# Introduction

This report provides technical studies on the adjacent-band co-existence between 5G MFCN network operating below 3800 MHz and WBB LMP local area network above 3800 MHz considering unsynchronized operation.

Parameters used for the studies are listed in section 2 taken from agreed list of parameters. Scenarios covered are urban/sub-urban outdoor deployment. Indoor and rural area scenarios are not covered in this report.

# Parameters

## Deployment Parameters

Table 1: WBB LMP and MFCN Deployment Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | WBB LMP BS | WBB LMP UE | 5G MFCN | Note |
| Centre frequency (MHz) | 3850, 3910 | | 3750 |  |
| Channel bandwidth (MHz) | 100  (98.280 MHz Nrb=273 Rb=12\*30kHz) | | |  |
| SCS (kHz) | 30 | |  |  |
| Maximum BS Tx Power (EIRP) | 51 dBm/100 MHz |  | N/A | 5G MFCN uplink is simulated. |
| Non-AAS antenna gain (dBi) | 13 dBi for MR non-AAS BS |  | 18 dBi |  |
| Non-AAS antenna pattern | ITU-R F.1336 |  | ITU-R F.1336 |  |
| AAS antenna configuration | 4x4x3 |  | 4x8x3 | For MR BS (Gain = 23.2 dBi) |
| Element gain (dBi) | 6.4 |  |  | For MR BS |
| H\_Spacing  V\_Spacing | 0.5 for H  0.7 for V |  |  | For MR BS |
| BS antenna height (m) | 25 |  |  | Outdoor MR BS |
| BS antenna downtilt(°) | -6° |  |  |  |
| Noise figure (dB) | 10 for MR BS  13 for LA BS  5 dB (Macro cell scenario) | 9 |  | 5 |
| UE Tx Power (dBm) |  | 24 |  | UE power control is used. |
| Indoor/Outdoor UE height (m) |  | 1.5 above ground |  |  |
| Mobile/Nomadic UE antenna gain (dBi) |  | -4 |  |  |
| UE Tx mask |  | ACLR=30 dB | ACLR=30 dB | 3GPP TS.38.101 |
| UE Rx mask |  | ACS=30 dB | ACS=30 dB | 3GPP TS.38.101 |
| Network loading (%) | 100% for single BS case  50% for network case | |  | The simulation is done on single BS with 100% load |
| Indoor/outdoor UE percentage | 70% / 30% in urban/suburban  50% / 50% in Rural | |  | Only urban/suburban used in studies |
| Cell Range (m) | Urban & Suburban:  400 m for Hbs=25m | |  |  |

## WBB LMP Tx Mask

### WBB LMP Non-AAS

Table 2: Out-of-block emission limits of the WBB LMP non-AAS providing local area network connectivity in 3.8-4.2 GHz from UK approach, 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 3: Out-of-band emission limits of the WBB LMP non-AAS providing local area network connectivity in 3.8-4.2 GHz from UK approach, 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  Note: The spurious emission domain for the base station in these frequency bands start 40 MHz from the band edge and the corresponding limits are defined in current ERC Recommendation 74-01 which is used Below 3760 MHz Above 4240 MHz. | |

### WBB LMP AAS

The EIRP based emission mask in section 2.2.1 above is taken from UK regulations which is not suitable for medium power AAS BS. BEM for AAS BS in all the legacy regulations is defined in TRP. Therefore, following BEM in table 4 for MR WBB BS is used in the studies as per 3GPP Medium Range (MR) BS operating band unwanted emission limits for Prated,c,TRP  40 dBm as starting point.

Table 4: Proposed baseline and transitional power limits for synchronised WBB (medium Power) AAS BS as per 3GPP.

| **BEM element** | **Frequency range** | **AAS TRP limit per cell** |
| --- | --- | --- |
| Transitional region | -5 to 0 MHz offset from lower block edge  0 to 5 MHz offset from upper block edge | +0.94 dBm/5 MHz |
| Transitional region | -10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge | -3 dBm/5 MHz |
| Baseline | Below -10 MHz offset from lower block edge. Above 10 MHz offset from upper block edge. Within 3400 - 3800 MHz. | -3 dBm/5 MHz |
| The BS transitional region BEM elements are based on the assumption that the emissions come from a Micro BS. In a multi-sector base station, the radiated power limit applies to each one of the individual sectors.  Note: The spurious emission domain for the base station in these frequency bands start 40 MHz from the band edge and the corresponding limits are defined in current ERC Recommendation 74-01 | | |

### Restricted Mask

To improve the coexistence between MFCN and WBB LMP following strict BEM from 11(06) is also used in the studies.

