.2 GHz frequency band can enable the deployment of terrestrial wireless broadband systems to provide local area connectivity for a variety of services in indoor and outdoor environments. In addressing the EC Mandate tasks on the shared use of the 3.8-4.2 GHz band for local area connectivity, it is important to address the technological and deployment requirements for a wide range of use-cases and users, ranging from "vertical industries"[[3]](#footnote-4) to local communities. Some examples of the non-exhaustive list of use-cases which could utilise the 3.8-4.2 GHz frequency band are listed below:

Table 2: WBB LMP use-cases[[4]](#footnote-5)

|  |  |
| --- | --- |
| Local areas services | Use-case example |
| Transport | Connectivity in transport hubs including logistics in ports, remote control of cranes, autonomous driving of vehicles and ships |
| Manufacturing | Connectivity to support smart factories and warehouses including sensor and machine connectivity, real-time monitoring of production lines, predictive maintenance, automation and other types of IoT applications |
| Construction | Connectivity for remote site surveys and remote monitoring and operations in construction sites |
| Entertainment and content production | Connectivity for UHD video live-streaming and use of AR/XR applications for immersive user experience. Support of multiple camera feeds and control signals within TV production environments (indoors/outdoors) |
| Education | Connectivity for video streaming in online learning platforms supported by the use of AR/XR applications |
| Health | Connectivity for sensors and medical equipment to support real-time remote medical operations |
| Utilities | Connectivity for smart grid real-time operations, including network control and optimisation as well as remote infrastructure monitoring and management |
| Smart cities | Connectivity for urban planning and real-time information conveyance |
| Rural broadband connectivity | Connectivity for industries located in rural environments such as e.g. agriculture, mining and fishing as well as for local communities through Fixed Wireless Access (FWA) |

It should be noted that some use-cases may be time-critical in nature and have strict requirements, such as strict latency and reliability requirements as well as requirements for flexible UL/DL ratios.

The wide range of local use-cases, used across different industrial and non-industrial environments both indoors and outdoors, will benefit from harmonised technical conditions,

ANNEX 3 presents an example use-case, requiring coverage of a given industrial site, demonstrating how different BS deployment configurations can affect the coverage and deployment complexity of WBB LMP networks in the frequency band.

## WBB LMP parameters used for studies

Two WBB LMP technologies have been considered, one based on 3GPP technical specifications and the other based on DECT-2020 NR standards.

### 3GPP 5G NR

Table 3: Parameters of the WBB LMP providing local area network connectivity in 3.8-4.2 GHz

|  |  |  |
| --- | --- | --- |
| Parameter | Low Power BS | Medium Power BS |
| Bandwidth | 10 MHz to 100 MHz | 10 MHz to 100 MHz |
| Antenna height | Outdoor: Limited to a maximum of 10 m above ground  Indoor: Any height within building | No limit |
| Deployment scenario | Outdoor/indoor  or  Indoor-only | Rural areas only |
| BS Tx EIRP limit  (for AAS & non-AAS) | 24 dBm / carrier for carriers ≤ 20 MHz; or  18 dBm / 5 MHz for carriers > 20 MHz | 42 dBm / carrier for carriers ≤ 20 MHz; or  36 dBm / 5 MHz for carriers > 20 MHz |
| Maximum terminal power | Mobile/nomadic: TRP 28 dBm (Note 2)  Fixed: EIRP 28 dBm (Note 2) | Mobile/nomadic: TRP 28 dBm (Note 2)  Fixed: TRP 28 dBm and EIRP 35 dBm/5 MHz (Note 1) |
| Note 1: Higher EIRP limit for fixed terminals in the medium power BS case is to account for the use case of Fixed Wireless Access (FWA)  Note 2: The authorisation of 28 dBm includes a 2 dB tolerance consistent with the European harmonisation. | | |

Table 4: Out-of-block emission limits of the WBB LMP (AAS & non-AAS) providing local area network connectivity in 3.8-4.2 GHz, derived from ECC Decision (11)06

|  |  |
| --- | --- |
| Frequency offset | Maximum mean EIRP density |
| -5 to 0 MHz offset from lower channel edge  0 to 5 MHz offset from upper channel edge | (Pmax – 40) dBm / 5 MHz EIRP per antenna |
| -10 to -5 MHz offset from lower channel edge  5 to 10 MHz offset from upper channel edge | (Pmax – 43) dBm / 5 MHz EIRP per antenna |
| Out of block baseline power limit (BS)  < -10 MHz offset from lower channel edge  > 10 MHz offset from upper channel edge | (Pmax – 43) dBm / 5 MHz EIRP per antenna |

Table 5: Out-of-band emission limits of the WBB LMP (AAS & non-AAS) providing local area network connectivity in 3.8-4.2 GHz, derived from ECC Decision (11)06

|  |  |
| --- | --- |
| Frequency offset | Maximum mean EIRP density |
| 3795 MHz-3800 MHz, 4200 MHz-4205 MHz | (Pmax – 40) dBm / 5 MHz EIRP per antenna |
| 3790 MHz-3795 MHz 4205 MHz-4210 MHz | (Pmax – 43) dBm / 5 MHz EIRP per antenna |
| 3760 MHz-3790 MHz, 4210 MHz-4240 MHz | (Pmax – 43) dBm / 5 MHz EIRP per antenna |
| Below 3760 MHz Above 4240 MHz | -2 dBm / 5 MHz EIRP per antenna |
| Note: Pmax is the maximum mean carrier power in dBm for the base station measured as e.i.r.p. per carrier, interpreted as per antenna | |

In Table 4 and Table 5 “per antenna" means per radiating unit/component (irrespective of the number of radiating elements that make up that unit/component). Therefore, when applying the "per antenna" limit to an AAS unit, this should be interpreted as a "per sector" limit as an AAS sector is seen as one "radiating unit".

Table 6: Parameters of the WBB providing local area network connectivity in 3.8-4.2 GHz

|  |  |  |
| --- | --- | --- |
| Parameter | Low Power BS | Medium Power BS |
| TDD / FDD | TDD | TDD |
| BS Sectorization | 1 | 1 |
| Use case information  single BS cell range (AAS & non-AAS) | 0.05–0.4 km for outdoor BS  typical antenna height above ground 10 m  0.01–0.1 km for indoor BS  any height within building | 0.05–3 km (check WP5D guidance) (Note 1)  antenna height above ground 5 m ~ 30 m  for indoor/outdoor BS (Note 2) |
| BS TDD activity factor | 25-75% | 25-75% |
| Network loading factor | 50% (for the network)  50% and/or 100% (for a single base station) | 50% (for the network)  50% and/or 100% (for a single base station) |
| BS Frequency reuse | 1 | 1 |
| Terminal antenna gain | -4 dBi | -4 dBi |
| Antenna gain for AAS/non-AAS | See Table 7 for AAS and Table 8 for non-AAS | |
| MIMO (number of RF chains) | 4T/4R for Medium Range and Local Area BS | |
| MIMO gain | 6 dB for 4T/4R | |
| BS Noise Figure | 13 – 5 (for MIMO processing gain) dB (Note 3)  Note: not include MIMO Rx gain, if for MIMO processing gain is used | 10 – 5 (for MIMO processing gain) dB (note 4)  Note: not include MIMO Rx gain, if for MIMO processing gain is used |
| UE Noise Figure | 9 dB | 9 dB |
| Interference criteria | I/N threshold -6 dB  and/or  5% throughput loss | I I/N threshold -6 dB  and/or  5% throughput loss |
| Estimated indoor/outdoor UE percentage (Note 5) | For outdoor BS: 70/30 %  For indoor BS: 100/0 % | For outdoor BS rural: 50/50 %  For indoor BS: 100/0 %  For incremental approach:  For outdoor BS suburban: 70/30% |
| Building entry loss (dB) | A value of 12 dB is used in the UK coordination approach for indoor WBB LMP BSs (Note 6) and should be applied in initial studies of indoor WBB LMP | A value of 12 dB is used in the UK coordination approach for indoor WBB LMP BSs (Note 6) and should be applied in initial studies of indoor WBB LMP |
| UE height | For outdoor BS: 1.5 m  For indoor BS: all UE are indoor at the same floor as indoor BS at 1.5 m above floor | For outdoor BS: 1.5 m  For indoor BS: all UE are indoor at the same floor as indoor BS at 1.5 m above floor |
| Note 1: In UK medium power BS are permitted for rural only  Note 2: The BS cell range depends on the antenna height and indoor/outdoor deployment  Note 3: Picocell Noise Figure as per Report ITU-R M.2292 [16]  Note 4: Microcell Noise Figure as per Report ITU-R M.2292  Note 5: Report ITU-R M.2292  Note 6: The coordination approach BEL value of 12 dB is described in Ofcom’s consultation [Enabling opportunities for innovation: Shared access to spectrum supporting mobile](https://eur01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.ofcom.org.uk%2F__data%2Fassets%2Fpdf_file%2F0022%2F130747%2FEnabling-opportunities-for-innovation.pdf&data=05%7C01%7CShaun.Moors%40ofcom.org.uk%7C2f5ce7d5ef324014d5ce08db1e5a35bf%7C0af648de310c40688ae4f9418bae24cc%7C0%7C1%7C638137145040616435%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=RLXhwlTwQhDBKbOTArDzJ1xd0AE8b9gHNttViDeF3JI%3D&reserved=0), see paragraph 5.54 [18], and is based on the BEL CDFs of traditional and thermally efficient buildings defined in Recommendation ITU-R P.2109 [13] | | |

Table 7 and Table 8 define antenna patterns for simulation of AAS and non-AAS systems respectively. It should be noted that some existing national frameworks for WBB LMP do not account for the pointing direction and pattern of the antenna in their coordination processes, applying licenced EIRP in the coordination where WBB LMP is the interferer and peak Rx gain where WBB LMP is the victim for coordination. To account for this difference in the approach, both an omnidirectional antenna pattern and those defined in Tables 5 and 6 could be studied for all cases. Omnidirectional antennas can be used for simulation, if the antenna pointing is not known.

Table 7: WBB LMP Base station AAS antenna characteristics

|  |  |
| --- | --- |
| AAS antenna pattern | Recommendation ITU-R M.2101, section 5 [19]  Extended AAS Model 3GPP TR 38.803,section 5.2.3.2.4 [20] |
| Element gain (dBi) | 6.4 |
| Horizontal/vertical front‑to‑back ratio (dB) | 30 for both H/V |
| Antenna polarisation | Linear ±45º |
| Antenna array configuration (Row × Column) (Note 1) | 8x8 elements  4x4 elements  (4x8 elements could be used as well) |
| Horizontal/Vertical radiating element/sub-array spacing, dh /dv | 0.5 of wavelength for H, 0.7 of wavelength for V |
| Number of element rows in sub-array, Msub (Note 2) | 3 |
| Vertical radiating element spacing in sub-array, dv,sub (Note 2) | 0.7 of wavelength of V |
| Pre-set sub-array down-tilt, θsubtilt (degrees) (Note 2) | 3 |
| Base station horizontal coverage range (degrees) | ±60° |
| Base station vertical coverage range (degrees) (Note 3) | 0 to -30 |
| Mechanical downtilt (degrees) | 0 and 10 |
| Note 1: For the small/micro cell case, 8×8 means that there are 8 vertical and 8 horizontal radiating elements. For the extended AAS model case, 4×8 means that there are 4 vertical and 8 horizontal radiating sub-arrays.  Note 2: Only needed when subarray antenna model is used  Note 3: The vertical coverage range is given in global coordinate system, i.e. 0° being at the horizon. | |

Table 8: Directional WBB LMP base station non-AAS antenna characteristics

|  |  |
| --- | --- |
| Non-AAS antenna pattern | Recommendation ITU-R F.1336 [21] |
| Sectorization | 1 sector for single BS; tri-sector for network layout simulation |
| Non-AAS BS downtilt (degrees) | 0 and 10 |
| Frequency reuse | 1 |
| Non-AAS BS antenna pattern | Recommendation ITU-R F.1336 (recommends 3.1)  ka = 0.7  kp = 0.7  kh = 0.7  kv = 0.3  Horizontal 3 dB beamwidth: 65 degrees  Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336.  Vertical beamwidths of actual antennas may also be used when available. |
| Antenna polarisation | Linear ±45° |
| Non-AAS BS Tx and Rx antenna gain per RF chain (including system loss) | 10 dBi for Medium Range (MR) BS  6 dBi for Local Area (LA) BS  0 dBi (omni) for indoor BS |

Note: The combination of power and antenna gain should be such, that the maximum defined EIRP per sector/BS is not exceeded.

Table 9: Adjacent band receiver characteristics for WBS LMP base station

|  |  |  |
| --- | --- | --- |
| Parameter | Low Power BS | Medium Power BS |
| ACS | -47 dBm for LP BS (Note 1) | -44 dBm for MR BS (Note 2) |
| In-band blocking | -38 dBm | -35 dBm |
| Out-of-band blocking | -15 dBm | -15 dBm |
| Note 1: From 3GPP standard  Note 2: From 3GPP standard | | |

Relative ACS and in-band blocking to be derived with the associated bandwidth and NF (Report ITU-R M.2039 [6]).

The studies have been developed on the basis on an incremental approach, with initial studies based on the parameters for terrestrial wireless broadband systems with low/medium power providing local-area network connectivity in 3.8-4.2 GHz (WBB LMP) that are already in use in some existing national frameworks.

The following parameters for WBB LMP have then been used for an incremental approach, differing from those used in the initial studies (see table hereafter).

Table 10: Parameters for the incremental studies (first step) for non-AAS and AAS Medium Power BS

|  |  |
| --- | --- |
| Parameter | Medium Power BS |
| Maximum antenna height | 30 m |
| Deployment scenario | Rural, suburban, urban |
| BS Tx EIRP limit (for AAS & non-AAS) | 51 dBm/100 MHz |

### DECT-2020 NR

#### Technical parameters for DECT

Table 11 summarises the technical parameters of DECT devices used in studies. These parameters are taken from the ETSI TS 103 636-2 v1.4.1 [7], with modified noise figures due to higher frequencies. All DECT-2020 NR devices are the same, i.e. there is no distinction between 'base station' equipment or 'user device' equipment. Devices within a DECT-2020 NR network may be considered a radio device fixed terminal (RDFT) or radio device portable terminal (RDPT) and can dynamically change their roles depending on the network’s needs. Consequently, only a single set of parameters for DECT-2020 NR is considered.

Table 11: Parameters of DECT-2020 NR providing local network connectivity in the 3.8-4.2 GHz band

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | | |
| Nominal channel bandwidth (MHz) | 1.728 | 3.456 | 6.912 |
| Transmission channel bandwidth (MHz) | 1.539 | 3.051 | 6.075 |
| Transmitter power (dBm) | 23 | 23 | 23 |
| Radiated power e.i.r.p. (dBm) | 23 per carrier, limited to 24 dBm/10 MHz | | |
| Antenna gain | 0 dBi | | |
| Antenna height | Outdoor: Limited to a maximum of 10 m above ground  Indoor: Any height within building | | |
| Noise figure (dB) | 9 | 9 | 9 |
| Rx indoor receiving level | 20 dBm to reference sensitivity | | |
| Rx outdoor receiving level | 20 dBm to reference sensitivity | | |
| Rx sensitivity (dBm) | -97.7 | -94.7 | -91.7 |
| Protection criteria | 5 dB S/N+I | | |

#### Transmitter spectrum emission requirements

Out of band emissions

The spectrum emission mask of the device applies to frequencies (ΔfOOB) starting from the ± edge of the assigned channel. For frequency offsets greater than ΔfOOB the spurious emission requirements in Table 12 are applicable.

Table 12: Spectrum emission limit for 1.728 MHz channel bandwidth

|  |  |  |
| --- | --- | --- |
| Spectrum emission limit (dBm) | | |
| ΔfOOB/MHz | 1.728 MHz channel bandwidth | Measurement bandwidth |
| ±0 to 0.0945 | -10 | 30 kHz |
| ±0.0945 to 1.6335 | -10 | 1 MHz |
| ±1.6335 to 1.8225 | -13 | 1 MHz |
| ±1.8225 to 3.3615 | -20 | 1 MHz |
| ±3.3615 to 3.456 | -23 | 1 MHz |

Table 13: Spectrum emission limit for 3.456 MHz channel bandwidth

|  |  |  |
| --- | --- | --- |
| Spectrum emission limit (dBm) | | |
| ΔfOOB/MHz | 3.456 MHz channel bandwidth | Measurement bandwidth |
| ±0 to 0.2025 | -10 | 30 kHz |
| ±0.2025 to 3.2535 | -10 | 1 MHz |
| ±3.2535 to 3.6585 | -13 | 1 MHz |
| ±3.6585 to 6.7095 | -20 | 1 MHz |
| ±6.7095 to 6.912 | -23 | 1 MHz |

Table 14: Spectrum emission limit for 6.912 MHz channel bandwidth

|  |  |  |
| --- | --- | --- |
| Spectrum emission limit (dBm) | | |
| ΔfOOB/MHz | 6.912 MHz channel bandwidth | Measurement bandwidth |
| ±0 to 0.4185 | -10 | 30 kHz |
| ±0.4185 to 6.4935 | -10 | 1 MHz |
| ±6.4935 to 7.3305 | -13 | 1 MHz |
| ±7.3305 to 13.4055 | -20 | 1 MHz |
| ±13.4055 to 13.824 | -23 | 1 MHz |

Spurious emissions

The spurious emission limits apply for the frequency ranges that are more than ΔfOOB (MHz) in Table 12 from the edge of the channel bandwidth. The spurious emission limits in Table 15 apply for all transmitter bands and channel bandwidths.

Table 15: Spurious emission limits

|  |  |  |
| --- | --- | --- |
| Spurious emission limit (dBm) | | |
| Frequency Range | Maximum Level | Measurement bandwidth |
| 9 kHz ≤ f < 150 kHz | -36 | 1 kHz |
| 150 kHz ≤ f < 30 MHz | -36 | 10 kHz |
| 30 MHz ≤ f < 1 000 MHz | -36 | 100 kHz |
| 1 GHz ≤ f < 12.75 GHz | -30 | 1 MHz |
| 12.75 GHz ≤ f < 5th harmonic of the upper frequency edge in GHz | -30 | 1 MHz |

#### Receiver characteristics

Adjacent channel selectivity

Table 16: Adjacent channel selectivity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Adjacent Channel Selectivity | | | | |
| Rx parameter | Channel bandwidth (MHz) | | | Unit |
| 1.728 | 3.456 | 6.912 |
| Own signal input level | RXsensitivity + 14 dB | | | dBm |
| PInterferer | RXsensitivity + 39 dB | RXsensitivity + 39 dB | RXsensitivity + 39 dB | dBm |
| BWInterferer | 1.728 | 3.456 | 6.912 | MHz |
| FInterferer (offset) | 1.728 or -1.728 | 3.456 or -3.456 | 6.912 or -6.912 | MHz |

In-band blocking characteristics

Table 17: In-band blocking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| In-band blocking | | | | |
| Rx parameter | Channel bandwidth (MHz) | | | Unit |
| 1.728 | 3.456 | 6.912 |
| Own signal input level | RXsensitivity + 6 dB | | | dBm |
| PInterferer | RXsensitivity + 52 dB | RXsensitivity + 52 dB | RXsensitivity + 52 dB | dBm |
| BWInterferer | 1.728 | 3.456 | 6.912 | MHz |
| FInterferer (offset from operating channel edge) | 2.592 + additional channel frequency step  Or  -2.592 - additional channel frequency step | 5.184 + additional channel frequency step  Or  -5.184 - additional channel frequency step | 10.368 + additional channel frequency step  Or  -10.368 - additional channel frequency step | MHz |

# Other parameters and assumptions for studies on 3800-4200 MHz

## Parameters for Sharing studies with in-band services

### Fixed service

Table 18: Main differences between generic and case study deployment parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Generic case | Case study 1 deployment | Case study 2 deployment |
| Antenna height | 50 m | 180 m | 2.1-100 m |
| Antenna gain | 42 dBi | 38 dBi | 33-47 dBi |
| Worst case frequency | 3800 MHz | | |

System parameters for PtP FS systems in allocated bands between 3 and 12 GHz.

Table 19: System parameters for PtP FS systems from Recommendation ITU-R F.758-7

(excerpt from Table 17) [15]

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range (MHz) | 3600-4200 | | 3700-4200 |
| **Reference ITU-R Recommendation** | **F.635 [22]** | | **F.382 [23]** |
| Modulation | 64-QAM | 512-QAM | QPSK |
| Channel spacing and receiver noise bandwidth (MHz) | 10, 30, 40, 60, 80, 90 | 10, 30, 40, 60, 80, 90 | 28, 29 |
| Maximum Tx output power range (dBW) | −1 | 7 | 0 |
| Maximum Tx output power density range (dBW/MHz) (Note 1) | −16…−11 | −9.0 | −15 |
| Minimum feeder/multiplexer loss range (dB) | 0 | 3 | 3 |
| Maximum antenna gain range (dBi) | 42 | 40 | 37 |
| Maximum e.i.r.p. range (dBW) | 41 | 44 | 38 |
| Maximum e.i.r.p. density range (dBW/MHz) (Note 1) | 26…31 | 28 | 23 |
| Receiver noise figure (dB) (Note 2) | 3 | 2 | 4 |
| Receiver noise power density typical (=NRX) (dBW/MHz) | −141 | −142 | −140 |
| Normalized Rx input level for 1 × 10–6 BER (dBW/MHz) | −114.5 | −106.5 | −126.5 |
| Nominal long-term interference power density (dBW/MHz) (Note 2 and Note 3) | −141 + I/N | −142 + I/N | −140 + I/N |
| Note 1: To calculate the values for the Tx/e.i.r.p. densities, channel spacing/bandwidth needs to be identified. In these Tables, the channel spacing indicated in bold text is used.  Note 2: Only 3 dB receiver noise figure was used in the study.  Note 3: Nominal long-term interference power density is defined by “Receiver noise power density + (required I/N)” as described in § 4.13 in Annex 2 (see also § 4.1 in Annex 1) of Recommendation ITU-R F.758-7 [15] | | | |

Long-term interference criteria.

Table 20: System parameters for PtP FS systems from Recommendation ITU-R F.758-7

(excerpt from Table 5) [15]

|  |  |  |
| --- | --- | --- |
| I/N (Note 1) | Frequency range | Sharing/compatibility conditions (Note 2) |
| ≤ –10 dB for 20% of time | Above 3 GHz | Sharing with more than one co-primary service |
| Note 1: These values of I/N apply to the aggregate interference from the operations of the shared service.  Note 2: For purposes of this Recommendation, compatibility studies refer to those studies performed between FWS and:  – systems in services having allocation on a secondary basis in bands allocated to the fixed service on a primary basis;  – systems in services having allocation in other bands (e.g. in adjacent bands); or  – sources of emissions other than radio services. | | |

To simplify the analysis of interference, separate consideration is given to short-term interference, which is the term used to describe the highest levels of interference power that occur for less than 1 per cent of the time, and to long-term interference, which addresses the remaining portion of the interference power distribution.

The derivation of permitted short-term interference levels, and associated time percentages, is a complex process which is not presented in Recommendation ITU-R F.758-7 [15]. In order to understand the potential impact of WBB LMP interference on FS, short-term protection could be modelled as sensitivity analysis, taking into account FS availability requirements. A suitable case study could be submitted with the reasonings on the assumptions.

### Fixed satellite service (Space-to-Earth)

In the 3.8-4.2 GHz band, licensed earth stations communicate only with geostationary satellites (GSO).

#### FSS earth station receiver characteristics

FSS parameters are based on characteristics provided by ITU-R WP 4A[[5]](#footnote-6) as well as on characteristics of existing FSS ES where indicated, as shown in the following table.

Table 21: FSS earth station parameters

|  |  |
| --- | --- |
| Parameter | Typical value |
| Antenna size (m) | 2.4-12 m |
| ES Carrier Bandwidth (MHz) | 40 MHz |
| Antenna reference pattern | Recommendation ITU-R S.465 [24] |
| Receiving system noise temperature | 120 K for small antennas (1.2-3 m)  70 K for large antennas (4.5 metres and above) |
| ES antenna elevation pointing | 10 degrees |
| ES Antenna Centre Height above ground | 10 m |

#### FSS protection criteria

Table 22: Protection criteria for FSS (in-band)

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range |  | Percentage of time for which the I/N value could be exceeded (%) | I/N criteria (dB) |
| 3800-4200 MHz | Long term  Short term | 20%  0.005% (NOTE) | −10.5  −1.3 (NOTE) |
| NOTE: Studies using these short-term protection criteria could be assessed on the basis that these values were put forward by WP 4A to facilitate and complete the work for WRC-23 agenda items and these values may evolve in the future based on inputs to the ITU-R. WP 4A has not completed its work in developing short-term protection criteria, however WP 5D is invited to consider these short-term protection criteria to the extent practicable. | | | |

## Parameters for compatibility studies with adjacent band services

### Mobile service below 3.8 GHz

#### 5G commercial

The parameters to be used for the coexistence studies of 5G commercial services with terrestrial WBS in the adjacent band are shown in Table 23.

Table 23: General parameters of the 5G commercial systems to be used in the coexistence studies - Beamforming antenna characteristics for IMT in 1710-4990 MHz

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Rural macro | Suburban macro | Urban macro | Urban small cell (outdoor)/Micro cell | Indoor (small cell) |
| 1 | Base station antenna characteristics | | | | | |
| 1.1 | Antenna pattern | Refer to the extended AAS model in Table A of Annex 3 | | | Refer to section 5 of Recommendation [ITU-R M.2101](https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2101-0-201702-I!!PDF-E.pdf) [19] | N/A |
| 1.2 | Element gain (dBi) (Note 1) | 6.4 | 6.4 | 6.4 | 6.4 | N/A |
| 1.3 | Horizontal/vertical 3 dB beam width of single element (degree) | 90º for H 65º for V | 90º for H 65º for V | 90º for H 65º for V | 90º for H 65º for V | N/A |
| 1.4 | Horizontal/vertical front‑to‑back ratio (dB) | 30 for both H/V | 30 for both H/V | 30 for both H/V | 30 for both H/V | N/A |
| 1.5 | Antenna polarisation | Linear ±45º | Linear ±45º | Linear ±45º | Linear ±45º | N/A |
| 1.6 | Antenna array configuration (Row × Column) (Note 2) | 4 × 8 elements | 4 × 8 elements | 4 × 8 elements | 8 × 8 elements | N/A |
| 1.7 | Horizontal/Vertical radiating element/sub-array spacing, dh /dv | 0.5 of wavelength for H, 2.1 of wavelength for V | 0.5 of wavelength for H, 2.1 of wavelength for V | 0.5 of wavelength for H, 2.1 of wavelength for V | 0.5 of wavelength for H, 0.7 of wavelength for V | N/A |
| 1.7a | Number of element rows in sub-array, Msub | 3 | 3 | 3 | N/A | N/A |
| 1.7b | Vertical radiating element spacing in sub-array, dv,sub | 0.7 of wavelength of V | 0.7 of wavelength of V | 0.7 of wavelength of V | N/A | N/A |
| 1.7c | Pre-set sub-array down-tilt, θsubtilt (degrees) | 3 | 3 | 3 | N/A | N/A |
| 1.8 | Array Ohmic loss (dB) (Note 1) | 2 | 2 | 2 | 2 | N/A |
| 1.9 | Conducted power (before Ohmic loss) per antenna element/sub-array (dBm) (Note 5, 6) | 31.7 (Note 8)  28 (for sensitivity analysis) | 31.7 (Note 8)  28 (for sensitivity analysis) | 31.7 (Note 8)  28 (for sensitivity analysis) | 16 | N/A |
| 1.10 | Base station horizontal coverage range (degrees) | ±60 | ±60 | ±60 | ±60 | N/A |
| 1.11 | Base station vertical coverage range (degrees) (Notes 3, 4, 7) | 90-100 | 90-100 | 90-100 | 90-120 | N/A |
| 1.12 | Mechanical downtilt (degrees) (Note 4) | 3 | 6 | 6 | 0-10 | N/A |
| 1.13 | Maximum base station output power/sector (e.i.r.p.) (dBm) | 76 (Note 8)  72.28 (for sensitivity analysis) | 76 (Note 8)  72.28 (for sensitivity analysis) | 76 (Note 8)  72.28 (for sensitivity analysis) | 61.53 | N/A |
| Note 1: The element gain in row 1.2 includes the loss given in row 1.8 and is per polarisation. This means that this parameter in row 1.8 is not needed for the calculation of the BS composite antenna gain and e.i.r.p.  Note 2: For the small/micro cell case, 8 × 8 means that there are 8 vertical and 8 horizontal radiating elements. For the extended AAS model case, 4 × 8 means that there are 4 vertical and 8 horizontal radiating sub-arrays.  Note 3: The vertical coverage range is given in a global coordination system, i.e. 90° being at the horizon.  Note 4: The vertical coverage range in row 1.11 includes the mechanical downtilt given in row 1.12.  Note 5: The conducted power per element assumes 8 × 8 × 2 elements for the micro/small cell case, and 4 x 8 x 2 sub-arrays for the macro case (i.e. power per H/V polarized element).  Note 6: In sharing studies, the transmit power calculated using row 1.9 is applied to the typical channel bandwidth given in Table 5-1 and 6-1 respectively for the corresponding frequency bands.  Note 7: In sharing studies, the UEs that are below the base station vertical coverage range can be considered to be served by the “lower” bound of the electrical beam, i.e. beam steered towards the max. coverage angle. A minimum BS-UE distance along the ground of 35 m should be used for urban/suburban and rural macro environments, 5 m for micro/outdoor small cell, and 2 m for indoor small cell/urban scenarios.  Note 8: Typical EIRP value of 5G currently deployed in a field | | | | | | |

Table 24: 5G specifications and deployment related parameters

|  |  |  |
| --- | --- | --- |
| Parameter | 5G NR BS | 5G NR UE |
| Channel bandwidth (MHz) | 100 (98.280 MHz Nrb=273 Rb=12\*30kHz) | |
| BS non-AAS antenna gain | 0 dBi for indoor BS (Recommendation ITU-R F.1336-omni [21]) |  |
| BS antenna height (m) | 20 for outdoor urban macrocell BS  25 for outdoor suburban macrocell BS  6 for outdoor urban/suburban smallcell BS  3 above floor for indoor BS |  |
| BS Tx Mask | 3800-3840 MHz: SEM  Above 3840 MHz: -30 dBm/MHz |  |
| BS Rx Mask | 3800-3820 MHz: ACS of 34.3 dBc (-52 dBm)  3820-3860 MHz: in-band blocking of 43.3 dBc (-43 dBm)  3860-4200 MHz: out-of-band blocking of 71.3 dBc (-15 dBm)  Note: values above are valid for 100 MHz bandwidth and for a macro cell BS with NF=3 dB |  |
| BS noise figure (dB) | 3 | 9 |
| Cell range (m)  Note: typical values from deployed networks | Urban: 400 ~ 600  Suburban: 800 ~ 1500  Rural: 1600 ~ 3000 | |
| UE Tx power (dBm) |  | 23 |
| UE Tx Mask |  | SEM in 3GPP TS 38.101 |
| UE antenna gain (dBi) |  | -4 |
| Body loss (dB) |  | 4 |
| Indoor/outdoor UE |  | Urban/suburban: 70/30 %  Rural: 50/50 % |
| Building wall loss (dB) | 12 | |
| UE heights (above ground or building floors) (m) | N/A | 1.5 |
| TDD activity factor | 75% DL | 25% UL |

## Propagation parameters

### Propagation parameters for WBB LMP vs MFCN and WBB LMP vs WBB LMP co-existence

Table 25: Propagation model for the BS to BS link

|  |  |  |
| --- | --- | --- |
| Case | Urban/Suburban | Rural |
| Both ends above clutters | Recommendation ITU-R P.452 [14] / Recommendation P.2001 [17] 50% of time, without clutter loss  Note: Recommendation ITU-R P.1546 [11] may be used for studies beyond radio horizon | |
| One end above clutters and one end within clutters  to be used >= 250 m | Recommendation ITU-R P.452 / Recommendation ITU-R P.2001 50% of time, with Recommendation ITU-R P.2108 [10] fixed clutter loss corresponding to 50% locations (for urban) or 30% (for sub-urban) applied to one end.  Other values for clutter loss can be used as a sensitivity analysis. | ITU-R P.1546 Land Rural 50% of time |
| Both ends within clutters  to be used >= 1km (with appropriate LoS probability) | Recommendation ITU-R P.452 / Recommendation ITU-R P.2001 50% of time, with- Recommendation ITU-R P.2108 fixed clutter loss corresponding to 50% locations (for urban) or 30% (for sub-urban) applied to two ends.  Other values for clutter loss can be used as a sensitivity analysis. |  |
| Both BSs below rooftops and in the same street adjacent to each other | 3GPP TR 38.901 Umi LOS |  |
| Both BSs are in indoor area in the same building | Recommendation ITU-R P.1238 [12] for BSs in the same building, other valid model can be used with explanation |  |
| One or two BSs are in indoor area in different building | Outdoor model + Wall Loss 12 dB at each indoor BS or Recommendation ITU-R P.2109 [13] for incremental study |  |

### Propagation parameters for WBB LMP vs other services

Table 26: Propagation models used in the simulations with systems other than MFCN

|  |  |
| --- | --- |
| Link | Model |
| Outdoor LMP BS to FS/FSS receiving earth station | Recommendation ITU-R P.452-16 [14] / Recommendation ITU-R P.2001-4 [17]  (Note 1) |
| Indoor LMP BS to FS/FSS receiving earth station | Recommendation ITU-R P.452-16 / Recommendation ITU-R P.2001-4  (Note 1) + Wall Loss 12 dB at each indoor BS or fixed value taken from Recommendation ITU-R P.2109 for incremental study (Note 2) |
| Note 1: If the study assumes non-time variant assumptions, e.g. both victim services and interfering services are static, the percentage of time assumed for Recommendation P.452-16 [14] / Recommendation ITU-R P.2001-4 [17] be the percentage of time linked to the protection criteria of the victim service.  In the case of a time-varying Monte Carlo analysis, the percentage of time should be random at each iteration along with time variant variables Non time variant variables shall not be randomised.  To extend P.452 model time percentage (Tpc) range to 0-100%, the SG3 guidance (or similar) in Liaison statement to WP6A ([198]) should be included, namely, that Tpc range should be 0-100% and for Tpc > 50% the losses are equal to the case Tpc = 50  Where the antenna heights of the transmitter and/or receiver are below the nominal clutter heights specified in Recommendation ITU-R P.452, table 4, clutter attenuation based on Recommendation ITU-R P.452 or Recommendation ITU-R P.2108 [10] at a specified % shall be considered. In case of ITU-R P.2108 implementation the choice of % should be documented.  Note 2: In case of Recommendation ITU-R P.2109 implementation the choice of value should be documented. | |

## Coexistence scenarios

A table of allocation of services and application according to ECO Frequency Information System (EFIS) for frequency range 3400-4400 MHz is provided in Table 1. An overview of the interference scenarios studied in the present document is provided in Table 27.

Table 27: Overview of studied interference scenarios (interference links)

|  |  |  |
| --- | --- | --- |
| Interfering system | Victim system | Studies |
| Between WBB LMP | | |
| WBB LP (outdoor) | WBB LP (outdoor) | In-band |
| WBB LP (indoor) | WBB LP (outdoor) | In-band |
| WBB LP (outdoor) | WBB LP (indoor) | In-band |
| WBB MP | WBB MP | In-band |
| WBB MP | WBB LP (indoor) | In-band |
| WBB MP | WBB LP (outdoor) | In-band |
| Between WBB LMP and MFCN | | |
| WBB LP (indoor) | MFCN | Adj-band |
| WBB LP (outdoor) | MFCN | Adj-band |
| WBB MP | MFCN | Adj-band |
| MFCN (outdoor & indoor) | WBB LP (indoor) | Adj-band |
| MFCN (outdoor) | WBB LP (outdoor) | Adj-band |
| MFCN | WBB MP | Adj-band |
| Between WBB LMP and FS | | |
| WBB LP (outdoor) | FS | In-band |
| WBB MP | FS | In-band |
| Between WBB LMP and FSS (s-E) | | |
| WBB LP (outdoor) | FSS (s-E) | In-band |
| WBB MP | FSS (s-E) | In-band |
| Between WBB LMP and other applications | | |
| WBB LP (outdoor) | VGOS (Note 1) | In-band |
| WBB MP | VGOS (Note 1) | In-band |
| Note 1: The in-band interference scenario between WBB LMP and VLBI Global Observing System (VGOS) stations operating in few CEPT countries, is supporting EU interests as part of the European Critical Infrastructure Project Galileo. | | |

Studies between WBB LMP and RA were conducted in ECC Report [XYZ] [1].

# Sharing studies with in-band services

## Between 3GPP WBB LMP in the 3.8-4.2 GHz frequency band

### Study 1 – Co-channel coexistence study between WBB LMPs in the band 3.8-4.2 GHz for unsynchronised case [Nokia]

Study is in A1.1.1. Study is based on I/N protection ratio.

This study focuses on the coexistence between two unsynchronised WBB LMP networks operating co-channel and outdoors. The deployment and operational characteristics of the two networks were sourced from the agreed parameters for studies. Non-AAS antennas were considered for Low Power BS, while AAS antennas with a 4x8 element configuration were considered for the Medium Power BS. The high level WBB LMP operational and deployment parameters are shown in Table 28.

Table 28:

|  |  |
| --- | --- |
| Parameter | Value |
| Max EIRP (Low Power WBB) | 31 dBm/100 MHz |
| Max EIRP (Medium Power WBB) | 49 dBm/100 MHz  51 dBm/100 MHz |
| Antenna height (Low Power WBB) | 10 m |
| Antenna height (Medium Power WBB) | 12 m (dense sub-urban)  15 m (rural) |
| Propagation model | Recommendation ITU-R P.452 |
| Clutter (Fixed % from Recommendation ITU-R P.2108 [10]) | 50% (urban)  30% (dense sub-urban)  0% (rural) |
| WBB LMP protection criterion | I/N = -6 dB |

Regarding the methodology of the study, Monte Carlo simulations were performed in a 3GPP compliant simulator, where the dynamic nature of WBB LMP services was captured. Each simulation step was considered to be 250 m with 10000 interference snapshots being captured at each one of those steps, creating an interference CDF, For each separation distance step of 250 m the worst-case interference snapshot was considered which was then assessed against the I/N protection criterion to determine the minimum separation distance required.

The results indicate that to satisfy the I/N=-6dB protection criterion, the minimum separation distance between two Low Power WBB LMPs is below 250 m in urban environments, and approximately 600 m in rural environments. For a Low Power WBB LMP BS to satisfy the I/N protection criterion of a Medium Power WBB LMP BS in an urban environment, the separation distance was about 300 m. When assuming two rural Medium Power BS, the minimum separation distances become approximately 22 km and 23 km for EIRPs of 49 dBm/100 MHz and 51 dBm/100 MHz respectively and approximately 500 m in dense sub-urban environments. The separation distance required between a sub-urban and a rural Medium Power WBB LMP was found to be approximately 1 km.

The results of the studies are shown in Figure 2.

Figure 2: The minimum separation distance between two Low Power WBB LMPs to satisfy the I/N=-6dB protection criterion

### Study 2 – Co-channel and adjacent channel coexistence study between WBB LMPs in the band 3.8-4.2 GHz [Orange]

Study is in A1.1.2. The study is based on 5% throughput loss. Several other throughput losses of 10%, 20%, and 30% are also considered.

The study 2 provides technical analysis of the in-band co-channel and adjacent-channel co-existence between two local area networks operating within the frequency band 3800-4200 MHz. As shown in Figure 3, a local area network is modelled by a single BS, Two neighbouring local area networks are modelled as a single BS to a single BS. UEs are uniformly and randomly distributed within the interfering WBB LMP\_A network area and also within the victim WBB LMP\_B network area. Monte-Carlo simulations are performed to simulate the victim WBB LMP\_B BS uplink throughput loss caused by the interference from the interfering WBB LMP\_A base station downlink emissions.

A line with a dotted line

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Figure 3: A local area network is modelled by a single BS

In this technical study, WBB Low Power non-AAS BS with EIRP=31 dBm/100 MHz and Medium Power non-AAS and AAS BS with EIRP=49 dBm/100 MHz are considered with Monte-Carlo simulations. For WBB LP non-AAS BS with 31 dBm/100 MHz EIRP, the BS antenna height is set at 10 m, in urban and sub-urban area and it is below the clutters. The BS-to-BS link propagation model for this case was Recommendation ITU-R P.452 [14] + Recommendation ITU-R P.2108 [10] 50% Clutter loss.

For the case of WBB MP non-AAS and AAS BS with 49 dBm/100 MHz EIRP, the BS antenna height was at 20 m in urban area, 25 m in sub-urban area, and 30 m in rural area., The propagation model P.452 without adding clutter loss was used for the BS-to-BS link. In rural area, Recommendation ITU-R P.1546 [11] rural propagation model is used for BS-to-BS link.

For unsynchronized operation between two neighbouring local area networks, the first step is that the victim BS uplink throughput loss was simulated. The separation distance D corresponding 5%, 10%, 20%, and 30% for each case was obtained. The second step is to simulate the median power level at the middle point (D/2) from the WBB LMP BS and is simulated with a omni-directional 0 dBi antenna gain at 3 meters height. The third step is to convert the median power level (dBm) into the field strength E (dBµV/m) with the following equation:

|  |  |
| --- | --- |
|  | (1) |

Where:

* F is the frequency in MHz.

For the synchronized case, the field strength value was simulated at the Local Area network cell coverage edge with a omni-directional antenna with 0 dBi antenna gain at 3 m height.

Based on the simulation results, it is proposed to use the following field strength values at the local area network coverage border.