Table 5: Restricted baseline power limits for unsynchronised and semi­synchronised MFCN networks, for non-AAS and AAS base stations ECC DEC (11)06

| **BEM element** | **Frequency range** | **Non-AAS e.i.r.p. limit**  **dBm/(5 MHz) per cell (2)** | **AAS TRP limit dBm/(5 MHz) per cell (1)** |
| --- | --- | --- | --- |
| Restricted baseline | Unsynchronised and semi-synchronised blocks.  Below the lower block edge. Above the upper block edge.  Within 3400-3800 MHz | -34 | -43 |
| (1) In a multi-sector base station, the radiated power limit applies to each one of the individual sectors  (2) It is assumed that note (1) also applies in this case. | | | |

## WBB LMP BS Rx mask

Not used in the study as WBB LMP is the aggressor with downlink only.

Table 6: Adjacent band receiver characteristics for WBS LMP base station (3GPP 38.104)

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Low Power BS**  (Interfering signal mean power (dBm) 6 dB desensitization) | **Medium Power BS**  (Interfering signal mean power (dBm) 6 dB desensitization) |
| ACS | -47 dBm for LP BS | -44 dBm for MR BS |
| In-band blocking | -38 dBm | -35 dBm |
| Out-of-band blocking (3GPP 1-H) | -15 dBm | -15 dBm |

Relative ACS and in-band blocking attenuation to be derived with the associated bandwidth (100 MHz) and NF (ITU-R M.2039).

The above ACS, In-band and out of band blocking level are defined for a 6 dB desensitization in 3GPP. However, in co-existence studies, 1 dB desensitization is considered for the protection of MFCN bands from harmful interference. Hence, the above values of ACS/In-band and out of band blocking were recalculated assuming 1 dB desensitization as the highest (ECC Report 165, 252 & 325).

A 1 dB noise rise is equivalent to I/N = -6 dB. For 6 dB desensitization, the maximum interference experienced by the receiver is Noise\_floor + 4.74 dB. Similarly, for a 1 dB desensitization, the maximum interference experienced by the receiver is Noise\_floor-5.87 dB. Therefore, the values in Table 6 can be adjusted by 10.5 dB for 1 dB desensitization. And for positive attenuation values shown in table 7 below, the blocking response for SEAMCAT can be calculated by using following equation [ECC report 326]:

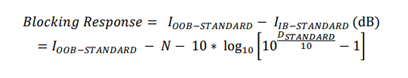


Table 7: WBB LMP Receiver Mask in SEAMCAT

|  |  |  |
| --- | --- | --- |
| Frequency offset | Medium Power – 1 dB Desensitization (Attenuation) | Low Power - – 1 dB Desensitization (Attenuation) |
| 3800 MHz-3780 MHz | 35.5 dB | 29.5 dB |
| 3780 MHz-3740 MHz | 44.5 dB | 38.5 dB |
| Below 3740 | 64.5 dB | 61.5 dB |

## 5G MFCN BS Tx Mask

Not required as in the study only 5G MFCN uplink is simulated. UE Tx mask from table 1 is used.

## 5G MFCN BS Rx Mask

Table 8: 5G Macro BS Receiver mask (3GPP 38.104)

|  |  |  |  |
| --- | --- | --- | --- |
| AAS/ non-AAS | ACS  3800-3820 MHz  (Interfering signal mean power (dBm) | In-band blocking  3820-3860 MHz (Interfering signal mean power (dBm) | Out-of-blocking  >3860 MHz  (Interfering signal mean power (dBm) |
| Interferer signal level  6dB desensitization | -52dBm  (Table 7.4.1.2-1) | -43dBm  (Table 7.4.2.2-1) | -15dBm  (Table 7.5.2-1)  (3GPP 1-H) |

As explained in section 2.3 above, the above values of ACS/In-band and out of band blocking were recalculated assuming 1 dB desensitization and corresponding positive attenuation values are shown in table 8 below:

Table 9: 5G Macro BS Receiver mask SEAMCAT

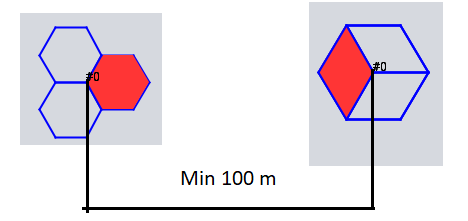
|  |  |  |  |
| --- | --- | --- | --- |
| AAS/ non-AAS | ACS  3800-3820 MHz | In-band blocking  3820-3860 MHz | Out-of-blocking  >3860 MHz |
| Attenuation (considering 1 dB desensitization) | 34.3dB | 43.3dB | 71.3dB |

# Methodology and deployment scenario

In this report a monte-Carlo analysis is performed using SEAMCAT to analyse coexistence conditions between WBB LMP and MFCN below 3800 MHz. The simulation scenario is shown in Figure 1 where a single LAN BS (non-AAS / AAS) in LOS of a 5G MFCN BS (AAS / non-AAS). Appropriate antenna pattern and downtilt considered as mentioned in parameters table above. One million iterations are run for each case and UEs are randomly generated within the coverage area of the base station for each iteration.