Table 29: Field strength values (dBµV/m/5 MHz) at 3 m at each local area network coverage border for unsynchronized operation with neighbouring local area networks

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Environment | Urban/Sub-urban | | | Rural | | |
| Power class | LP EIRP<=31 dBm/100 MHz  Hbs<=10 m | MP 31 dBm/100MHz < EIRP<= 51 dBm/100 MHz | | LP EIRP<=31 dBm/100 MHz | MP 31 dBm/100MHz < EIRP<= 51 dBm/100 MHz | |
| BS type | Non-AAS | Non-AAS | AAS | Non-AAS | Non-AAS | AAS |
| Non-Preferential frequency | 37 | -17 | 0 | 33 | 22 | 35 |
| Preferential frequency | 48 | 26 | 48 | 48 | | |
| Note::  Non-Preferential frequency is defined as the case where the local area network has full or partial frequency overlap with at least one of the neighbouring local area networks.  Preferential frequency is defined as the case where the local area network has no-frequency overlap (full or partial) with any neighbouring local area networks. | | | | | | |

Table 30: Field strength values (dBµV/m/5 MHz) at 3 m at each local area network coverage border between WBB LMP neighbouring local area networks in unsynchronized operation

|  |  |  |
| --- | --- | --- |
| Environment | LP BS  Urban/Sub-urban/Rural | MP BS  Urban/Sub-urban/Rural |
| Non-Preferential frequency | 32 | N.A |
| Preferential frequency | 48 | 26 for non-AAS BS  48 for AAS BS |

In case of synchronised operation with neighbouring local area networks, the Field Strength values in Table 28 can be considered for both non-AAS and AAS.

Table 31: Field strength values (dBµV/m/5 MHz) at 3 m at each local area network coverage border for synchronised operation with neighbouring local area networks (for both non-AAS and AAS BS)

|  |  |
| --- | --- |
| Environment | Field strength Value (dBµV/m/5 MHz) |
| Urban/Sub-urban/Rural | 61 |

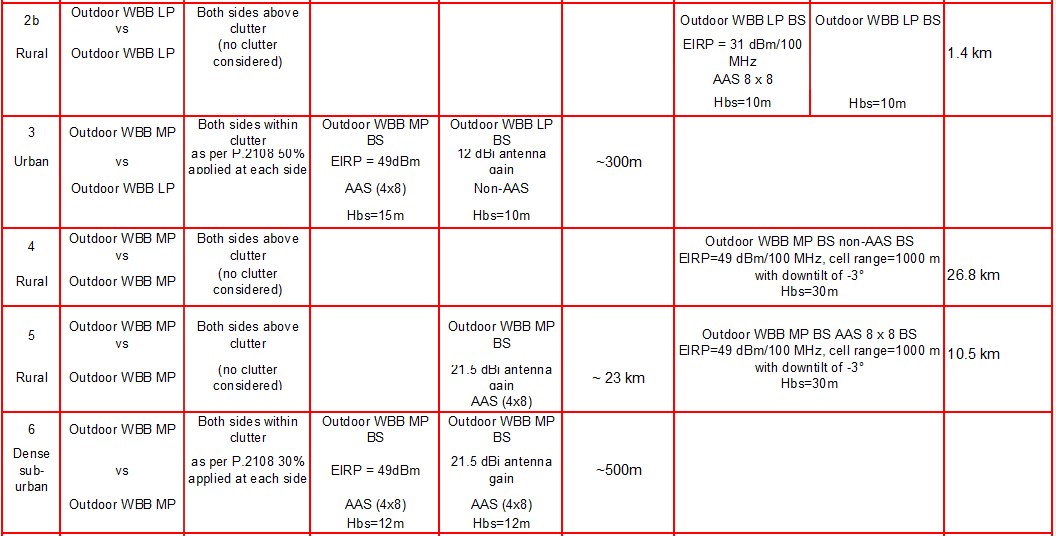
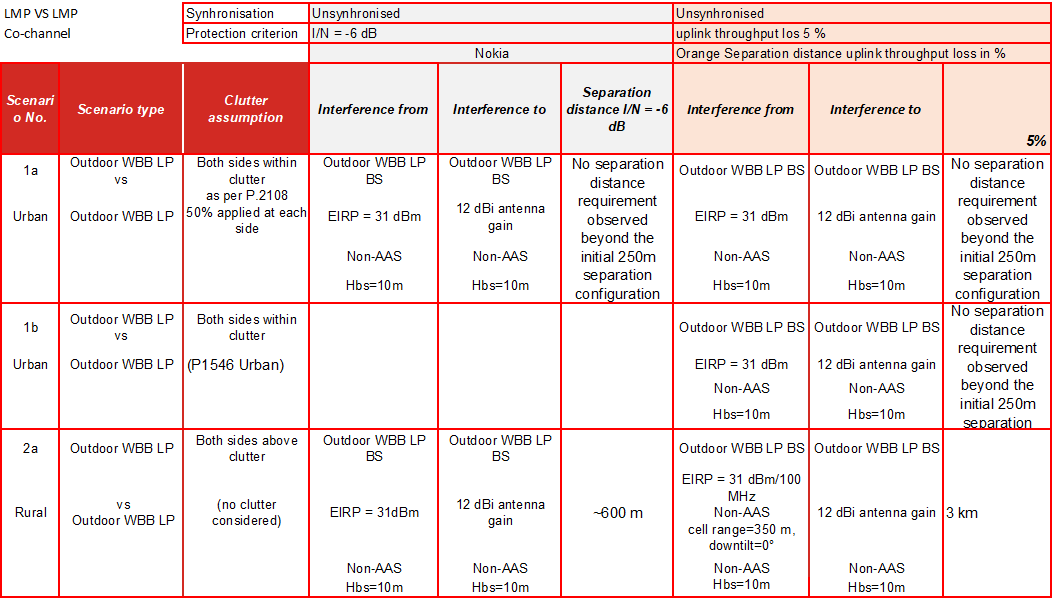
There are several possible case by case coordination solutions between two local area networks. This study proposes two:

* 1) Synchronisation between two neighbouring local area networks;
* 2) Field strength levels at the local area network coverage edge between two local area networks.

The field strength level can be defined as function of the acceptable throughput loss. As a sensitivity analysis the field strength level of throughput losses of 10%, 20%, 30% was given for information in addition to the agreed 5% throughput loss. The choice of the field strength values at different throughput losses can be made at national level (on case-by-case basis) based on the principle of equal access to the spectrum use.

### Summary and Conclusions

Table 32: Separation distances between WBB LMPs in unsynchronised operation

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Table 33: Separation distances - for different throughput losses (5% is reference)

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Both studies (Study 1 and Study 2) described in the section 6.1 provide Monte-Carlo simulations on the co-existence between two WBB LMP local area networks. Study 1 simulated the separation distance using a protection criterion of I/N=-6 dB for a co-channel scenario, while study 2 simulated the separation distance and the field strength values at the middle point for co-channel and adjacent channel scenarios based on the criterion that uplink throughput loss should not be exceeded by 5%, 10%, 20%, and 30%.

The simulation results show that

1. In urban/sub-urban areas, when WBB non-AAS Low Power BSs are within clutter, there is no particular requirement of separation distance and no coordination measure is required for this situation even in co-channel in such scenarios.
2. In rural areas, when non-AAS WBB - low power BSs are above clutter, the required separation distance between low power non-AAS WBB BSs in the co-channel scenario can be up to 3 km depending the antenna height, downtilt etc.
3. The more challenging co-existence scenario is that between the WBB Medium Power BSs. In those cases the required separation distance can go up to 26.8 km depending the type of antenna, the antenna height, downtilt, environment, etc. The result of the studies also indicate that co-existence between co-channel WBB Medium Power BSs using AAS antennas is less challenging compared to using non-AAS antennas. The required separation distances for WBB AAS Medium Power BS range up to 23km depending on the AAS configuration, the EIRP, antenna height, downtilt, environment etc..
4. Adjacent channel operation between neighbouring WBB Medium Power BSs is more feasible based on the simulation results.

Study 2 also proposed the following mean/medium field strength values (not to be exceeded) at the WBB LMP local area network licensed area edge for consideration by national regulators:

Table 34: Field strength values (dBµV/m/5 MHz) at 3 m at each local area network licensed area border between neighbouring local area networks in unsynchronized operation

|  |  |  |
| --- | --- | --- |
| Environment | LP WBB BS  Urban/Sub-urban/Rural  (dBµV/m/5 MHz) at 3 m | MP WBB BS  Urban/Sub-urban/Rural |
| Co-channel | 32 | NA |
| Adjacent channel | 48 | 26 for non-AAS BS  48 for AAS BS |
| Note:  Co-channel case is defined as the case where the local area network has full or partial frequency overlap with at least one of the neighbouring local area networks.  Adjacent channel case is defined as the case where the local area network has no-frequency overlap (full or partial) with any neighbouring local area networks. | | |

Table 35: Field strength values (dBµV/m/5 MHz) at 3 m at each local area network coverage border for synchronized operation with neighbouring local area networks (for both non-AAS and AAS BS)

|  |  |
| --- | --- |
| Environment | Field strength value (dBµV/m/5 MHz) |
| Urban/Sub-urban/Rural | 61 |

The above study results could be used for developing guidelines for managing co-existence between WBB LMPs.

## Between 3GPP WBB LMP and FS in 3.8-4.2 GHz

### Study 1 – Sharing study between WBB LMP and FS in the band 3.8-4.2 GHz for co-frequency case [Germany]

Study is in A1.2.1.

This sharing study describes the interference scenarios from a single WBB LMP BS transmitter to a co-frequency the FS receiver (50 m above ground).

The results indicate that the required separation distances to protect FS from WBB LMP may go up to 90.5 km for medium power WBB BS (25 m above ground, i.e. above typical clutter height) and up to 38.5 km for low power WBB BS (10 m above ground, i.e. bellow typical clutter height) for a worst-case realistic scenario (MCL). This distance reduces to about 300 m for the WBB low power BS, if the BS is placed in the side lobe of the FS antenna. No clutter was applied for the medium power BS scenario, the antenna height for both services is considered above the average clutter level. The interference distances would decrease significantly if the BS is placed inside the clutter. The results for the medium power WBB BS show interference distances of up to 46 km for the FS side lobe. Coordination with a medium power WBB BS could therefore be challenging.

### Study 2 – Sharing study between WBB LMP and FS in the band 3800-4200 MHz [Italy]

Study is in A1.2.2.

This sharing study considers co-frequency coexistence analyses between WBB LMP BS interferer and real FS victim receivers in Italy. Results in terms of separation distances between LMP WBB BS and FS receivers and exclusion areas around the FS receivers (i.e. geographical area where WBB BS transmitters are not allowed) have been evaluated considering both flat terrain and the real terrain elevation.

Low Power (LP) WBB deployment (antenna height 10 m, below typical clutter height) has been considered in dense urban, urban and suburban environments. The FS antenna heights range from 7.3 m to 100 m.

The separation distances in the direction of the FS main lobe that have been obtained in the coexistence analyses in case of LP WBB considering flat terrain vary from 6 km to almost 46.3 km depending on the FS receiver antenna height, the maximum FS antenna gain, the FS elevation angle and the feeder loss.

Medium Power (MP) WBB deployment (antenna height 30 m, above typical clutter height) has been considered in rural environment. The FS antenna heights range from 2.1 m to 84 m. No clutter was applied, the antenna height for both services is considered above the average clutter level.

The separation distances in the direction of the FS main lobe that have been obtained in the coexistence analyses in case of MP WBB in rural scenario considering flat terrain vary from 34.5 km to 101 km depending on the FS receiver antenna height, the maximum FS antenna gain, the FS elevation angle and the feeder loss.

Sharing studies considering real data of the FS links as well as real terrain elevation have been performed.

Comparing the results of the analysis in terms of separation distances and exclusion areas, considering both the flat terrain and the real terrain elevation, some conclusions can be drawn:

* - The altimetry of the real terrain should be taken into account in the coexistence assessments on a case-by-case basis. Flat terrain is not the worst case, in fact altimetry can hinder (this occurs when the first Fresnel zone of the FS link is intersected by the terrain) or favour (when there is not any intersection) propagation.
* When altimetry is taken into account:
* the exclusion area may not be continuous;
* the separation distance alone could be used as a coexistence condition only if the exclusion zone remains continuous;
* the calculation of the exclusion area and the population within it provides more relevant information on the reduction of the impact of the interference in real cases.

It follows from the above considerations that in all real cases not only the theoretical maximum separation distance but also the exclusion area should be assessed, both taking into account the altimetry of the terrain, therefore a case-by-case coexistence assessment is needed.

Since it is not possible a priori to define the technical conditions that guarantee the protection of the incumbent FS, and its future development, particular attention shall be paid to the borders.

According to the analyses, coexistence between FS and both low and medium power WBB systems should not be managed at national level only but requires coordination and related bilateral or even multilateral agreements among neighbouring countries, taking into account the use of appropriate mitigation techniques that could facilitate coexistence.

### Study 3 – Sharing study between WBB LMP and FS in the band 3.8-4.2 GHz [Ericsson]

Study is in A1.2.3.

In this study, interference analysis is conducted on various FS stations, with antenna heights ranging from 15 m to 80 m. Provided the specific Fixed Service (FS) stations and the following specific assumptions considered in this study:

* maximum EIRP of 51 dBm of the WBB MP BS;
* 10 m of antenna height of the WBB MP BS;
* flat terrain;
* urban scenario;
* clutter loss based on Recommendation ITU-R P.2108 [10], with fixed percentage of locations equal to 50% (in line with the characterisation of the clutter in urban scenario) on one end of the propagation path, based on the assumption that statistical clutter loss models should only be used to characterise clutter for urban and suburban scenarios when the radio path is not precisely known;
* determination of the basic transmission losses based on Recommendation ITU-R P.452 [14], with a random time percentage.

Simulation results indicate that to prevent harmful interference from an active antenna system (AAS) WBB MP base station (BS), separation distances up to 56 km might be necessary in urban or suburban scenario. Additionally, note that for larger AAS antenna arrays, the separation distances decrease due to the enhanced directivity of such larger arrays.

Furthermore, for sensitivity analyses, additional assumptions on the user terminal (UE) deployments and the WBB BS activity factor are considered to determine their impact on the required separation distances to prevent harmful interference:

Assuming that Hotspot deployments are similar to those for WBB MP networks, A Rayleigh distribution for the UE ground distance from its BS is deemed suitable for non-public local networks provided that these networks are deployed where users are expected to remain in the local network cell, rather than moving between different cells as in MFCN networks.

It is assumed that a WBB base station is active either 100% or 50% of the time, accounting for varying network loading factors. Considering a TDD activity factor of 75% for downlink (3:1), the equivalent activity factors become 75% (100%x0.75) and 37.5% (50%x0.75) respectively.

This study shows that considering the mentioned factors (BS activity factor, UE Rayleigh distribution, network loading factors), the distances are reduced by an average of 15% in the case of the main lobe and 25% in the case of the side lobe. The accuracy of these results can be improved if local clutter data is used instead of statistical clutter assumptions.

Finally, the sensitivity analysis assessment for the chosen short-term protection criterion indicates that for some instances the required separation distances are nearly the same or lower compared to those needed for the long-term protection criterion, i.e., FS short-term protection is less stringent than long-term protection.

### Summary and Conclusions

Based on agreed assumptions on WBB LMP/FS parameters, these studies reveal that in case of flat terrain different separation distances may be necessary between WBB LMP and FS systems in order to protect FS links:

* in case of WBB LP studies show that maximum separation distances in the direction of the FS main lobe could range up to 56.5 km while in the side lobe maximum separation distances could be up to 300 m (clutter was assumed for these values);
* in case of WBB MP studies show that maximum separation distances in the direction of the FS main lobe could range up to 113 km while in the side lobe maximum separation distances could be up to 69 km (no clutter assumed for these values).

The mentioned separation distances depend on various factors such as clutters (which depends on the environment: rural, sub-urban, urban, indoor/outdoor), direction/antenna, antenna heights, the maximum FS antenna gain, the FS elevation angle, the feeder loss and others. In case of WBB LP indoor the separation distances in the direction of the FS main lobe vary from 2.6 km to 25.5 km and they can be less than 100 m in the side lobe. These values depend on the building material and consequently on the BEL (building entry loss).

One of the studies shows the importance that real terrain data are taken into account in the coexistence assessments, because real terrain data can not only hinder, but also favour propagation significantly and then affect the maximum separation distances and the excluded areas (exclusion zones) accordingly.

In conclusion, according to the analyses, it is not possible to define generic technical conditions that guarantee the protection of FS, including its long-term development, but a case-by-case analysis is needed. In addition, due to the large separation distances that may be necessary for coexistence even without considering real terrain data and to the potentially unfavourable impacts of real terrain on separation distances and exclusion areas that are required, coexistence between FS and both low and medium power WBB systems cannot always be managed at national level only but may require cross border coordination on a case-by-case basis and related bilateral or even multilateral agreements among neighbouring countries.

Nevertheless, appropriate mitigation techniques can facilitate coexistence between WBB and FS systems, both at national level and with the neighbouring countries.

CEPT intends to develop a guideline in order to help administrations to address this issue nationally and in cross border cases as appropriate.

## Between 3GPP WBB LMP and FSS in 3.8-4.2 GHz

### Study 1 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Intelsat]

Study is in A1.3.1.

The study concentrates on studying the required separation distance to protect FSS ES from WBB LMP BS deployments. Various assumptions were considered in the study, including:

1. Three different maximum EIRP levels for WBB LMP BS
   1. “Low power”: maximum e.i.r.p. = 18 dBm/5 MHz
   2. “Medium power”: maximum e.i.r.p. = 36 dBm/5 MHz
   3. Intermediate value: maximum e.i.r.p. = 24 dBm/5 MHz
2. BS antenna types to consider differences in radiation patterns: AAS (dynamic pointing considered with Monte Carlo analysis) and non AAS (fixed pointing)
3. BS antenna height of 10m and 20m. This characteristic impacts the line of sight distance (higher antenna height means longer LoS distance) as well as on the consideration of clutter (if station is higher than assumed nominal clutter height, clutter was not considered)

Table 36 summarises the results of the separation distances for the various cases to meet the long term and short term FSS protection criteria.

Table 36: Results of the separation distances for the various cases to meet the long term and short term FSS protection criteria

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case # | Antenna type and clutter consideration | Max. e.i.r.p. | Distance to meet the FSS long term protection criteria (km) | Distance to meet the FSS long short-term protection criteria (km) |
| 1.1 | AAS antenna without clutter | 36 dBm/5 MHz | 36.5 | 275 |
| 1.2 | 18 dBm/5 MHz | 21.5 | 90 |
| 1.3 | 24 dBm/5 MHz | 25.5 | 160 |
| 1.1 | AAS antenna with clutter (31 dB, 50% location) | 36 dBm/5 MHz | 14 | 18 |
| 1.2 | 18 dBm/5 MHz | 2 | 2 |
| 1.3 | 24 dBm/5 MHz | 4.2 | 4.2 |
| 2.1 | Non-AAS antenna without clutter | 36 dBm/5 MHz | 47.5 | 273 |
| 2.2 | 18 dBm/5 MHz | 32.5 | 104 |
| 2.3 | 24 dBm/5 MHz | 38.1 | 163 |
| 2.1 | Non-AAS antenna with clutter (P.452 clutter) | 36 dBm/5 MHz | 35 | 120 |
| 2.2 | 18 dBm/5 MHz | 20.9 | 23 |
| 2.3 | 24 dBm/5 MHz | 25.3 | 29 |
| 3.1 | Omnidirectional antenna without clutter | 36 dBm/5 MHz | 47.9 | 276.8 |
| 3.2 | 18 dBm/5 MHz | 33.3 | 109.2 |
| 3.3 | 24 dBm/5 MHz | 38.5 | 167.2 |
| 3.1 | Omnidirectional antenna with clutter (P.452 clutter) | 36 dBm/5 MHz | 35.8 | 126.2 |
| 3.2 | 18 dBm/5 MHz | 21.5 | 23.1 |
| 3.3 | 24 dBm/5 MHz | 25.9 | 29.1 |

From the above table, it is clear that the low power level WBB LMP BS drastically reduces the required separation distance and that clutter attenuation also drastically impacts the results of the study. This study also shows that the higher the BS, the larger the separation distance and the less likely clutter attenuation would apply. This study was conducted without using terrain data and results could differ on case-by-case basis. However, the study provides a good idea of the coordination distance (for long term protection criteria) required depending on the WBB LMP power level:

* For low power (18 dBm/5 MHz) around 20 km;
* For medium power (36 dBm/5 MHz) around 40 km.

### Study 2 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Nokia]

Study is in A1.3.2.

This study focuses on the coexistence between WBB LMP networks and FSS ES receivers. The deployment and operational characteristics of the WBB LMP networks were sourced from the agreed parameters for studies. Non-AAS antennas were considered for Low Power BS, while AAS antennas with a 4x8 element configuration were considered for the Medium Power BS. The high level WBB LMP operational and deployment parameters are shown in the Table 37.

Table 37: The high level WBB LMP operational and deployment parameters

|  |  |
| --- | --- |
| Parameter | Value |
| Max EIRP (Low Power WBB) | 31 dBm/100 MHz |
| Max EIRP (Medium Power WBB) | 49 dBm/100 MHz  51 dBm/100 MHz |
| Antenna height (Low Power WBB) | 10 m |
| Antenna height (Medium Power WBB) | 12 m (dense sub-urban)  15 m (rural) |
| Propagation model | Recommendation ITU-R P.452 [14] |
| Clutter (Fixed % from Recommendation ITU-R P.2108 [10]) | FSS ES Receiver  30% at all times  WBB LMP  50% (urban)  0% (rural) |
| FSS ES long-term protection criterion | I/N = -10.5 dB for 20% of time |

Regarding the methodology of the study, Monte Carlo simulations were performed in a 3GPP compliant simulator, where the dynamic nature of WBB LMP services was captured. Each simulation step was considered to be 250 m with 10000 interference snapshots being captured at each one of those steps, creating an interference CDF. For each separation distance step of 250 m the worst-case interference snapshot was considered which was then assessed against the FSS ES I/N protection criterion to determine the minimum separation distance required.

The results indicate that to satisfy the I/N=-10.5dB FSS ES long-term protection criterion, the minimum separation distance for a Low Power WBB LMP BS is approximately 850m in urban and approximately 4km in rural environments. For rural Medium Power WBB LMP BS with EIRPs 49dBm/100MHz and 51dBm/100MHz the minimum separation distances required are approximately 12.5 km approximately 16km respectively. When a higher elevation angle for the FSS ES receiver is considered (i.e. 48 degrees instead of 10 degrees), the required separation distance from a rural Medium Power BS becomes approximately 2.5 km.

The results of the studies are shown in the Figure 4.



Figure 4: The minimum separation distance to satisfy the I/N=-10.5dB FSS ES long-term protection criterion

### Study 3 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [France]

Study is in A1.3.3.

This sharing study between WBB LMP Base Stations and FSS Earth-stations was two-fold.

The first part is a collection of static studies and was done considering a site-specific environment (Rambouillet, France), taking into account Low Power (31dBm EIRP/100 MHz) and Medium Power (51dBm EIRP/100 MHz) non-AAS WBB Base Stations and using the FSS long-term protection criteria (exceedance of I/N=-10.5dB for no more than 20% of the time). Different antenna height and down-tilt angle combinations were considered.

The attenuation loss due to the terrain and buildings was determined using Recommendation ITU-R P.452-16 [14] and the terrain path profile. The terrain path profile was computed using a combination of the SRTM database (1 Arcsec resolution) and the French IGN building database (5 m resolution).

The calculations resulted in required protection distances between WBB LMP Base Stations and FSS Earth Stations ranging from 5.3 to 15.5 km for the Low Power case and ranging from 17.5 to 26.6 km for the Medium Power case, depending on the antenna height and down-tilt angle.

The second part is a collection of dynamic studies and was done considering a more generic smooth Earth approach, taking only into account Medium Power (51 dBm EIRP/100 MHz) AAS (4x8) Base Stations and using the FSS long-term protection criteria (exceedance of I/N=-10.5dB for no more than 20% of the time).

The individual runs were performed using a Monte Carlo analysis assuming many random UE locations within the coverage area of the Base Station and the attenuation loss was determined using Recommendation ITU-R P.452-16 [14] for a random percentage of time (between 0% and 100%) for each of the random UE. In addition, an arbitrary statistical clutter attenuation was also taken into account in some cases on one side of the propagation path using Recommendation ITU-R P.2108-1 [10] for 2 different percentages of time (30% and 50%).

The simulations resulted in required protection distances between WBB LMP Base Stations and FSS Earth Stations ranging from 27 to 52 km depending on the clutter loss considered.

### Study 4 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Ericsson]

Study is in A1.3.4.

The results of this single-entry study indicate indicates that separations distances ranging from less than one kilometre to few tens of kilometres may be needed to prevent harmful interference to FSS earth stations. These results consider clutter on one side or both sides of the propagation path.

Assuming clutter is present at one end of the propagation path and considering that the WBB base station and the FSS earth station are pointing towards each other, the results indicate that the longest separation distance is approximately 16.5 km for medium-power WBB base stations without AASs (corresponding to a maximum EIRP of 49 dBm/5 MHz). In this scenario, if natural or artificial clutter is present at both ends of the propagation path, separation distances are reduced to less than 1.5 km.

Conversely, for the situation where the WBB base station is pointing in the opposite direction of the FSS earth station, results indicate that for all cases tested (including natural or artificial clutter at one or both ends of the propagation path) separation distances are below 1 km.

For the cases presented in this study, note that the size of the AAS antenna changes little the long-term criterion results.

By means of coordination on a case-by-case basis, e.g., boresight pointing direction of the WBB base station, separation distances can be decreased to just few kilometres to prevent harmful interference to FSS earth stations for a wide range of WBB base station antenna configurations and EIRP levels.

### Study 5 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Luxembourg]

Study is in A1.3.5.

This study provides a co-frequency compatibility analysis between WBB LMP BS as interferer and FSS ES as victim receiver. It has been conducted considering:

A static analysis that provides a clear picture of the various parameters impacting the interference received by the FSS ES from WBB LMP BS and allows identifying possible ways to mitigate the interference by applying site specific adjustments.

A statistical case study analysis which explores site-specific configuration for two locations of FSS hubs and allows assessing the impact of the terrain and environment around the FSS ES in the received interference, including considering both long-term and short-term interferences.

Different configurations have been investigated, including various transmitting power, the consideration of clutter loss and antenna pointing. Under baseline assumptions, these assumptions could be summarised as follows.

The WBB transmitting powers are 21dBm/40MHz for low power, 35dBm/40MHz for medium power and 37dBm/40MHz for incremental medium power BS. The required separation distance increases with the raise of the BS power.

Angular discrimination was considered, with an elevation discrimination assuming BS mechanical down-tilt of 0° for LP BS and 6° for MP BS cases and FSS elevation angle spanning from 10° to 50°. Azimuth discrimination was also assessed, with two cases where the BS points towards the FSS (0°) or sees the FSS from the back-lobes (180°). The required separation distance reduces with the raise of either the vertical or azimuthal angular discrimination.

The impact of clutter loss was verified, considering no clutter loss, suburban clutter (29dB) or urban clutter (31dB). Clutter reduces the required separation distance.

The BS antenna height was assessed from 10 m up to 35 m and it plays a role in the received interference by the FSS antenna. Increasing the antenna height increases the required separation distance.

Impact of environment between the transmitting BS and receiving FSS earth station plays a key role in the level of interference received by the victim FSS system. In some cases, a hilly terrain reduces the likelihood of interference compared to a flat terrain.

Sensitivity analysis was also conducted, which extended further some of the values used for these parameters.

The results of this study show that a coordination distance of 40km around an FSS ES location, with no consideration of terrain, is suitable to protect FSS ES receivers. Below that distance the use of one or combination of some of the various mitigation techniques mentioned in the study could be implemented to minimize the interference received and reduce the required separation distance between the WBB LMP and the FSS earth stations.

Based on the assumptions considered in this study, the analysis concluded that specific actions or measures could be implemented, as appropriate, to facilitate the deployment of LMP 5G systems while protecting existing and future use of FSS systems.

### Study 6 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Germany]

Study is in A1.3.6.

This sharing study analyses the interference scenario between WBB LMP transmitters and FSS receivers by simulating examples of two existing FSS ES in Germany, using real terrain data and real ES parameters.

This sensitivity study is a complement to the theoretical approaches by applying the agreed WBB LMP BS parameters to realistic ES scenarios.

The study is based on MATLAB simulations using Recommendation ITU-R P.452-17 and terrain data (DTM) (no clutter heights used along the path) in combination with Recommendation ITU-R P.2108-1, section 3.1 (“representative clutter section”) [10] to provide more realistic path loss results than the same Recommendations using section 3.2 (“statistical clutter section) instead. The results for both sections of Recommendation ITU-R P.2108-1 are included to show their differences in combination with real deployment data. The simulation results show that the separation distances required to protect FSS ES from WBB LMP BS go up to 70 km for WBB MP BS (for long term criteria) and up to 17 km for WBB LP BS (for long term criteria) when simulated with real terrain data and using the clutter correction in Recommendation ITU-R P.2108-1, section 3.1 (representative clutter). Additional calculations are performed to highlight the impact of using statistical clutter value (Recommendation ITU-R P.2108-1, section 3.2) for the clutter attenuation.

The different sensitivity simulations in this study show that the resulting interference distances are highly dependent on realistic assumptions like the local terrain data and actual antenna height of the WBB LMP BS to ensure the protection of existing FSS ES from the WBB LMP BS.

### Study 7 – Additional sharing studies between WBS LMP base stations and FSS earth stations in the band 3.8-4.2 GHz [Ericsson]

Study is in A1.3.7.

In this study, interference analysis is conducted on various FSS earth stations, with antenna diameters ranging from 3 m to 32 m. Provided the specific FSS ESs and the following specific assumptions considered in this study:

* maximum EIRP of 51 dBm of the WBB MP BS;
* 10 m of antenna height of the WBB MP BS;
* flat terrain;
* urban scenario;
* clutter loss based on Recommendation ITU-R P.2108 [10], with fixed percentage of locations equal to 50% (in line with the characterisation of the clutter in urban scenario) on one end of the propagation path, based on the assumption that statistical clutter loss models should only be used to characterise clutter for urban and suburban scenarios when the radio path is not precisely known,

simulation results indicate that to prevent harmful interference from an AAS WBB MP BS, separation distances up to 23 km might be necessary in urban or suburban scenario. Additionally, it is noteworthy that larger AAS antenna arrays result in decreased separation distances due to the enhanced directivity of such arrays.

Furthermore, for sensitivity analyses, additional assumptions on the user terminal (UE) deployments and the WBB BS activity factor are considered to determine their impact on the required separation distances to prevent harmful interference:

* Assuming that Hotspot deployments are similar to those for WBB MP networks, Rayleigh distribution for the UE ground distance from its BS is deemed suitable for non-public local networks provided that these networks are deployed where users are expected to remain in the local network cell, rather than moving between different cells as in MFCN networks.
* It is assumed that a WBB base station is active either 100% or 50% of the time, accounting for varying network loading factors. Considering a TDD activity factor of 75% for downlink (3:1), the equivalent activity factors become 75% (100%x0.75) and 37.5% (50%x0.75) respectively.

This study shows that taking into account the mentioned factors leads to a reduction in distances. Depending on the cases considered the separation distance is reduced by a few km (2 km in one case) up to several km (16km in one case). It is noted that the accuracy of these results can be improved if local clutter data is used instead of statistical clutter assumptions.

Lastly, in the sensitivity analysis assessment for the short-term protection criterion, the results show that the separation distances are in the same range as for the long-term protection criterion (up to approximately 11.4 km for the DLR FSS ES case). On the other hand, the short-term results are not significantly influenced by the activity factor, as the cumulative distribution function (CDF) curves exhibit steep slopes at the short-term low probabilities values, i.e. 0.005%.

### Summary and Conclusions

Table 38: Separation distances for long-term protection criteria

A close-up of a chart

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Table 39: Separation distances for short-term protection criteria

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As highlighted in the tables above summarising the results of the various studies, the separation distances required between WBB LMP and FSS can vary significantly depending on the assumptions taken. An overall depiction of generic studies (without terrain data) are provided below:

* Considering the FSS ES long term protection criteria:

Medium power WBB LMP: 36.5-47.9 km (without clutter) and 10.5-18 km (with one sited clutter)

Low power WBB LMP: 21.5-33.3km (without clutter) and 2-4.7km (with one sited clutter)

* Considering the FSS ES short term protection criteria:

Medium power WBB LMP: 273-277 km (without clutter) and 18 km (with one sited clutter)

Low power WBB LMP: 90-109 km (without clutter) and 2 km (with one sited clutter)

Some studies show that the real terrain should be taken into account in the coexistence assessments, because it can hinder or favour propagation and then the separation distance. Resulting separation distances from those studies range in 5.3-17.2 km for WBB Low Power stations and 17.5-70 km for WBB Medium Power stations when considering long term protection criterion. One study considering the real terrain and the short-term protection criteria indicated separation distances of up to 9.3 km for WBB LP and 35 km for WBB MP for one earth station example.

The results of Study 5 suggest a coordination distance around an FSS ES location of 40km is suitable to protect FSS ES receivers, below which the use of one or combination of some of the various mitigation techniques presented in that study could be implemented to minimize the interference received and reduce the required separation distance between the WBB LMP and the FSS earth station.

According to the analyses, it is not possible to define technical conditions that guarantee the protection of FSS, including its long-term development and coexistence between FSS and both low and medium power WBB systems cannot be always managed at national level only but requires coordination and related bilateral or even multilateral agreements among neighbouring countries.

Appropriate mitigation techniques can facilitate coexistence between WBB and FSS systems, both at national level and with the neighbouring countries.

CEPT intends to develop guidelines in order to help administration to address this issue as appropriate.

## DECT-2020 NR technical sharing studies in the band 3.8-4.2 GHz

### DECT-2020 NR summary

Study is in A1.4.

In-band coexistence studies are based on Minimum Coupling Loss (MCL) analysis using the agreed protection criteria for each service and propagation parameters. For in-band adjacent channel analysis, Net Filter Discrimination (NFD)[[6]](#footnote-7) has been used to account for the defined mask of the interfering transmitter and defined receiver filter mask.

Medium power operation is not envisioned for DECT-2020 NR, therefore only 'low power' is considered in these studies. The e.i.r.p of DECT-2020 NR is 23 dBm (assuming a 0 dBi antenna) for the current bandwidth options of 1.728, 3.456 and 6.912 MHz. If wider area coverage is needed by a user at their site, additional DECT-2020 NR devices can be deployed within a self-organising mesh network rather than increasing the output power (and the consequential increase in possible interference to other users). For the purpose of these studies, only the bandwidth option of 6.912 MHz is included on the assumption that narrow bandwidths would improve coexistence, particularly with adjacent channel applications.

### DECT-2020 NR - Results between two DECT-2020 NR systems

DECT-2020 NR uses advanced spectrum protocols that enable local, device-based interference management through autonomous, time-accurate interference avoidance between DECT-2020 NR devices in the same network, and also with devices operating in other DECT-2020 NR networks. These protocols can manage coexistence between networks locally, and therefore the need to study DECT-to-DECT coexistence is largely inconsequential but is included for information and completeness.

The analysis was performed with 6.912 MHz channel bandwidth systems (operating in the centre of the 10 MHz channel raster). The maximum separation distance needed between DECT-2020 NR deployments is 0.582 km when considering the co-channel operation with no clutter. This distance reduces to 0.250 km when assuming clutter at one terminal. Separation distances for two immediate adjacent 10 MHz channels are 30 metres.

### Results between DECT-2020 NR and 3GPP WBB LMP systems

#### DECT-2020 NR interfering 3GPP WBB LMP

Two 3GPP WBB bandwidths have been assumed within these studies, i.e. 10 MHz and 100 MHz victim bandwidths for both low and medium power 3GPP WBB scenarios. In the co-channel case with 100 MHz 3GPP WBB channels, one 6.912 MHz DECT-2020 NR interferer has been assumed to be operating in each 10 MHz (10 DECT-2020 NR in 100 MHz) to assess the effect of aggregated interference from DECT-2020 NR, which is representing the theoretical worst case and not necessarily experienced in practice.

For co-channel, when clutter is applied separation distances of the order of 2 to 3 km are calculated. When no clutter is applied, separation distances increase to approximately 30 to 33 km. There is no discernible increase in separation distances when considering aggregation.

For adjacent channel studies, separation distances range between 1.1 and 5 km, depending on LP or MP 3GPP WBB and their receiver bandwidths.

For shared spectrum operation DECT-2020 NR has the capability to detect interference from any other systems sharing the same or adjacent spectrum. DECT-2020 NR supports polite spectrum operation, i.e. the device senses the spectrum use prior its own transmission to avoid collision with other transmissions and to enable operation on least interfered channels by supporting Listen Before Talk (LBT) protocol. These polite protocols would enhance spectrum sharing but have not been considered in the MCL analysis.

#### 3GPP WBB LMP interfering DECT-2020 NR

Studies show in the co-channel case separation distances range from 0.25 km to 3.6 km depending on assumed clutter losses and bandwidth of the interferer. In the adjacent channel case, separation distances are approximately 100 m or less.

For the 3GPP WBB as the interferer and DECT-2020 NR as the victim, only the medium power (3GPP WBB) case has been modelled as the worst-case scenario. Separation distances for low power 3GPP WBB would be less than those derived here.

#### Conclusions on interference between DECT-2020 NR and 3GPP WBB LMP

It is noted that the difference in required separation distances between DECT-2020 NR into 3GPP WBB and vice versa is primarily a consequence of the assumed operation and protection criteria which are more conservative when considering protection of 3GPP WBB.

For 3GPP WBB LMP the interference threshold level is -105 dBm/10 MHz or -95 dBm/100 MHz i.e. 6 dB below thermal noise and for DECT-2020 NR the respective interference threshold was -76.7 dBm/6.912 MHz, i.e. 20 dB above thermal noise. The interference threshold used for DECT-2020 NR is consistent with other compatibility studies in ECC.

### Results on sharing studies between DECT-2020 NR and FSS

The studies of DECT-2020 NR into the FSS considers both long-term and short-term interference scenarios. The effect of applying clutter at one terminal significantly reduces the required separation distances. Studies consider the DECT-2020 NR interferer at 0-, 10- and 180-degrees azimuth with respect to the FSS antenna.

For long-term interference, at 0 degrees azimuth, i.e., the DECT-2020 NR interferer is on the maximum FSS antenna gain with the inclination set to 10 degrees, the separation distances range from 3 to 51 km depending on the application of clutter. In the adjacent channel separation distances range between 0.6 and 15 km. Outside the main beam separation distances reduce as would be expected.

In the short-term scenario, separation distances vary between 91 km and 1.2 km in the co-channel, 0-degree azimuth case. In the adjacent channel, separation distances vary between 13 km and 0.37 km, and reduce further when azimuth separation increases.

### Results on sharing studies between DECT-2020 NR and FS

The study assesses the geographical separation required when the DECT-2020 NR interfering signal is incident to the victim receiver at 0-, 10- and 180-degrees azimuth. The largest separation distance for a single-entry interferer at 0 degrees without clutter is 130 km. This reduces to 37 km when clutter is assumed.

In the adjacent channel case, separation distances reduce to between 81 km and 5 km depending on applying clutter. In off-axis geometries separation distances reduce significantly, for example down to 1.3 km when clutter is applied in the co-channel, 10-degree azimuth case.

### Conclusions for DECT-2020 NR

Table 40 provides a summary of the co-channel MCL analysis outlined above when considering clutter at the DECT-2020 NR terminal operating with a maximum antenna height of 10 m.

Table 40: Summary of DECT-2020 NR in-band coexistence studies

|  |  |  |  |
| --- | --- | --- | --- |
| Interferer | Victim | Co-channel separation distance (km) | Comment |
| DECT-2020 NR | DECT-2020 NR | 0.250 | DECT-2020 NR spectrum management functionality removes the need to consider separation distances between different DECT-2020 NR networks |
| DECT-2020 NR | 3GPP LP WBB | 1.8 | For 10 MHz 3GPP WBB |
| 0.7 | For 100 MHz 3GPP WBB |
| DECT-2020 NR | 3GPP MP WBB | 2.7 | For 10 MHz 3GPP WBB |
| 1.0 | For 100 MHz 3GPP WBB |
| 3GPP MP (only MP considered as the worst-case) | DECT-2020 NR | 0.29 | For 10 MHz 3GPP WBB |
| 0.25 | For 100 MHz 3GPP WBB |
| DECT-2020 NR | FSS | 3 | Long-term interference |
| 1.2 | Short-term interference |
| DECT-2020 NR | FS | 37 |  |

Note: The e.i.r.p of DECT-2020 NR is 23 dBm (0 dBi antenna gain)

Studies show that the required separation distances needed between for DECT-2020 NR WBB LMP and 3GPP WBB LMP networks, and between for DECT-2020 NR WBB LMP and incumbent services demonstrate the feasibility of for DECT-2020 NR LMP WBB operation in the 3.8 to 4.2 GHz band. As noted above, adjacent (in frequency and/or geography) DECT-2020 NR WBB LMP networks can be locally managed autonomously by the devices themselves, removing the need for manual coordination and the requirement for a separation distance.

# Compatibility studies with adjacent band services

## Between 3GPP WBB LMP and MFCN below 3.8 GHz

### Study 1 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Nokia]

Study is in A2.1.1.

Study 1 provides technical analysis on the interference between a single WBB LMP BS and a single 5G MFCN AAS BS (both as interferer and as victim) using Monte-Carlo simulations, the protection threshold for 5G MFCN BS and WBB LMP BS were I/N=-6 dB. The study results are expressed as separation distances assuming no or clutter loss at the vicinity of WBB LMP BS or/and 5G MFCN BS. Study 1 results provide useful information for the coordination between WBB LMP BS and 5G MFCN BS. The study results do not contain any BEM elements for WBB LMP unsynchronised operation in 3.8-4.2 GHz band.

This study focuses on the coexistence between WBB LMP networks and MFCN networks operating in an unsynchronised manner in immediately adjacent-bands and outdoors. The deployment and operational characteristics of the WBB LMP networks were sourced from the agreed parameters for studies Non-AAS antennas were considered for Low Power BS while AAS antennas with a 4x8 element configuration were considered for the Medium Power BS. MFCN networks were assumed to be deployed with BS with AAS antennas with 4x8 and 8x8 elements configuration. The high level WBB LMP operational and deployment parameters are shown in Table 41.