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 and realistic coexistence.

In the study 5G MFCN uplink throughput loss is simulated. The study analyses the impact of separation distance, frequency separation, in-block power and restricted BEM on coexistence between WBB LMP BS and 5G MFCN BS. The target 5G MFCN BS uplink throughput loss is < 5%.



Four scenarios are considered in this report:

1. Unsynchronized 5G non-AAS BS vs WBB non-AAS.
2. Unsynchronized 5G AAS BS vs WBB non-AAS.
3. Unsynchronized 5G non-AAS BS vs WBB AAS
4. Unsynchronized 5G AAS BS vs WBB AAS

# Study results

## Unsynchronized 5G non-AAS BS vs WBB non-AAS

Table 10: 5G MFCN non-AAS vs WBB LMP non-AAS Unsynchronized

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS Tx EIRP (dBm/100 MHz) | LMP BS OOBE EIRP  Below 3800 MHz | WBB LMP CF MHz | Mean iRSS\_unwanted (dBm) | Mean iRSS\_blocking (dBm) | Distance between BS (km) | Average 5G MFCN UL TP Loss (%) |
| 51 | Table 3\* | *3850* | -56.96 | -63.82 | 0.1 | 100 |
| 51 | -76.97 | -83.82 | 1 | 76.781 |
| 51 | -83 | -89.95 | 2 | 48.242 |
| 51 | -90.98 | -97.84 | 5 | 15.239 |
| **51** | **-97.04** | **-103.9** | **10** | **4.686** |
| 51 | - 40 dBm/MHz | -94.5 | -63.82 | 0.1 | 100 |
| **16** | **-45 dBm/MHz** | **-99.5** | **-98.82** | **0.1** | **4.492** |
| 51 | - 40 dBm/MHz | 3910 | -94.64 | -94.86 | 0.1 | 11.547 |
| 31 | - 40 dBm/MHz | -94.64 | -114.86 | 0.1 | 6.529 |
| **45** | **- 45 dBm/MHz** | **-99.64** | **-100.86** | **0.1** | **3.801** |
| \*Spurious value in dBc adjusted in SEAMCAT according to in block power to maintain spurious level of -30dBm/MHz. | | | | | | |

## Unsynchronized 5G AAS BS vs WBB non-AAS

Table 11: 5G MFCN AAS vs WBB LMP non-AAS Unsynchronized

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS Tx EIRP (dBm/100 MHz) | LMP BS OOBE EIRP  Below 3800 MHz | WBB LMP CF MHz | Mean iRSS\_unwanted (dBm) | Mean iRSS\_blocking (dBm) | Distance between BS (Km) | 5G MFCN UL TP Loss (%) |
| 51 | Table 3\* | 3850 | -67.81 | -66.02 | 0.1 | 93.907 |
| 51 | -87.82 | -86.03 | 1 | 30.247 |
| 51 | -93.83 | -92.06, | 2 | 14.557 |
| 51 | -97.36 | -95.59 | 3 | 9.123 |
| **51** | **-100.91** | **-99.12** | **4.5** | **5.161** |
| 51 | - 40 dBm/MHz | -105.33 | -66.02 | 0.1 | 88.278 |
| 28 | **- 40 dBm/MHz** | **-105.35** | **-89.02** | **0.1** | **4.097** |
| 51 | **- 40 dBm/MHz** | **3910** | **-105.46** | **-97.07** | **0.1** | **1.876** |