Table 41: WBB LMP operational and deployment parameters

|  |  |
| --- | --- |
| Parameter | Value |
| Max EIRP (Low Power WBB) | 31 dBm/100 MHz |
| Max EIRP (Medium Power WBB) | 49 dBm/100 MHz  51 dBm/100 MHz |
| Antenna height (Low Power WBB) | 10 m |
| Antenna height (Medium Power WBB) | 12 m (dense sub-urban)  15 m (rural) |
| Antenna height (MFCN) | 25 m |
| Propagation model | Recommendation ITU-R P.452 |
| Clutter (Fixed % from Recommendation ITU-R P.2108 [10]) | MFCN  0% at all times  WBB LMP  50% (urban)  30% (sub-urban)  0% (rural) |
| MFCN protection criterion | I/N = -6 dB |

The study assesses the coexistence both when the WBB LMP network acts as the interferer towards MFCN as well as when the MFCN network acts as the interferer towards the WBB LMP network. Regarding the methodology of the study, Monte Carlo simulations were performed in a 3GPP compliant simulator, where the dynamic nature of WBB LMP and MFCN services was captured. Each simulation step was considered to be 250 m with 10000 interference snapshots being captured at each one of those steps, creating an interference CDF, For each separation distance step of 250 m the worst-case interference snapshot was considered which was then assessed against the WBB LMP or MFCN I/N protection criterion to determine the minimum separation distance required.

The results of the study indicate that to satisfy the I/N protection criterion of MFCN, the separation distances between for a Low Power WBB LMP BS are below 250 m when both are located at an urban environment and approximately 850 m when both are located in a rural environment. Below 250 m is also the separation distance required to satisfy the MFCN criterion of I/N = -6dB for Medium Power WBB LMP networks with EIRP 49dBm/100MHz and 51dBm/100MHz located in urban and dense sub-urban environments. When both networks were located in rural environments, the separation distance to protect MFCN services was approximately 1km.

When the MFCN network acts as an interferer, for the WBB LMP services to be protected against the I/N protection criterion, the required separation distances are below 250 m for urban Low Power WBB LMPs and approximately 1.6 km for rural Low Power WBB LMPs. Medium Power WBB LMP BS need to maintain approximately up to 300 m separation in order to be protected from MFCN in dense suburban environments and approximately 5.75 km in rural environments.

The results of the studies are shown in Figure 5, Figure 6 and Figure 7.



Figure 5:

Figure 6:

Figure 7:

### Study 2 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Orange]

Study is in A2.1.2.

Study 2 presented the simulation results as separation distance for the case with and without clutter loss applied to one or both ends in different environment.

Study 2 provides Monte-Carlo simulations results of interference from WBB LMP BS to 5G MFCN by modelling the local area network as a single BS and 5G MFCN network as a single BS, the 5G MFCN BS out of band blocking characteristics used in the simulation is a type 1-H (-15 dBm[[7]](#footnote-8) at frequency offset from the band edge). This single BS to single BS simulation scenario does not take into account the inter-cell interference within 5G MFCN network, the simulation results are worse than that of the Study 5 where the 5G MFCN network is modelled as multi-sites (cluster of 19 tri-sector sites: 57 cells) cellular network.

The interference from 5G MFCN BS to WBB LMP BS was also simulated, the simulation results show LMP BS suffers a lot of interference from 5G MFCN due to receiver blocking as well as out of band emissions from 5G MFCN above 3800 MHz. An improved WBB LMP BS receiver blocking level improves the situation, but is not sufficient.

The conclusions of this study\_2 are that: 1) For unsynchronised operation between WBB LMP in 3800-3860 MHz and 5G MFCN below 3800 MHz is difficult without coordination; 2) The LMP BS with in-band power level <= 30 dBm/100 MHz in 3860-4200 MHz can co-exist with 5G MPCN below 3800 MHz in unsynchronised operation without coordination; 3) synchronization or semi-synchronization between WBB LMP and 5G MFCN is a good solution to ensure a good co-existence.

### Study 3 – Adjacent-band co-existence study between unsynchronised WBB LMP local area network and 5G MFCN for 100 m separation distance [Orange]

Study is in A2.1.3.

This study provides simulation results of interference from WBB LMP BS to 5G MFCN BS and of interference from 5G MFCN to WBB LMP. In the simulation, both 1-O and 1-H 5G MFCN base station out of band blocking levels are considered. The microcellular 5G MFCN network is modelled with a cluster of 19 tri-sector sites (57 cells), the victim 5G MFCN BS is placed in the centre of this network cluster, in this way the intra-network intercell interference is taken into account in the 5G MFCN uplink throughput loss. 100 m separation distance between the 5G MFCN reference cell base station and LMP base station was used in the simulations.

WBB low power non-AAS BS with an EIRP of 31 dBm/100 MHz with an antenna gain of 12 dBi is considered. Two types of WBB medium power base stations are considered: 1) Non-AAS BS with transmit power of 49 dBm/100 MHz EIRP and 51 dBm/100 MHz EIRP with an antenna gain of 16 dBi; 2) AAS BS with 4x4 AAS antenna configuration (antenna gain 18.5 dBi), the AAS BS transmit power of 49 dBm/100 MHz EIRP (30.5 dBm/100 MHz TRP) and 51 dBm/100 MHz EIRP (32.5 dBm/100 MHz TRP).

Based on the simulation results, the following conclusions can be made:

1. The regulatory technical conditions for WBB LP BS in 3800-4200 MHz in unsynchronised operation with 5G MFCN below 3800 MHz - Table 42.

Table 42: The regulatory technical conditions for WBB LP BS in 3800-4200 MHz in unsynchronised operation with 5G MFCN below 3800 MHz

|  |  |  |
| --- | --- | --- |
|  | Maximum In-band Power Limit and antenna height | Additional Baseline OOBE below 3800 MHz per cell |
| Low Power Non-AAS BS | 31 dBm/100 MHz (EIRP per cell)  Antenna height <= 10 m | -45 dBm/MHz conducted |

1. The regulatory technical conditions for WBB MP BS in 3860-4200 MHz in unsynchronised operation with 5G MFCN below 3800 MHz - Table 43.

Table 43: The regulatory technical conditions for WBB MP BS in 3860-4200 MHz in unsynchronised operation with 5G MFCN below 3800 MHz

|  |  |  |
| --- | --- | --- |
|  | Maximum In-band Power Limit and antenna height | Additional Baseline OOBE below 3800 MHz per cell |
| Medium Power Non-AAS BS | 51 dBm/100 MHz (EIRP per cell) | -45 dBm/MHz conducted |
| Medium Power AAS BS | 51 dBm/100 MHz (EIRP per cell)  (33 dBm/100 MHz TRP per cell) | -45 dBm/MHz TRP |

The simulation results show that for Medium Power AAS BS operating in 3860-4200 MHz, an OOBE of -35 dBm/MHz TRP can provide a sufficient protection, but in Rural Area with large cell size of 5G MFCN network, an OOBE of WBB MR AAS BS should be -54 dBm/MHz TRP.

1. The regulatory technical conditions for WBB LMP BS in 3800-4200 MHz in synchronised operation or semi-synchronised operation with 5G MFCN below 3800 MHz - Table 44.

Table 44: The regulatory technical conditions for WBB LMP BS in 3800-4200 MHz in synchronised operation or semi-synchronized operation with 5G MFCN below 3800 MHz

|  |  |  |
| --- | --- | --- |
|  | Maximum In-band Power Limit | Additional Baseline OOBE below 3800 MHz |
| Non-AAS BS | 51 dBm/100 MHz (EIRP per cell) | -25 dBm/MHz conducted per cell below 3800 MHz |
| AAS BS | 51 dBm/100 MHz (EIRP per cell)  (33 dBm/100 MHz TRP per cell) | -23 dBm/MHz TRP per cell below 3800 MHz |

1. The regulatory technical conditions for WBB LMP terminals in 3800-4200 MHz in synchronised operation or semi-synchronised operation with 5G MFCN below 3800 MHz - Table 45.

Table 45: The regulatory technical conditions for WBB LMP terminals in 3800-4200 MHz in synchronised operation or semi-synchronised operation with 5G MFCN below 3800 MHz

|  |  |  |
| --- | --- | --- |
|  | Maximum In-band Power Limit | Power control |
| All type terminals including Mobile, Nomadic, IoT, Machine, FWA | 28 dBm EIRP | Obligatory |

1. When the WBB LMP BS and 5G MFCN smallcell BS are deployed in the same street in outdoor area or in the same indoor area, synchronization or other coordination measures are required.

Study 3 provides simulation results of interference from WBB LMP BS to 5G MFCN BS with Out-of-band emission level of one category of Macro AAS defined in the standard (BS type 1-O) with the assumption that WBB LMP BS and 5G MFCN BS separation distance is fixed as 100 m. The simulation scenario is that the 5G MFCN network is modelled as a cluster of 57 cells, the victim 5G MFCN BS is placed in the middle of the network cluster, so the intra-network intercell interference was taken into account. Based on the simulation results, the following BEM elements are proposed: 1) For unsynchronised operation, the WBB LMP BS in-band power limit should be set as <= 31 dBm/100 MHz (EIRP per cell) with antenna height <=10 m; The additional baseline requirement of OOBE for WBB LMP BS is -26 dBm/5 MHz EIRP per cell below 3800 MHz; 2) For synchronised operation or semi-synchronised operation, the WBB in-band EIRP can be limited to 51 dBm/100 MHz per cell/sector for both Medium Power non-AAS BS and AAS BS with Additional baseline OOBE of -7 dBm/5 MHz EIRP per cell/sector for non-AAS BS and -23 dBm/5 MHz TRP per cell/sector for AAS BS below 3800 MHz. 3) All type terminals including Mobile, Nomadic, IoT, Machine, FWA with in-band power limit of 28 dBm EIRP with power control activation as an obligatory requirement.

Considering that two major European 5G MFCN vendors have confirmed that the 5G AAS MFCN BSs deployed in Europe within 3400-3800 MHz belong to another category (1-H) more robust to interference due to blocking, this study should be updated with the inclusion of 1-H BS assumption for the receiver out of band blocking requirement.

### Study 4 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in semi-synchronised operation [Qualcomm]

Study is in A2.1.4.

This study focuses on the specific sub-case of semi-synchronised operation, in which DL to UL modifications are allowed. This case is especially interesting for those scenarios where WBB LMP networks require more UL resources than those available in the frame structure of the MFCN network. In the case of semi-synchronised operation with DL to UL modifications, only the default DL transmission direction in the default frame structure may be modified into UL. As a result, if DL to UL modifications are only performed by the WBB LMP networks, MFCN below 3800 MHz will not receive additional BS-to-BS cross interference from the WBB LMP network. While semi-synchronised operation is also possible employing UL to DL modifications, this case is not considered in this study since this would cause additional BS-to-BS cross interference from the WBB LMP network to MFCN below 3800 MHz.

Table 46 summarises results of the reduction of the separation distance to achieve an average UL TP loss of 5% in the WBB LMP network for different scenarios compared to unsynchronised operation. For no clutter loss the reduction of the separation distance is between 47% and 76%, while for clutter at the receiver side a reduction of the separation distance by 27% to 50% can be achieved.

Table 46: Reduction of the separation distance with semi-synchronised compared to unsynchronised operation to achieve 5% average UL TP loss

|  |  |  |  |
| --- | --- | --- | --- |
| # | Description | No clutter | Clutter at receiver side |
| 1 | WBB LP BS Non-AAS, urban | 51% | 27% |
| 2 | WBB LP BS Non-AAS, rural | 47% | 30% |
| 3 | WBB LP BS AAS, urban | 76% | approx. 50% |
| 4 | WBB LP BS AAS, rural | 72% | 49% |

Table 47 summarises the proposed tolerable interference margin in dB depending on the percentage of synchronised slots for low and medium power WBB networks. For completeness, in case AAS BS will not be allowed in the regulation, also simulation results for medium power WBB networks with non-AAS have been added, which were obtained by replacing the AAS antennas with non-AAS antennas for the WBB MP network in scenario 4. Comparing the tolerable interference margin between AAS and non-AAS for MP and 90% synchronised slots, the I tolerable interference margin increases by more than 12 dB when employing AAS, which shows that due to the adaptive antenna concept and the pointing of the beams the tolerable interference can be further reduced compared to non-AAS.

Table 47: Tolerable interference margin in dB compared to unsynchronised operation for semi-synchronised operation depending on the percentage of synchronised slots for different scenarios

|  |  |  |  |
| --- | --- | --- | --- |
|  | Tolerable interference margin in dB (Note) | | |
| **% synchronised slots** | **Non-AAS LP** | **AAS MP** | **Non-AAS MP** |
| 0 | 0.0 | 0.0 | 0.0 |
| 10 | 0.5 | 0.7 | 0.6 |
| 20 | 1.1 | 1.5 | 1.2 |
| 30 | 1.7 | 2.4 | 2.0 |
| 40 | 2.4 | 3.6 | 2.9 |
| 50 | 3.4 | 5.0 | 4.1 |
| 60 | 4.5 | 7.0 | 5.6 |
| 70 | 6.0 | 10.1 | 7.8 |
| 80 | 8.4 | 16.2 | 11.6 |
| 90 | 14.1 | 32.9 | 20.3 |
| Note: Tolerable interference margin of semi-synchronised operation compared to unsynchronised operation in dB depending on the percentage of slots synchronised with the MFCN network below 3800 MHz. | | | |

In summary, by using the tolerable interference margin in Table 47 the I/N thresholds for semi- synchronised operation can be obtained for LP and MP WBB networks depending on the percentage of DL to UL modifications and using the I/N threshold for unsynchronised operation as a reference.

The particular semi-synchronisation could be further investigated as part of relevant toolbox in order to implement this approach on case-by-case basis in order to ensure more efficient usage of the spectrum as appropriate.

Study 4 describes the semi-synchronisation, a special case in which only DL to UL modifications are allowed to avoid interference from WBB LMP to 5G MFCN. With respect to the regulatory conditions for semi-synchronised operation with DL to UL modifications, it is recommended that the BEM below 3800 MHz should be identical to synchronised operation.

### Study 5 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in indoor area of the same building in unsynchronised operation [Orange]

Study is in A2.1.5.

Based on 5% throughput loss.

Study 5 provides simulations of interference from WBB LMP indoor smallcell BS to 5G MFCN indoor smallcell BS in unsynchronised operation, the simulation results show that the co-existence between WBB LMP indoor BS and 5G MFCN smallcell indoor BS in the same room is difficult, even with a reduced conducted OOBE level of -60 dBm/MHz for WBB LMP indoor BS. It is possible to deploy WBB LMP indoor BS and 5G MFCN indoor BS in different rooms on the same floor or on different floor. The study results show the indoor deployment of WBB LMP and 5G MFCN should be in synchronised operation or coordinated when they are in unsynchronised operation.

### Study 6 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in indoor/outdoor/urban/suburban/rural area in unsynchronised operation [France]

The study in A2.1.6 . The study is based on protection criteria of I/N=-6 dBm

The Study\_6 proposed a combination of WBB LMP out-of-band emission level+blocking requirement coordination method for WBB LMP deployment in unsynchronised operation with 5G MFCN: based on I/N=-6 dB protection, by considering the WBB LMP BS OOBE and 5G MFCN BS receiver selectivity (in-band and out of band blocking for 5G MFCN BS type 1-H and 1-O), the MFCN protection pfd level or field strength level at the border of WBB licensed area. This threshold was derived using I/N=-6dB protection criterion for MFCN and an 80th percentile of 5G MFCN BS AAS antenna gain (due to its varying nature) for different environments (Urban, Sub-urban, Rural).

The examples of the calculated field strength levels at border of WBB licensed area to be measured at the 5G MFCN BS antenna height are summarised in the Table below.

Table 48: FS value at border of WBB licensed area to be measured at the 5G MFCN BS antenna height

|  |  |
| --- | --- |
| Environment | FS below 3800 MHz |
| Urban | 34.5 |
| Sub-urban | 32.) |
| Rural | 32. |

The coordination process is to be decided at national level on a case-by-case basis.

The following technical conditions are proposed to facilitate and then reduce the number of coordination cases:

Table 49: WBB LP Non-AAS BS

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range | OOBE  <3800 MHz | In-block Power | Receiver blocking  <3800 MHz |
| 3800-4200 MHz | -45 dBm/MHz conducted | 31 dBm/100 MHz EIRP | -15 dBm at 6 dB desens |

Table 50: WBB MP Non-AAS and AAS BS

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range | OOBE  <3800 MHz | In-block Power | Receiver blocking  <3800 MHz |
| 3800-4200 MHz | -45 dBm/MHz conducted for MP non-AAS BS  -45 dBm/MHz TRP for MP AAS BS | 51 dBm/100 MHz EIRP | -15 dBm at 6 dB desens |

### Study 7 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Ericsson]

Study is in A2.1.7.

In this study a monte-Carlo analysis is performed using SEAMCAT to analyse coexistence conditions between unsynchronised WBB LMP and MFCN below 3800 MHz. A single WBB LMP BS (non-AAS / AAS) is placed in LOS of a 5G MFCN BS (AAS / non-AAS). Appropriate antenna pattern and down tilt considered as in agreed parameters table above. Minimum separation distance of 100 m between the WBB LMP BS and the 5G MFCN BS is assumed considering the dense urban/ sub-urban environment. The distance between the BS is incrementally increased until uplink throughput loss at 5G MFCN BS is less than 5%. Furthermore, effect of strict block edge mask (BEM), guard band and in-block power reduction are also analysed for better coexistence.

The study results shows that adjacent channel unsynchronised coexistence between outdoor MFCN below 3800 MHz and WBB LMP above 3800 MHz is quite challenging as technical conditions will be too restrictive.

Separation distance of at least 10km is needed between MFCN and WBB MP networks to keep the interference level < 5% in MFCN UL throughput. The study also shows that by defining only a strict BEM will not solve the problem, blocking impact from WBB LMP systems also needs to be considered for which guard band of at least 60 MHz is needed between the two networks.

The impact of MFCN macro-BS interference towards unsynchronised WBB LMP BS is not analysed in this study. However, considering the high power of macro-BS the separation distance could be considerably large to achieve the desirable quality of service in a WBB LMP network depending upon the use case

For efficient use of spectrum synchronize operation seems a better option in case enough geographical or frequency separation is not available.

Study 7 is quite similar to the Study 2 with Monte-Carlo simulations of interference from WBB LMP BS to 5G MFCN by modelling the local area network with a single BS and 5G MFCN network as a single BS, this single BS to single BS simulation scenario does not take into account the inter-cell interference within 5G MFCN network, the simulation results are worse than that of the Study 3 where the 5G MFCN network is modelled as multi-sites (cluster of 19 tr-sector sites: 57 cells) cellular network. Both Study 2 and Study 7 considered the 5G MFCN BS type 1-H with an out of band blocking level of -15 dBm at frequency off\_set of 60 MHz. Study 7 considered a 5G MFCN BS receiver 5 dB noise figure, while the study 2 used a 5G MFCN BS noise figure of 3 dB.

The interference from 5G MFCN to WBB LMP was not studied.

The conclusions of the Study 7 based on 100 m separation distance and 5% 5G MFCN (AAS BS) UL throughput loss can be summarised as:

Table 51: Technical conditions for WBB LMP non-AAS BS

|  |  |  |
| --- | --- | --- |
| Frequency range | OOBE  <3800 MHz | In-block Power |
| 3800-3860 MHz | -40 dBm/MHz EIRP | 28 dBm/100 MHz EIRP |
| 3860-4200 MHz | -40 dBm/MHz EIRP | 51 dBm/100 MHz EIRP |

Table 52: Technical conditions for WBB MP AAS BS

|  |  |  |
| --- | --- | --- |
| Frequency range | OOBE | In-block Power |
| 3800-3860 MHz | -43 dBm/5 MHz TRP | 23.2 dBm/100 MHz EIRP |
| 3860-4200 MHz | -43 dBm/5 MHz TRP | 51 dBm/100 MHz EIRP |

### Summary and Conclusions

Summary

The conclusions drawn from the studies in this Report are strongly correlated to the input assumptions used in the various studies. If local or national circumstances are different from those assumptions e.g. clutter, availability of terrain information density of existing and planned/future deployments, then different coexistence conclusions may be reached.

All studies assumed unsynchronised WBB LMP operation with in band EIRPs of up-to 31 dBm/100 MHz for WBB LP and up-to 51 dBm/100 MHz for WBB MP base stations.

There are 4 issues identified by the results of the studies:

* Issue 1: Need for lower unwanted emission levels for unsynchronised WBB LMPs to protect MFCN below 3.8 GHz
* Issue 2: Need for frequency separation for unsynchronised WBB LMPs to protect MFCN below 3.8 GHz due to MFCN receiver blocking, in particular with WBB MP BS.
* Issue 3: Need for defining blocking levels below 3.8 GHz for WBB LMPs to ensure they are not impacted by the emissions of MFCN below 3.8 GHz
* Issue 4: Need for defining the maximum EIRP for WBB terminals

The studies were performed based on two protection criteria. Study 1 and Study 6 used the I/N protection criterion (i.e., I/N = -6dB), while Studies 2, 3, 5, 7 used the throughput loss metric (i.e. throughput loss not to be exceeded by more than 5%)

Issue 1 (unwanted emissions below 3.8 GHz):

The conclusions from Study 3, Study 6 and Study 7 regarding the need for lower unwanted emissions for WBB LMPs to protect MFCN below 3.8 GHz are shown in Table 53.

Table 53: The conclusions from Study 3, Study 6 and Study 7 regarding the need for lower unwanted emissions for WBB LMPs to protect MFCN below 3.8 GHz

|  |  |  |  |
| --- | --- | --- | --- |
| Studies | Low Power unwanted emissions below 3.8 GHz | Medium Power non-AAS unwanted emissions below 3.8 GHz | Medium Power AAS unwanted emissions below 3.8 GHz |
| Study 3 | -45 dBm/MHz conducted | -45 dBm/MHz conducted | -45 dBm/MHz TRP |
| Study 6 | -45 dBm/MHz conducted | -45 dBm/MHz conducted | -45 dBm/MHz TRP |
| Study 7 | -40 dBm/MHz EIRP | -40 dBm/MHz EIRP | -43 dBm/5 MHz TRP |

* Study 7 considered throughput loss metric for the MFCN and the Monte-Carlo simulation was performed over a single MFCN Macro BS isolated from the network i.e. without calculating intra-network inter-cell interference (i.e. interference caused from adjacent cells of the same MFCN) in the assessment of the throughput loss.
* Such approach may result in overestimating the degradation of the MFCN throughput. [if the reference throughput (over which the loss is calculated) did not cover the intra-network intercell interference and the associated conclusion (e.g. -43dBm/5 MHz TRP for WBB MP AAS, -40dBm/MHz EIRP for WBB LMP non-AAS) would appear to be very pessimistic and then not realistic.]

Issue 2 (need for frequency separation from 3.8 GHz border)

Study 3 and Study 7 conclude that unsynchronised WBB LMPs to prevent causing interference to MFCN below 3.8 GHz due to the MFCN receiver blocking, a 60 MHz frequency separation is needed from the 3.8 GHz border. Analysis in Study 7 suggests that by defining only a strict BEM will not solve the blocking problem. The impact from WBB MP systems also needs to be considered for which a frequency separation of at least 60 MHz is needed between the two networks. Analysis in Study 3 suggests that for Medium Power AAS BS operating in 3860-4200 MHz, an OOBE of -35 dBm/MHz TRP can provide sufficient protection, but in Rural Areas with large cell size of 5G MFCN network, an OOBE of WBB MR AAS BS should be -54 dBm/MHz TRP.

Issue 3 (blocking levels below 3.8 GHz for WBB LMP receivers)

Study 6 suggests that to avoid interference from MFCN below 3.8 GHz, WBB LMP receivers should have blocking level of -15 dBm at 6 dB desensitisation below 3.8 GHz.

Issue 4 (WBB terminal maximum power limits)

Study 2 and Study 3 suggest to limit the WBB terminal maximum power as 28 dBm EIRP for all types of WBB terminals (Mobile, Nomadic; IoT, Machine, FWA) with power control activation as an obligation.

Conclusions

As a result of the studies, the following technical conditions for unsynchronised WBB LMPs in 3.8-4.2 GHz would reduce the need for coordination with MFCN BS below 3.8 GHz - Table 54 and Table 56.

Table 54: In-block power limit in 3800-4200 MHz

|  |  |  |
| --- | --- | --- |
|  |  |  |
| WBB Low Power non-AAS BS | 31 dBm/100 MHz e.i.r.p per BS (Sector) | For other block size BW, a conversion factor 10\*log10(BW/100) should be added |
| WBB Medium Power non-AAS BS | 51 dBm/100 MHz e.i.r.p per BS (Sector) | For other block size BW, a conversion factor 10\*log10(BW/100) should be added |
| WBB Medium Power AAS BS | 51 dBm/100 MHz e.i.r.p per BS (Sector) | For other block size BW, a conversion factor 10\*log10(BW/100) should be added |
| WBB Terminals (Mobile, Nomadic, IoT, Machine, FWA terminals) | 28 dBm EIRP | Power Control activation is obligatory |

Out of band emission level below 3800 MHz (to protect MFCN). Studies 3 and 7 assumed minimum separation distance of 100 m, Study 6 assumed conditions with smaller cell sizes, which will reduce the coordination cases - Table 55.

Table 55: Additional measures which will reduce the coordination cases

|  |  |
| --- | --- |
| Additional OOBE below 3800 MHz | Frequency separation related to of MFCN BS receiver blocking |
| -45 dBm/MHz conducted per BS (Sector) for LP & MP non-AAS BS (Sector)  -45 dBm/MHz TRP per BS for MP AAS BS (Sector) | With 60 MHz frequency separation from 3.8 GHz border for MP non-AAS BS  With 60 MHz frequency separation from 3.8 GHz border for MP AAS BS |

Suggested receiver blocking level below 3800 MHz (to tolerate interference from MFCN) - Table 56.

Table 56: Suggested receiver blocking level below 3800 MHz (to tolerate interference from MFCN

|  |  |  |
| --- | --- | --- |
|  |  |  |
| Additional receiver blocking requirement | -15 dBm for LP & MP non-AAS BS  -15 dBm per BS for MP AAS BS | Wanted signal level: P\_ref\_sens +6 dB  For WBB MP AAS BS, the measurement point for both wanted signal and interference signal is after AAS antenna, the interfering signal should be a 5 MHz NR signal |

Note: Frequency offset may be needed to achieve this blocking level

Additional considerations for the coordination of unsynchronised WBB LMPs with MFCN below 3.8 GHz

* Through separation distance: The results of Study 1, presented in the form of geographical separation (separation distances), provide useful information for the coordination between WBB LMPs and MFCN using the parameters of the studies (i.e. without making use of the suggested technical conditions described in the above tables).
* Through protection threshold: Study 6 provides an example of required field strength value at the border of the service area of WBB LMP measured at the 5G MFCN BS antenna height in different environments - Table 57.

Table 57: An example of required field strength value at the border of the service area of WBB LMP measured at the 5G MFCN BS antenna height in different environments

|  |  |
| --- | --- |
| Environment | Field strength level below 3800 MHz at WBB LMP allotment edge and victim MFCN BS antenna height |
| Urban | 34.5 dBµV/m/100 MHz |
| Sub-urban | 32.8 dBµV/m/100 MHz |
| Rural | 32.2 dBµV/m/100 MHz |

* Through synchronization: Study 5 examines the interference from WBB LMP indoor smallcell BS to 5G MFCN indoor smallcell BS suggesting that coexistence in the same room is challenging, while coexistence in different rooms or different floors of the same building is possible. The study results also show the indoor deployment of WBB LMP and 5G MFCN should be in synchronised operation or coordinated when they are in unsynchronised operation;
* Through semi-synchronization: Study 4 examines the effects of semi-synchronisation in coexistence between WBB LMPs and MFCN below 3.8 GHz. The results of the study suggest that, if DL to UL modifications are only performed by the WBB LMP networks, MFCN below 3800 MHz will not receive additional BS-to-BS cross interference from the WBB LMP network, compared to the synchronised case. The study concludes that compared to the unsynchronised case, using semi-synchronisation the separation distances (based on the throughput loss metric) can be reduced by a range of 27-72 % depending on the environment and the clutter assumed.

In order to facilitate the deployment of terrestrial wireless broadband systems providing local-area network connectivity and when implementing harmonised technical conditions, administrations may want to be able to complement certain aspects of their use of the band 3.8-4.2 GHz to national circumstances, in order to manage remaining coordination cases not addressed by the harmonised technical conditions (for example on synchronisation and/or frequency separation requirements). CEPT is developing a toolbox for administrations to provide guidance on the approach to coexistence in the band.

## Between DECT-2020 NR and MFCN below 3.8 GHz

1. The current study is intended to be replaced by the new study in document [ECC(24)025](https://api.cept.org/documents/ecc/82194/ecc-24-025_update-on-studies-between-dect-2020-nr-and-adjacent-mfcn-below-3_8-ghz) which has not been fully reviewed in ECC

### Summary

The focus of this study was to assess the risk of interference from DECT-2020 NR WBB LMP into MFCN below 3.8 GHz. This analysis adopts a Monte Carlo approach to assess the risk, from a statistical basis, of interference into MFCN on the basis that the location of MFCN base stations may not be known.

The analysis applied the agreed technical and propagation parameters and the protection requirements for the MFCN base station receiver. Net Filter Discrimination was used to combine the DECT-2020 NR transmitter spectrum emission mask and MFCN receiver mask (based on values taken from the relevant parameters in this report) into an NFD value. The NFD calculation is extended to cover in-band and out of band blocking of the MFCN base station receiver. As the frequency separation increases the integration of the transmit and receiver masks changes accordingly, with the NFD levelling off at 3915 MHz.

The study assumes outdoor operation of 6.912 MHz bandwidth DECT-2020 NR operating in the centre of the 10 MHz channel raster at 23 dBm e.i.r.p. (0 dBi antenna gain) with transmission power control to the minimum transmission of -40 dBm (see ETSI TR 103 943 V1.1.1 (2024-01) [9]) and an urban macro MFCN, with a 100 MHz MFCN carrier centred at 3.75 GHz, with assumed NFDs for DECT-2020 NR immediately adjacent to the 3.8 GHz border, i.e. 21.0574 dB at 3.805 GHz and the other at the point where the NFD levels off at 29.1195 dB at 3.915 GHz. Clutter is applied at the DECT-2020 NR end based on Recommendation ITU-R P.2108 [10].

The parameters for MFCN are taken from Tables 23 and 24. The MFCN base station is placed at a fixed location on a smooth Earth. A mobile terminal is randomly located within the service area of the base station (600 m cell range for the urban macro case) and the base station antenna is electronically steered towards the mobile terminal. The DECT-2020 NR device is also randomly placed within the base station service area and the interference from DECT-2020 NR at the base station receiver is calculated based on agreed parameters.

To statistically characterise the risk of interference the simulation is carried out for 1 million samples. The percentage of instances where the interference from DECT-2020 NR device exceeds the protection threshold of -6 dB I/N at the base station receiver is calculated over these samples and are provided in Table 58. As can be seen, this technical analysis indicates that for DECT-2020 NR operating at 3.805 GHz the percentage of locations of DECT-2020 NR transmitters that exceed the protection criteria for MFCN is less than 5% and improves to 2% as the frequency separation is increased.

This study indicates a low risk of interference into MFCN from adjacent WBB LMP devices operating at a maximum of 23 dBm e.i.r.p. and employing transmission power control.

Table 58: Percentage of DECT-2020 NR device locations that exceed -6 dB I/N at the MFCN base station receiver (Urban Macro case under assumptions of minimum and maximum NFD and with TPC applied to DECT-2020 NR)

|  |  |  |  |
| --- | --- | --- | --- |
| MFCN Scenario | Frequency of DECT‑2020 NR | NFD | % locations where DECT-2020 NR interferer exceeds -6 dB I/N at MFCN base station receiver |
| Urban Macro | 3.805 GHz | -21.0574 dB | 4.27%   1. Updated study indicates 1.76% |
| Urban Macro | 3.915 GHz | -29.1195 dB | 2.01 %   1. Updated study indicates 0.515% |

# Conclusions

1. To be the same text as executive summary after the resolution of public consultation comments of that section
2. Studies on in-band services
   1. Between WBB LMP in the 3.8-4.2 GHz frequency band
      1. Study 1 – Co-channel coexistence study between WBB LMPs in the band 3.8-4.2 GHz for unsynchronised case [Nokia]

Document [ECC PT1(24)008 Annex 1 App 1.1.1](https://api.cept.org/documents/ecc-pt1/81269/ecc-pt1-24-008-annex-1-app-1_1_1_nokia_between-wbb-lmp-co-ch-unsynch). Study is based on I/N protection ratio. Study is approved.

* + 1. Study 2 – Co-channel and adjacent channel coexistence study between WBB LMPs in the band 3.8-4.2 GHz for unsynchronised case [Orange]

Document [ECC PT1(24)060 Annex 12 App 1.1.2](https://api.cept.org/documents/ecc-pt1/81631/ecc-pt1-24-060-annex-12-app-1_1_2_orange_in-band-wbb-lmps). Study is based on 5% throughput loss. Study is approved.

* 1. Between WBB LMP and FS in 3.8-4.2 GHz
     1. Study 1 – Sharing study between WBB LMP and FS in the band 3.8-4.2 GHz [Germany]

Document [ECC PT1(24)008 Annex 1 App 1.2.1](https://api.cept.org/documents/ecc-pt1/81271/ecc-pt1-24-008-annex-1-app-1_2_1_germany_wbb-lmp-vs-fs). Study is approved.

* + 1. Study 2 – Sharing study between WBB LMP and FS in the band 3800-4200 MHz [Italy]

Document [ECC PT1(24)008 Annex 1 App 1.2.2](https://api.cept.org/documents/ecc-pt1/81272/ecc-pt1-24-008-annex-1-app-1_2_2_italy_wbb-lmp-vs-fs). Study is approved

* + 1. Study 3 – Sharing study between WBB LMP and FS in the band 3.8-4.2 GHz [Ericsson]

Document [ECC PT1(24)060 Annex 12 App 1.2.3](https://api.cept.org/documents/ecc-pt1/81632/ecc-pt1-24-060-annex-12-app-1_2_3_ericsson_wbb-lmp-vs-fs). Study is approved

* 1. Between WBB LMP and FSS in 3.8-4.2 GHz
     1. Study 1 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Intelsat]

Document [ECC PT1(24)008 Annex 1 App 1.3.1](https://api.cept.org/documents/ecc-pt1/81274/ecc-pt1-24-008-annex-1-app-1_3_1_intelsat_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 2 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Nokia]

Document [ECC PT1(24)008 Annex 1 App 1.3.2](https://api.cept.org/documents/ecc-pt1/81275/ecc-pt1-24-008-annex-1-app-1_3_2_nokia_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 3 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [France]

Document [ECC PT1(24)008 Annex 1 App 1.3.3](https://api.cept.org/documents/ecc-pt1/81276/ecc-pt1-24-008-annex-1-app-1_3_3_france_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 4 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Ericsson]

Document [ECC PT1(24)008 Annex 1 App 1.3.4](https://api.cept.org/documents/ecc-pt1/81277/ecc-pt1-24-008-annex-1-app-1_3_4_ericsson_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 5 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Luxembourg]

Document [ECC PT1(24)060 Annex 12 App 1.3.5](https://api.cept.org/documents/ecc-pt1/81633/ecc-pt1-24-060-annex-12-app-1_3_5_luxembourg_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 6 – Sharing study between WBB LMP and FSS in the band 3.8-4.2 GHz [Germany]

Document [ECC PT1(24)008 Annex 1 App 1.3.6](https://api.cept.org/documents/ecc-pt1/81279/ecc-pt1-24-008-annex-1-app-1_3_6_germany_wbb-lmp-vs-fss-co-ch). Study is approved.

* + 1. Study 7 – Additional sharing studies between WBS LMP base stations and FSS earth stations in the band 3.8-4.2 GHz [Ericsson]

Document [ECC PT1(24)060 Annex 12 App 1.3.7](https://api.cept.org/documents/ecc-pt1/81634/ecc-pt1-24-060-annex-12-app-1_3_7_ericsson_wbb-lmp-vs-fss-co-ch). Study is approved

* 1. Between DECT-2020 NR and other radio applications in the band 3.8-4.2 GHz

Document [ECC PT1(24)060 Annex 12 App 1.4](https://api.cept.org/documents/ecc-pt1/81635/ecc-pt1-24-060-annex-12-app-1_4_dect-forum_dect-nr-studies). Study is approved.

* 1. Between WBB LMP and other applications
     1. Study 1 – Sharing study between WBB LMP and VGOS in 3.8-4.2 GHz [Germany]

Document [ECC PT1(24)008 Annex 1 App 1.5.1](https://api.cept.org/documents/ecc-pt1/81282/ecc-pt1-24-008-annex-1-app-1_5_1_germany_wbb-lmp-vs-gow-co-ch). Study is approved.

1. Studies on services in the adjacent band
   1. Between WBB LMP and MFCN below 3.8 GHz
      1. Study 1 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Nokia]

Document [ECC PT1(24)008 Annex 1 App 2.1.1](https://api.cept.org/documents/ecc-pt1/81283/ecc-pt1-24-008-annex-1-app-2_1_1_nokia_wbb-lmp-vs-mfcn-unsynch). For WBB MP non sub array model and for MFCN sub array model is used. Study is approved.

* + 1. Study 2 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Orange]

Document [ECC PT1(24)008 Annex 1 App 2.1.2](https://api.cept.org/documents/ecc-pt1/81284/ecc-pt1-24-008-annex-1-app-2_1_2_orange_wbb-lmp-vs-mfcn-unsynch). For both WBB MP and MFCN the non-sub array model is used. Study is approved.

* + 1. Study 3 – Adjacent-band co-existence study between unsynchronised WBB LMP local area network and 5G MFCN for 100 m separation distance [Orange]

Document [ECC PT1(24)060 Annex 12 App 2.1.3](https://api.cept.org/documents/ecc-pt1/81636/ecc-pt1-24-060-annex-12-app-2_1_3_orange_wbb-lmp-vs-mfcn-100m-unsynch). Study is approved.

* + 1. Study 4 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in semi-synchronised operation [Qualcomm]

Document [ECC PT1(24)008 Annex 1 App 2.1.4](https://api.cept.org/documents/ecc-pt1/81286/ecc-pt1-24-008-annex-1-app-2_1_4_qualcomm_wbb-lmp-vs-mfcn-semi-synch). Study is approved.

* + 1. Study 5 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in indoor area of the same building in unsynchronised operation [Orange]

Document [ECC PT1(24)008 Annex 1 App 2.1.5](https://api.cept.org/documents/ecc-pt1/81287/ecc-pt1-24-008-annex-1-app-2_1_5_orange_wbb-lmp-vs-mfcn-indoor). Based on 5% throughput loss. Study is approved

* + 1. Study 6 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in indoor area /outdoor/urban/suburban/rural area in unsynchronised operation [France]

Document [ECC PT1(24)067\_Annex 04\_App 2.1.6](https://api.cept.org/documents/ecc-pt1/82169/ecc-pt1-24-067_annex-04_app-2_1_6_france_wbb-lmp-vs-mfcn-unsynch). Based on I/N=-6 dB protection ratio. Study is approved

* + 1. Study 7 – Adjacent-band co-existence study between WBB LMP and 5G MFCN in unsynchronised operation [Ericsson]

Document [ECC PT1(24)008 Annex 1 App 2.1.7](https://api.cept.org/documents/ecc-pt1/81289/ecc-pt1-24-008-annex-1-app-2_1_7_ericsson_wbb-lmp-vs-mfcn-unsynch). Study is approved.

* 1. Between DECT and MFCN below 3.8 GHz

1. The current study in the hyperlink below is intended to be replaced by the new study in document [ECC(24)025](https://api.cept.org/documents/ecc/82194/ecc-24-025_update-on-studies-between-dect-2020-nr-and-adjacent-mfcn-below-3_8-ghz) which has not been fully reviewed in ECC

Document [ECC PT1(24)008 Annex 1 App 2.2](https://api.cept.org/documents/ecc-pt1/81291/ecc-pt1-24-008-annex-1-app-2_2_dect-forum_dect-nr-vs-mfcn). Study is approved.

1. Example deployment scenarios for local area networks in the band 3.8-4.2 GHz
   1. Example of coverage of an industrial site

In this Annex, we present an example use-case using a commercially available 3GPP system in the 3.8-4.2 GHz frequency band, demonstrating how different Base Station (BS) deployment configurations can affect the coverage and the deployment complexity of local area networks in this frequency band for the coverage of a given industrial site.

This Annex is meant as example of actual deployment and do not consider sharing with in-band and adjacent band services.

* + 1. Introduction

In addressing the EC Mandate tasks on the shared use of the 3.8-4.2 GHz band for local area networks, it is important to capture and address the wide range of use-cases and requirements of potential users, such as enterprises and local communities. In this contribution, we present an example use-case using a commercially available system in the 3.8-4.2 GHz frequency band, demonstrating how different Base Station (BS) deployment configurations can affect the coverage and the deployment complexity of local area networks in this frequency band for the coverage of a given industrial site.

* + 1. Use cases and deployment environments

The 400 MHz available in the 3.8-4.2 GHz frequency band could enable terrestrial wireless broadband systems for local area networks to provide a variety of services for various users, such as local communities as well as industrial connectivity and automation. The wide range of use-cases for different industrial and non-industrial environments require different technical conditions to maximise capacity and cost-efficient connectivity for both indoor and outdoor environments.

Some industrial use-case examples in 3.8-4.2 GHz band are listed below, for both indoor and outdoor environments:

Indoors: Connectivity for remote asset monitoring and control, IoT based automation, quality and control management, predictive maintenance, energy optimisation etc.

Outdoors: Connectivity for logistics in ports, IoT services in agriculture, location tracking of moving assets, offshore operations etc.

* + 1. Coverage scenarios

In this section, we consider an outdoor industrial use-case – coverage of an industrial site near the sea (of an area of approximately 4km2). We evaluate the impact of different BS transmit power levels and antenna heights to the received signal strength at various locations around the industrial site. We assumed four different deployment scenarios to provide coverage to the 4km2 industrial area using a commercially available system.