## Unsynchronized 5G non-AAS BS vs WBB AAS

Table 12: 5G MFCN non-AAS vs WBB LMP AAS Unsynchronized

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS Tx EIRP (dBm/100 MHz) | LMP BS OOBE TRP  Below 3800 MHz | WBB LMP CF | Mean iRSS\_unwanted (dBm) | Mean iRSS\_blocking (dBm) | Distance between BS (KM) | 5G MFCN UL TP Loss (%) |
| 51 | Table 4\* | 3850 | -57.4 | -82.03 | 0.1 | 100 |
| 51 | **3850** | **-94.36** | **-118.99** | **7** | **4.146** |
| 21.8 | - 43 dBm/ 5 MHz | **3850** | **-95.5** | **-111.22** | **0.1** | **3.772** |
| 51 | - 43 dBm/ 5 MHz | 3850 | -94.1 | -82.01 | 0.1 | 47.517 |
| 51 | - 43 dBm/ 5 MHz | **3910** | **-94.24** | **-113.06** | **0.1** | **4.519** |
| \*Spurious value in dBc adjusted in SEAMCAT according to in block power to maintain spurious level of -30dBm/MHz. | | | | | | |

## Unsynchronized 5G AAS BS vs WBB AAS

Table 13: 5G MFCN AAS vs WBB LMP AAS Unsynchronized

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS Tx EIRP (dBm/100 MHz) | LMP BS OOBE TRP  Below 3800 MHz | WBB LMP CF | Mean iRSS\_unwanted (dBm) | Mean iRSS\_blocking (dBm) | Distance between BS (KM) | 5G MFCN UL TP Loss (%) |
| 51 | Table 4\* | 3850 | -69.77 | -84.21 | 0.1 | 81.319 |
| 51 | 3850 | -106.07 | -120.56 | 6.5 | 4.531 |
| 51 | - 43 dBm/ 5 MHz | 3850 | -106.48 | -84.25 | 0.1 | 42.502 |
| 23.2 | - 43 dBm/ 5 MHz | 3850 | -106.48 | -112.05 | 0.1 | 4.48 |
| 51 | Table 4\* | 3910 | -86.628 | -115.28 | 0.1 | 32.264 |
| 51 | - 43 dBm/ 5 MHz | 3910 | -106.61 | -115.29 | 0.1 | 3.978 |
| \*Spurious value in dBc adjusted in SEAMCAT according to in block power to maintain spurious level of -30dBm/MHz. | | | | | | |

# Conclusion

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

In-block power restriction of as low as 16 dBm/100 MHz EIRP for non-AAS WBB LMP BS with restrictive block edge mask (BEM) of - 45 dBm/ MHz EIRP will be needed. And for AAS, power restriction of 21.8 dBm/100 MHz EIRP with restricted emissions of - 43 dBm/ 5MHz TRP below 3800 MHz is required to sufficiently protect 5G MFCN network below 3800 MHz.

The study also shows that defining only a strict BEM will not solve the problem, blocking impact from WBB LMP systems also needs to be considered.

Measures like separation distance at least 10 km or frequency separation of at least 60 MHz with restrictive BEM significantly improve the coexistence in case of unsynchronized operation. However, in real world large separation distance of at least 10 km with MFCN network might not be possible so alternatively 60 MHz GB with restrictive BEM seems more appropriate.

Another solution for efficient use of spectrum is to use synchronize operation in case enough geographical or frequency separation is not available.

Furthermore, study also shows the coexistence improve significantly in case of AAS deployments. Results of the study are summarized in the table below.

Table 14: Summary of results (5G Uplink throughput loss < 5 %)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario | Min separation distance  (km) | Guard band (GB) | WBB LMP OOBE  Below 3800 MHz | Max in-block power  (dBm/100 MHz) | 5G MFCN UL TP Loss (%) |
| **WBB non-AAS vs MFCN non-AAS** | 10 | Nil | Table 3 (UK model) EIRP | 51 | 4.686 |
| 0.1 | Nil | -45 dBm/ MHz | 16 | 4.492 |
| 0.1 | 60 MHz | -45 dBm/ MHz | 45 | 3.801 |
| **WBB non-AAS vs MFCN AAS** | 4.5 | Nil | Table 3 (UK model) EIRP | 51 | 5.161 |
| 0.1 | Nil | -40 dBm/ MHz | 28 | 4.097 |
| 0.1 | 60 MHz | -40 dBm/ MHz | 51 | 1.876 |
| **WBB AAS vs MFCN non-AAS** | 7 | Nil | Table 4 (3GPP) TRP | 51 | 4.146 |
| 0.1 | Nil | -43 dBm/ 5 MHz | 21.8 | 3.772 |
| 0.1 | 60 MHz | -43 dBm/ 5 MHz | 51 | 4.519 |
| **WBB AAS vs MFCN AAS** | 6.5 | Nil | Table 4 (3GPP) TRP | 51 | 4.531 |
| 0.1 | Nil | -43 dBm/ 5 MHz | 23.2 | 4.48 |
| 0.1 | 60 MHz | -43 dBm/ 5 MHz | 51 | 3.978 |