Table 59: Network deployment scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Deployment Scenario | EIRP | BS height | Number of BS location | Number of Remote Radio Head (RRH) |
| 1 | 44 dBm | 15-40 m | 7 | 14 |
| 2 | 24 dBm | 15 m | 8 | 13 |
| 3 | 24 dBm | 25 m | 8 | 13 |
| 4 | 24 dBm | 5 m | 43 | 110 |

The received signal strength (Reference Signal Received Power, RSRP) is simulated at a receiver height of 1.5 m above ground.

* + - 1. Deployment Scenario 1

Table 2 summarises the parameters of a simulated local area network for deployment scenario 1. Figure 1 presents the received signal strength, in terms of RSRP. To achieve optimal coverage under this scenario, we have considered in our network planning the deployment of the same type of antennas at different heights between 15 and 40 metres. The results indicate that by deploying 14 RRHs[[8]](#footnote-9) in 7 BS locations it is possible to provide adequate coverage (RSRP ≥ -105 dBm) for 75.3% of the whole industrial site considered, with 33.8% of it having RSRP ≥ -90 dBm.

Table 60: Network parameters of deployment scenario 1

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| EIRP | 44 dBm |
| Bandwidth | 20 MHz |
| Base Station heights | 15-40 m |
| Number of BS locations | 7 |
| Number of RRHs | 14 |
| Receiver height | 1.5 m |

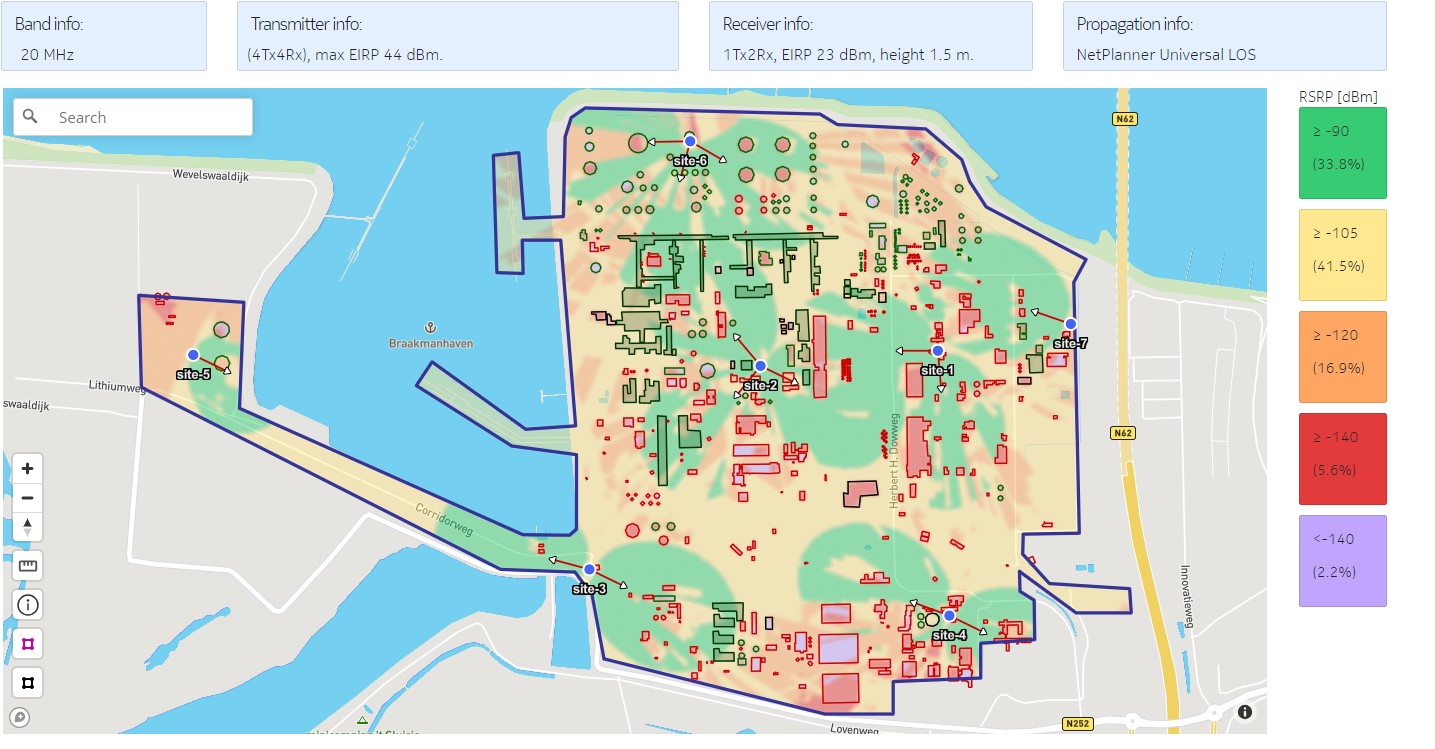


Figure 8: Simulated received signal strength (RSRP) of a local area network deployment as per the parameters of deployment Scenario 1

* + - 1. Deployment Scenario 2

To illustrate the importance and the impact of the transmit power levels in planning the coverage of the same area, we provide a comparison of the RSRP levels when deploying a local area network with lower BS power levels than those of deployment Scenario 1 and with fixed antenna heights at 15 m.

The following table summarises the parameters of a simulated local area network for deployment Scenario 2.

Table 61: Network parameters of deployment Scenario 2

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| EIRP | 24 dBm |
| Bandwidth | 20 MHz |
| Base Station height | 15 m |
| Number of BS location | 8 |
| Number of RRH | 13 |
| Receiver height | 1.5 m |

The following figure shows that by deploying 13 RRHs in 8 BS locations, adequate coverage (RSRP ≥ -105 dBm) is achieved only for 11.7% of the whole area considered, with 0% of it having RSRP ≥ -90 dBm.

A map of a city

Description automatically generated

Figure 9: Simulated received signal strength (RSRP) of a local area network deployment as per the parameters of deployment Scenario 2

* + - 1. Deployment Scenario 3

The same BS power level as Scenario 2 (i.e., 24 dBm) with a height of 25 m was considered to assess the impact on coverage.

Even if higher antenna heights are considered, as shown in Table 4, the coverage provided to the area of the industrial site, as seen in Figure 10, did not improve.

Table 62: Network parameters for deployment Scenario 3

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| EIRP | 24 dBm |
| Bandwidth | 20 MHz |
| Base Station height | 25 m |
| Number of BS location | 8 |
| Number of RRH | 13 |
| Receiver height | 1.5 m |

By deploying 13 RRHs in 8 BS location at 25 m height, adequate coverage (RSRP ≥ -105 dBm) is achieved for only 11.3% of the area, which is less than the coverage achieved in deployment Scenarios 1 and 2. This indicates that higher antenna heights, if considered independently, do not always present a solution for greater coverage. Therefore, having the possibility for deploying a range of antenna heights together with a range of BS transmit powers is a key aspect for finding an appropriate balance to overcome coverage challenges in industrial environments.

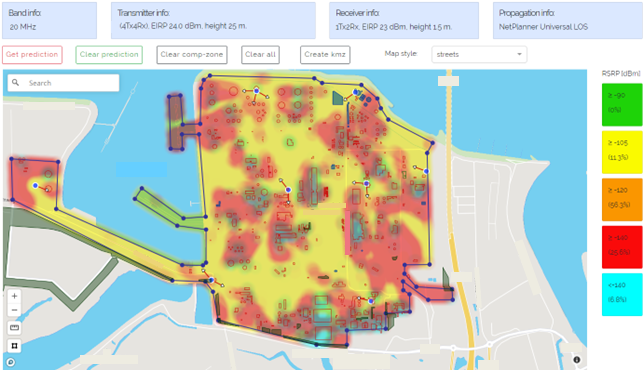


Figure 10: Simulated received signal strength (RSRP) of a local area network deployment as per the parameters of deployment Scenario 3

* + - 1. Deployment Scenario 4

Deployment Scenario 4 evaluates the impact to received signal strength levels for a local area network with BSs at 5 m height transmitting at 24 dBm (parameters in Table 5). To improve the coverage of the industrial site area, the number of RRHs and BS locations has been increased, compared to the previous scenarios. Therefore, as seen in Figure 4, by deploying 110 RRHs in 43 locations, adequate coverage is provided for 49.8% of the area, with just 4.3% of it having RSRP levels greater than or equal to -90 dBm.

Table 63: Network parameters for deployment Scenario 4

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| EIRP | 24 dBm |
| Bandwidth | 20 MHz |
| Base Station height | 5 m |
| Number of BS location | 43 |
| Number of RRH | 110 |
| Receiver height | 1.5 m |

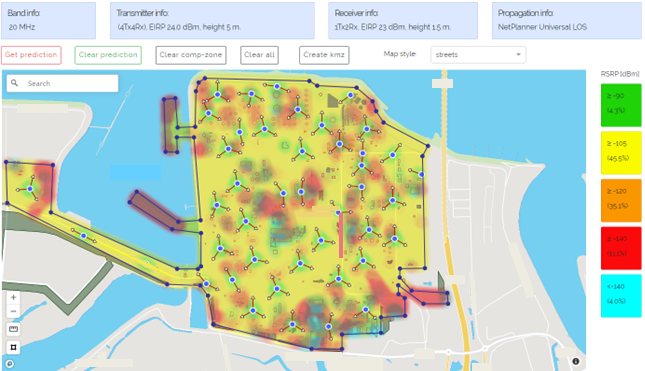


Figure 11: Simulated received signal strength (RSRP) of a local area network deployment as per the parameters of deployment Scenario 4

* + 1. Additional considerations

The results of the coverage studies of a specific industrial site under the four different deployment scenarios provided in the previous section, highlight that power limits and heights for BS deployments will impact the ability of potential users on how to utilise the 3.8-4.2 GHz band for the wide variety of industrial applications. Different environments and use-cases will require different deployment characteristics for local area networks in order to accommodate the coverage and capacity demands.

Furthermore, the need for identifying numerous suitable locations to deploy an extended number of BSs in industrial environments, as well as the requirement of extensive network planning to provide adequate coverage, will impose additional challenges and cost implications to enterprises. This would increase the risk of reduced adaptation and ecosystem development in the band. These aspects are contradictory to the “low cost – easy deployment” concept of the use of the 3.8-4.2 GHz band for local area networks.

* + 1. Conclusions

Table 64 summarises the coverage percentages of the area of the industrial site with RSRP levels greater or equal to -105 dBm at the receiver height of 1.5 m, for the four different deployment scenarios.

Table 64: Summary of percentage of area with adequate signal strength

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario No. | EIRP | BS antenna height | Number of BS location | Number of Remote Radio Head (RRH) | Percentage of area with RSRP ≥ -105 dBm |
| 1 | 44 dBm | 15-40 m | 7 | 14 | 75.3% |
| 2 | 24 dBm | 15 m | 8 | 13 | 11.7% |
| 3 | 24 dBm | 25 m | 8 | 13 | 11.3% |
| 4 | 24 dBm | 5 m | 43 | 110 | 49.8% |

Considering the wide range of industrial and local community type of use cases for the 3.8-4.2 GHz band, different applications will have different needs for coverage and capacity. We have presented a specific use-case of demonstrating the coverage requirements of an industrial site area (~4km2) for industrial operations. The results indicate that it is possible to provide adequate coverage for 75.3% of the area, using BSs with 44 dBm EIRP (14 RRHs in 7 locations) at heights between 15 and 40 metres. For the same area, when simulating BSs with lower power and fixed antenna heights (deployment Scenario 2 and 3), the coverage range was significantly reduced. Even when we simulated the coverage of the same area with a local area network of ~10x more RRHs in ~5x more BS locations (deployment Scenario 4), the range of adequate coverage was ~50% less compared to that achieved with the BS power levels of deployment Scenario 1.

The transmit level and the technical deployment parameters of the BSs in the 3.8-4.2 GHz band should be able to accommodate the variety of use-cases for verticals in a cost-efficient and easy-implementable manner in the different deployment environments. As an example, the use of local area networks for mining applications would require greater coverage in isolated locations, where incumbent use of the band is highly likely to be absent.

Furthermore, current use of incumbents in the 3.8-4.2 GHz as well as in the adjacent bands presents significant variations and differences among the CEPT countries.

* 1. Live testing between WBB LMP PMSE use case and 5G MFCN

This section presents results of live testing between WBB LMP PMSE use case and 5G MFCN on the occasion of the Coronation of HM King Charles III in May 2023 in a small area of London. The BBC, in association with Neutral Wireless, used in two 40 MHz bands blocks centred at 3835 MHz and 3875 MHz to implement a multicell network covering the procession route of 1 km. The guard band with the nearest mobile allocation at 3760 – 3800 MHz was 15 MHz. In order to accommodate a low latency constant bitrate encoder testbed while preserving the A/B spectrum reuse channel plan, an additional 40 MHz channel centred at 3915 MHz still covered by the initial testing licence was also used. Each cell used the uplink biased 2:7 TDD frame structure using a 40 MHz channel with SISO transmit. Downlink transmission powers were configured within the medium-power licence specification. An additional network designed to support low latency UHD camera feeds using constant bitrate encoders was deployed. This cell was configured to run the lower-latency 1:2 TDD frame structure, which significantly reduces latency and network jitter. While low latency was not the design goal for the newsgathering contribution network, one vendor reported a packet round trip time (RTT) of 37 ms from their encoder on The Mall to their data centre located in France; the transit time of 19 ms includes the 5G network (not optimised for latency), fibre backhaul and public internet connectivity and is impressive.

Over 20 broadcast camera crews successfully shared this network and reported stable performance. These devices were loaded with two SIM cards for the NPN, but also various SIMs for the public MNOs. The devices worked as expected, evenly splitting the stream bitrate over the public and private networks. However, as the crowds gathered and the public networks became congested, the device adapted to push the majority of the data over the private network. Users reported uninterrupted handover and continuous bitrate when walking the length of The Mall, with usable coverage found in unexpected and unplanned locations. The response from broadcasters was unanimously positive.

* + 1. Introduction

The opportunities presented by 5G Non-Public Networks (NPNs) for programme making have been the subject of several collaborative research projects. Mobile spectrum has traditionally been available only for public network as spectrum has been scarce and expensive. Identifying the value of smaller private networks, a block of spectrum in the 3.8-4.2 GHz has been made available in the UK by Ofcom for Shared Licence Access (SLA). This forms a subset of the 5G mobile band n77 for which commodity 5G terminal equipment is now readily available.

* + - 1. Advantages of 5G compared to traditional Wireless PMSE

Wireless Equipment for Programme Making and Special Events (PMSE) has been in common use since 2002. Implementations are generally derived from DVB-T COFDM technology deployed in custom frequency bands with unified tuning ranges. 5G also uses COFDM technology but can potentially benefit from recent advances including MIMO. Unlike traditional digital wireless cameras links, 5G provides native bi-directional TCP/IP network connections which integrate easily with modern IP studio architectures. The radio modems operate in wider bandwidths enabling higher throughput for enhanced services like UHD.

Unlike conventional PMSE, where separate radio devices are deployed for audio and video applications in forward and reverse directions for each connecting device, 5G allows a single base station to support multiple connections which can including audio, video, camera control, tally light or virtually any service that can be encapsulated in IP. The 5G radio modems do not require modification for use in a custom PMSE band as the SLA spectrum is natively supported by existing bonded SIM devices routinely used for Content Production. These aspects reduce complexity and cost when compared to traditional wireless PMSE techniques.

* + 1. Previous 5G trials

Several 5G trials have taken place since 2021, including the IBC Media Accelerator Programme 2022 Project of the Year, live contribution into coverage of the funeral of HM The Queen and the Birmingham Commonwealth Games and the technology is steadily maturing. Trials have typically used one or two macro cells, but the cell handover mechanism in mobile technology allows the network coverage to be readily extended by deploying additional radio units. The use of software-defined radio for the base station deployments have been a feature of most trials, with equipment usually supplied by small vendors. For programme making, the uplink performance is the key requirement, so networks must operate in the 5G standalone (SA) mode; non-standalone (NSA) 5G networks use 4G technology for the uplink and have insufficient capacity for video PMSE applications.

Networks in the n77 band use time division duplex (TDD), which facilitates the wide tuning range (3.8-4.2 GHz). The TDD parameters can be tuned for optimum performance, which usually involves biasing the link for uplink-heavy operation, whereby the majority of radio slots are allocated for the video traffic sent by the mobile video terminals.

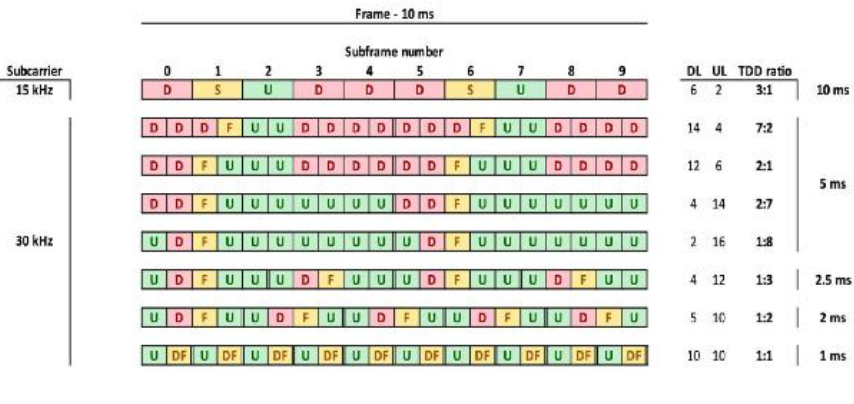


Figure 12: 5G TDD Configurations

Public mobile network operators are restricted to using a 3:1 (downlink:uplink) ratio to ensure that networks transmit and receive at the same time and avoid interfering with one another. Of the 10 subframes that make up a single 10 ms frame, there are six for downlink, two for uplink, and two ‘special’ subframes, during which the transition from transmit to receive takes place. 5G new radio (NR) supports more numerologies than LTE, and when using 30 kHz subcarriers (available in the midband) there are 20 time slots, allowing for 14:4 (7:2), increasing downlink bandwidth while remaining compatible with the 3:1 requirement. This restriction does not currently extend to the n77 band.

A typical PMSE application will instead use a reversed TDD ratio of 2:7, whereby 14/20 radio slots are allocated for uplink and 4/20 for the downlink. This can be pushed further to 1:8 to maximise uplink throughput, or reduced to 1:2 or even 1:1 to minimise latency. The special subframes, which were restricted to nine symbol configurations in LTE, can be defined arbitrarily in 5G NR, and are known as ‘flexible’ slots. They contain a mixture of uplink and downlink symbols, separated by gap symbol(s). The lowest-latency 1:1 frame structure makes use of the flexible slot to provide the uplink or downlink (for example, ‘DF’ in Figure 12).

* + - 1. 5G network capacity

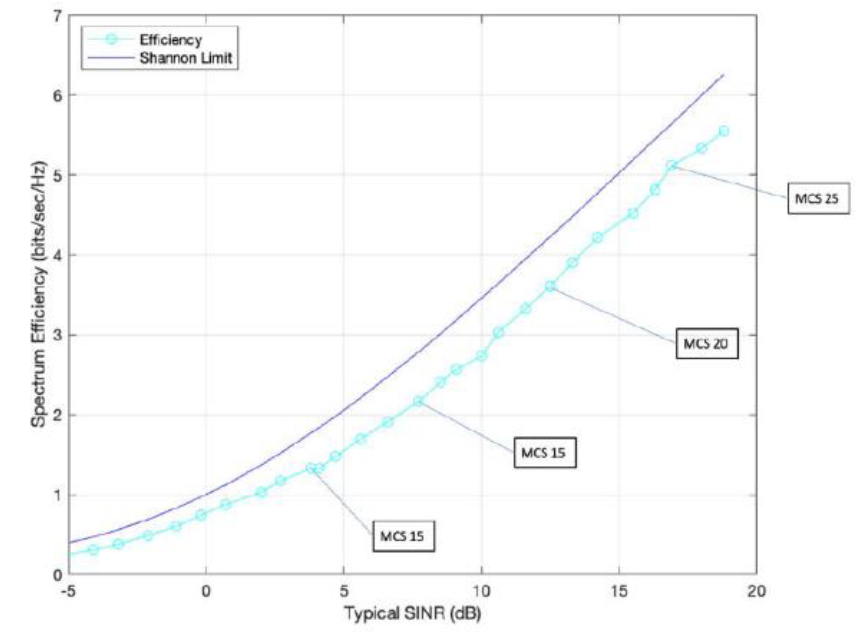


Figure 13: 5G NR MCS and capacity vs SINR

Like all radio systems, 5G is constrained by the Shannon-Hartley theorem and capacity is function of the signal to interference and noise ratio (SINR) on the radio link. At high SINR a higher order modulation and coding scheme (MCS) can be supported with a reduced level of forward error correction; for 5G NR links, modulation up to 256-QAM in the Physical Uplink Shared Channel (PUSCH) is defined with 2x2 MIMO. Practical implementations tend to be limited to 64-QAM and many commercial terminals have a single antenna, limiting the system to SISO operation. The typical relationship between SINR, MCS and capacity is shown in Figure 13.

* + - 1. Bitrate requirements for ENG Video streams

The bitrate requirement for broadcast content video distribution is a matter for debate. Ideally, the streams would be lightly compressed to minimise cascading artefacts in the codec chains within a typical broadcast system. This would advocate the use of a mezzanine video codec with a bitrate requirement of around 190 Mb/s for HD. In practice this is far too high for practical 5G implementations, and most video links will make use of H.264 (AVC) or H.265 (HEVC) compression. The bit rate requirements for artefact-free video will be dependent on the nature of the content. Noise-like material with fine-scale detail (such as running water, smoke and large crowd scenes with considerable motion) is particularly hard to encode, but talking heads against near-stationary backgrounds are much easier as there is considerable temporal and spatial redundancy that can be exploited by the codecs. The precise requirements are usually evaluated by expert viewing panels on specially selected test sequences. This is a time-consuming process. The use of perceptual codec evaluation methods, such as VMAF (Video Multi-Method Assessment Fusion), provide useful indicators and a set of hardware-accelerated H.265 encoders were evaluated ahead of the Coronation event. For simple material like the EBU “park dancer” sequence (1920x1080p50, 8-bit 4:2:0 chroma), H.265 implementations tend to give similar results. VMAF scores exceeding 90 at bitrates as low as 4Mb/s can be achieved. Demanding material, like the SVT open content “crowd run”, requires higher bit rates and exaggerates the implementation differences between vendors; up to 20 Mb/s can be necessary to achieve VMAF geometric mean scores exceeding 90. This is summarised in Figure 14, where three codec implementations are compared with a software reference (FFmpeg).

Interlaced HD video content regularly used for broadcast halves the pixel rate compared to the progressive test sequences. A codec rate ceiling of 12 Mb/s was set for the Coronation News contributions, with codecs adapting automatically according to the available bandwidth and network conditions. Many broadcasters either chose to set their maximum bitrate lower or were restricted by software licences on their devices.

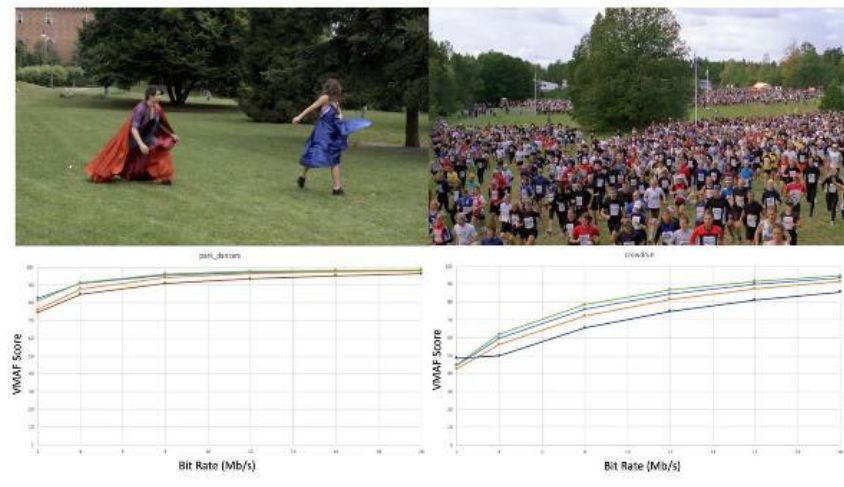


Figure 14: Video quality vs Bitrate for typical H.265 codecs

* + 1. Electronic news gathering using mobile networks

Electronic News Gathering (ENG) increasingly makes use of mobile systems utilising 3G and 4G bonded SIM devices in preference to the traditional private point-to-point radio links. The required uplink traffic for live HD broadcast video can, under normal network load, usually be carried on mobile network operator infrastructure. Systems are now readily available from a number of vendors that bond multiple MNO connections for resiliency and reduced individual network

resources, which are cost effective and convenient. Since the mobile capacity is provided on a best-effort basis, bonded systems can fail at large events with big crowds as the mobile networks are likely to be congested by the volume of traffic.

* + 1. News links for the coronation of King Charles III

Previous experience suggested that bonded 3G/4G systems would not be reliable for the Coronation, and investigations and trials to deploy a private 5G standalone network in the n77 band started in March 2023. Spectrum surveys revealed that the target spectrum band was relatively clear and that an SLA assignment of 100MHz was obtained from Ofcom. A commercial bonded cellular link was upgraded to support operation on a 5G Standalone Non Public Network and initial tests at Canada Gate confirmed stable operation over a cell radius of up to 350 m.

* + - 1. 5G coverage planning

To enable coverage along the 1km length of The Mall, the road running between Buckingham Palace and Admiralty Arch, a network of four cell sites was planned using 100 MHz of radio spectrum, following the initial tests.

Site 1 provided blanket coverage in the vicinity of the Palace using an omni antenna, while sites 2, 3 and 4 used panel antennas pointing in opposite directions deployed at the fixed camera platforms. The coverage prediction for the downlink received signal reference power (RSRP) is shown in Figure 15. Site 1 used a trailer mast in the media compound with antennas rigged at 8m. Sites 2, 3 and 4 were camera positions along The Mall with antennas at 4m.

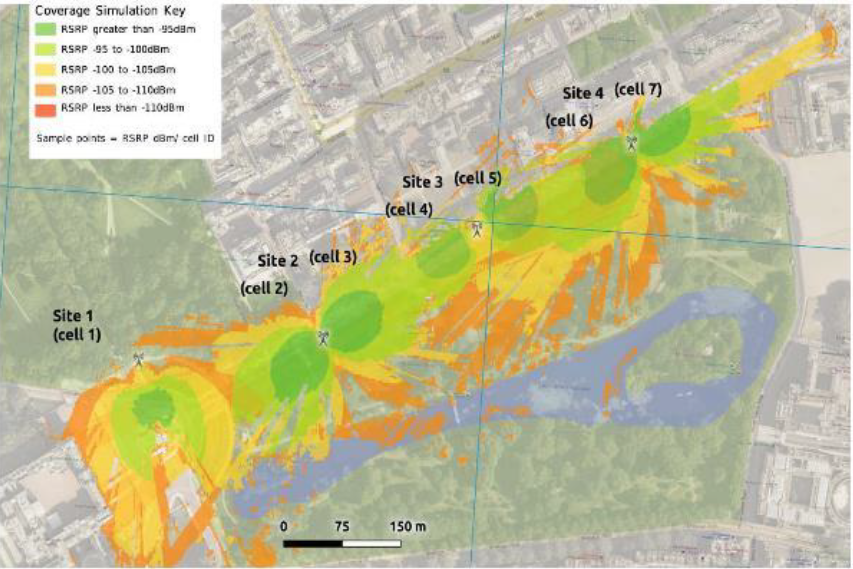


Figure 15: Predicted RSRP values for the 5G network

* + - 1. 5G network deployment

Rigging for the Coronation began one week prior to the event. Cell sites with remote radio heads (RRH) were connected back to the base band units (BBU) at the media compound in Green Park using 10 Gb/s armoured fibre (1310 nm, single mode). Tuning of the network began on the 3rd May, 3 days ahead of the Coronation. Cell 1 was complemented by an addition cell in non-overlapping radio channels. The lower frequency channel was configured in a low latency mode to support tests on experimental, low-latency UHD cameras from BBC R&D and Sony. The antenna arrangements for the cell sites are shown in Figure 16.



Figure 16: Antenna arrangements for Cell 2 (“The Mall”) and Cell 1 (“Green Park”)

* + - 1. Spectrum Measurements

A block of radio spectrum was initially allocated between 3835 and 3935 MHz, which was used for the initial trials as two 50 MHz channels to facilitate a standard A/B channel reuse plan along The Mall. Ofcom subsequently re-assigned spectrum, reducing the bandwidth to a pair of 40 MHz blocks centred at 3835 MHz and 3875 MHz. This was understood to be considered necessary to protect against potential interference to a nearby C band satellite receive site. This change though reduced the guard band with the nearest mobile allocation at 3760-3800 MHz from 35 MHz to 15 MHz. In order to accommodate a low latency constant bitrate encoder testbed while preserving the A/B spectrum reuse channel plan, an additional 40 MHz channel centred at 3915 MHz still covered by the initial testing licence was also used.



Figure 17: Radio spectrum of 5G NPN and Mobile services measured at Green Park

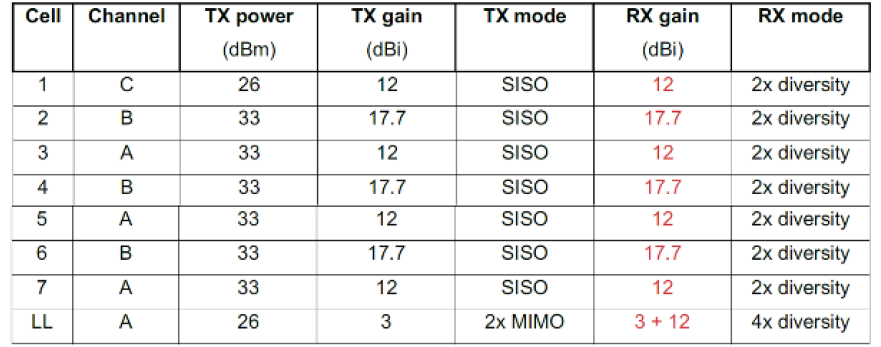
* + - 1. Network configuration

The network was designed to provide seamless coverage along The Mall, from Admiralty Arch to Buckingham Palace. Four antenna sites were identified to host seven cells, with a classic A/B channel plan used for spectrum reuse. The network was run on a custom-built rack located in the BBC News area of the media compound. To provide hardware redundancy, each site (hosting two cells) was hosted on individual hardware. Cell neighbours were fully specified to enable inter-gNB handover. Each cell used the uplink biased 2:7 TDD frame structure using a 40 MHz channel with SISO transmit. For the uplink, dual channel receive diversity was used to receive and combine both +45° and -45° polarisations simultaneously. Downlink transmission powers were configured within the medium-power licence specification.

The 2:7 TDD frame structure implemented across all cells was capable of supporting 4 bits/s/Hz, resulting in a capacity of 160 Mb/s for each 40 MHz cell. Across the seven cells for the main network, over 1 Gb/s of wireless connectivity was provided along The Mall to the broadcasters, at a time when the public mobile networks were saturated despite the provision of additional temporary cells. We note that, despite this wireless capacity, internet backhaul over the BBC Broadcast Contribution Network (BCN) to New Broadcasting House was limited to 450 Mb/s.

* + - 1. Cell Channel TX power

Table 65: Cells configurations



Channels: A – 3815-3855 MHz [ARFCN 655666];

B – 3855-3895 MHz [ARFCN 658334]; and

C – 3895-39351 MHz [ARFCN 661000].

An additional network designed to support low latency UHD camera feeds using constant bitrate encoders was deployed at Canada Gate alongside cell 1. This cell was configured to run the lower-latency 1:2 TDD frame structure, which significantly reduces latency and network jitter. This used a low gain omni-directional antenna for downlink transmission, allowing for connectivity within the media compound, with additional receive diversity on a high gain sector antenna facing the area outside the Palace. Since the Sony Xperia mobile handsets and modems used support MIMO, this cell was configured to provide 2x downlink MIMO.

* + - 1. Coverage validation

The coverage was checked by making mobile measurements at ground level using a smart phone running an RSRP logging app and using a 5G modem interfaced to a Raspberry Pi equipped with a GPS receiver. Paddle-type monopoles (~2 dBi) were used on the Raspberry Pi modem which returned signal strength values typically 12 dB greater compared to the phone. This would be consistent with the phone having an effective antenna gain of approximately –10 dBi.

Due to logistical complications onsite, the position of site 3 was moved from the intended camera platform to a BBC radio booth located nearby. In addition, the omni-directional antenna used for cell 1 at Canada Gate, which provided blanket coverage over the media compound during testing, was changed to a sector antenna the day before the event, as the coverage overlap with cell 2 was interfering with cell handover. RF simulations were repeated to model coverage on Coronation Day itself.

Figure 18 shows the predicted downlink signal strength, with logging data collected on a mobile handset overlaid. The agreement between the predictions and on-the-ground measurements is excellent, taking into account the gain of the handset.

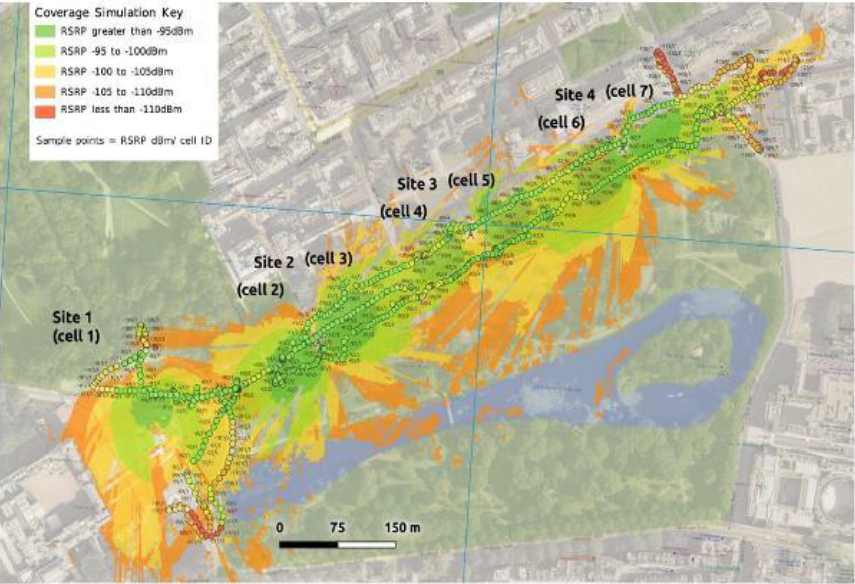


Figure 18: Predicted and measured RSRP values for the 5G network

* + - 1. Observed performance and throughput

In the days leading up to the Coronation, bonded cellular units started live news contributions. These devices were loaded with two SIM cards for the NPN, but also various SIMs for the public MNOs. The devices worked as expected, evenly splitting the stream bitrate over the public and private networks. However, as the crowds gathered and the public networks became congested, the device adapted to push the majority of the data over the private network.

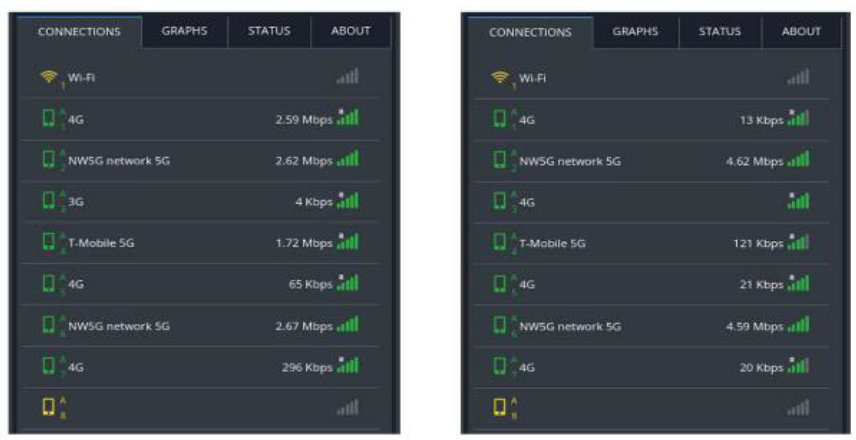


Figure 19: Monitoring screens from typical bonded cellular equipment

While low latency was not the design goal for the newsgathering contribution network, one vendor reported a packet round trip time (RTT) of 37 ms from their encoder on The Mall to their data centre located in France; the transit time of 19 ms includes the 5G network (not optimised for latency), fibre backhaul and public internet connectivity and is impressive.

Users reported uninterrupted handover and continuous bitrate when walking the length of The Mall, with usable coverage found in unexpected and unplanned locations, such as Duke of York Steps and outside Horse Guards. The response from broadcasters was unanimously positive.

Over the course of the week, over 60 devices accessed the NPN.

The 5G SA network carried 54.4 GB of uplink video, with the majority being on Friday 5th May and Saturday 6th May. On Coronation Day itself, 24.8 GB of video data were streamed – over 6 hours 50 minutes of continuous video at an average of 8 Mb/s. Since live news contributions typically do not air at the same time across broadcasters, the peak uplink was only 80 Mb/s, well within the capabilities of the network (see Figure 20). In addition, over 2.3 GB of downlink (return audio communications and radio contributions) were delivered to devices.

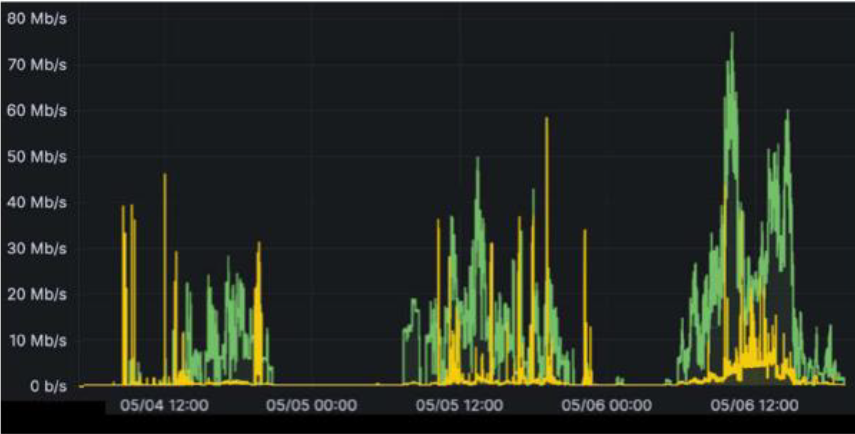


Figure 20: Network traffic from 5G network to backhaul

Testing of the complementary low-latency cell within the media compound resulted in excellent performance. An experimental low latency UHD camera operating at 55 Mb/s (CBR) was attached to the network using a handset configured as a USB connected 5G modem with HD return video. A novel core was used with dynamic on-the-fly QoS reconfiguration using the Network Exposure Function to alter bearers and priority on a per SIM basis.

The collocation of antennas for networks running different TDD configurations led to poor performance of the low-latency cell in front of the Palace which was affecting handover with cell 2. The decision was taken to match the 2:7 TDD structure and GPS lock the two networks. The cell performed as expected, providing an additional 160 Mb/s connectivity for low-latency devices, including a BBC R&D prototype. The increased network latency and jitter required increased data buffers to facilitate stable performance, with the UHD camera reporting a glass-to-glass latency of 115 ms.

* + 1. Conclusions

A 5G NPN was successfully deployed for the Coronation of King Charles III. The network was used to support news teams sending 1080i and 1080p streams from The Mall at bitrates in the range 6-12 Mb/s, typically using H.265 compression. Radio spectrum around 3.9 GHz was used in two 40 MHz bands to implement a multicell network covering the procession route of 1 km. Over 20 broadcast camera crews successfully shared this network and reported stable performance. The reported experience was positive, and the network allowed for the delivery of live content that could not have otherwise been broadcast. The sharing of a single non-public network to support a number of international broadcast contributions is considered a very efficient use of radio spectrum, particularly for a major national event where other PMSE spectrum was fully utilised for the main event coverage.

This trial of 5G NPN technology in standalone mode demonstrates a useful application of the Shared Licence Access scheme developed by Ofcom. Modems that can access the 5G n77 band are readily available and vendor equipment using Software Defined Radios running on commodity computers provide cost effective infrastructure.

The 5G standalone network technology is relatively new and has not been widely deployed by Mobile Network Operators (MNOs). Some issues with modem attachment delays were encountered, which appear to depend upon the firmware release used by the modem vendor. The cell handover characteristics of mobile are generally inferior to existing COFDM diversity receiver installs using maximum ratio combining but are fine for News feeds and will improve as the technology develops. Modems operation in MIMO is not yet available and early implementations do not appear to be sufficiently stable to support video streaming. Enhancements to the implementations are anticipated to address these short comings and further improve spectrum efficiency.

As 5G develops further, it is anticipated that the PMSE use case will continue to expand, limited only by achieving timely access to suitable spectrum, particularly in 3.8-4.2 GHz. This will facilitate the transition from traditional broadcast technology to IP operation supported by cloud services.

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2. <https://5gobservatory.eu/report-19-october-2023/> [↑](#footnote-ref-3)
3. such as transport, logistics, automotive, health, energy, smart factories, media and entertainment [↑](#footnote-ref-4)
4. https://www.techuk.org/resource/uk-spf-report-review-of-use-case-requirements-in-the-3-8-4-2ghz-band-via-ofcom-s-shared-access-licence-framework.html [↑](#footnote-ref-5)
5. Document 5A/395, available at <https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R19-WP5A-C-0395> [↑](#footnote-ref-6)
6. The NFD is calculated using the method given in ETSI TR 101 854. A bandwidth correction is applied if the interfering transmitter’s bandwidth is greater than that of the victim receiver. The NFD is included in the MCL as a loss on the radio interference path [↑](#footnote-ref-7)
7. Interfering signal level for a 6 dB desensitization, equivalent to -25.6 dBm level for 1 dB desensitization of the Macro BS AAS receiver. [↑](#footnote-ref-8)
8. RRH : Remote Radio Head [↑](#footnote-ref-9)