# Introduction

As per the EC Mandate, WBB LMP BS would need to consider the protection of incumbent services, such as FSS ES in the same band. In the sections below we provide the results of the study for a range of scenarios including EIRP values for WBB LMP.

# Co-channel Coexistence Studies WBB LMP vs fss es

## Study parameters

### Parameters for WBB LMP

In Table 1, we provide the deployment parameters of WBB LMP BS used in the studies.

Table 1: Deployment parameters of WBB LMP

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Low Power BS | Medium Power BS | Incremental Medium Power BS |
| EIRP | 31dBm/100 MHz | 49dBm/100 MHz | 51dBm/100 MHz |
| Antenna height | Specified to align with the clutter assumptions | | |
| BS Sectorization | 1 | 1 | 1 |
| UEs per sector | 3 | 3 | 3 |
| Use case information  single BS cell range | 0.05 km | 0.4 km | 0.4 km |
| BS TDD activity factor | 50% | 50% | 50% |
| Network loading factor | 100% | 100% | 100% |
| Terminal antenna gain | -4 dBi | -4 dBi | -4 dBi |
| Antenna gain for AAS/non-AAS | 12 dBi | AAS: 21.5 dBi  (4x8 elements) | AAS: 21.5 dBi  (4x8 elements) |
| Antenna pattern for AAS/non-AAS | F.1336 Omni | AAS: M.2101 | AAS: M.2101 |
| BS Noise Figure | 13 dB | 10 dB | 10 dB |
| UE Noise Figure | 9 dB | 9 dB | 9 dB |
| UE height | For outdoor BS: 1.5 m | For outdoor BS: 1.5 m | For outdoor BS: 1.5 m |

In Table 2, we provide the AAS antenna characteristics of WBB MP BS used in the studies.

Table 2: AAS Antenna characteristics for WBB LMP

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

### Parameters for FSS ES

In Table 3, we provide the FSS ES characteristics used in the studies.

Table 3: FSS ES characteristics

| Parameter | Value |
| --- | --- |
| Range of operating frequencies | 3800-4200 MHz |
| Antenna diameter | 3m |
| Antenna gain | 39.5 dBi |
| Antenna reference pattern | Recommendation ITU-R S.465-6 |
| Elevation angle | 10 degrees |
| Antenna height above ground | 10m |
| I/N long-term protection criterion | -10.5 dB for 20% of time |

### Propagation parameters

In Table 4 we provide the propagation parameters used in the studies.

Table 4: Propagation parameters used in coexistence studies

|  |  |  |
| --- | --- | --- |
| Link | Propagation Model | Clutter |
| Outdoor LMP BS into FSS ES receiving ES | ITU-R P.452-16 with a time % (Tpc) ranging from 0-100%, with Tpc>50% being considered as Tpc=50% | P.2108 applied according to clutter heights of P.452-16 Table 4 |

Since FSS ES are likely to be deployed in sites surrounded by additional clutter protection, natural or artificial local shielding and vegetation, in our studies we have assumed clutter (30% from P.2108) applied at the FSS ES side.

## Coexistence Simulations

Our simulation scenarios capture the potential interference effect from WBB LMP BS into FSS ES operating co-channel. The effect of interference is presented in the form of separation distances.

We have simulated a selected range of representative scenarios, including WBB LMPs with different EIRP values and heights and in a range of environments.

### Simulation Methodology

To assess the coexistence feasibility of WBB LMP BSs in the 3.8-4.2 GHz band with FSS ES co-channel in the same band we performed Monte Carlo simulations in a 3GPP compliant simulator, where the dynamic nature of WBB LMP services was captured. The WBB LMP BSs were assumed to serve three UE within the sector, with UEs uniformly distributed in the sector area. For the configurations based on AAS, at each snapshot the WBB LMP BS steers the beam in the direction of the UE to be served. For a conservative assessment of coexistence, full (100%) BS load was assumed. The Monte Carlo simulations consider the interference effect of a single WBB LMP BS since licences are planned to be authorised on a limited location basis and thus, the aggregated interference to the same victim at the same frequency channel is significantly small. The FSS ES operating in-band is assumed to have the antenna pointing towards the sky with a fixed elevation angle of 10 degrees.

Our methodology assumes that the WBB LMP BS acting as the interferer is initially placed 250 m away from the victim FSS ES receiver. Maintaining the separation distance fixed, the interference observed in 10,000 independent simulation runs (snapshots) is captured. The separation distance is then increased in steps of 250 m, with the received interference levels in 10,000 snapshots for each separation distance step being captured. With this, an empirical Cumulative Distribution Function (CDF) of interference levels (and eventually I/N levels) for each separation distance could be created. As indicated Table 3, the time percentage associated with the I/N protection criterion for the FSS ES is 20%. This implies that the I/N threshold should not be exceeded for more than 20% of the time. Thus, with a commonly used approximation for this kind of study, where the time percentage of the protection criterion is verified as the percentage of cases (snapshots), we use for each separation distance the 80th percentile of the CDF of I/N (i.e. the I/N value exceeded for 20% of cases). This long term I/N value as a function of the separation distance is then compared against the I/N limit of -10.5 dB to determine the minimum separation distance required to protect the FSS ES receiver.

### Simulating the potential interference from outdoor WBB LMP BS into FSS ES

#### Simulation scenarios (interference from outdoor WBB LMP BS into FSS ES)

In Table 5 below, we demonstrate the details of the scenarios that we have simulated for the interference potential of outdoor WBB LMP BS into FSS ES.

Table 5: Simulation scenarios WBB LMP into FSS ES

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario No. | Scenario type | Clutter assumption | Interference from | Interference to |
| 1  Urban WBB LP | Outdoor WBB LP vs  FSS ES | 50% applied at WBB LP BS side  30% applied at FSS ES side | Outdoor WBB LP BS  EIRP = 31 dBm  Non-AAS  10m height | FSS ES |
| 2  Rural WBB LP | Outdoor WBB LP vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB LP BS  EIRP = 31dBm  Non-AAS  10m height | FSS ES |
| 3  Rural WBB MP | Outdoor WBB MP  vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 51 dBm/100MHz  AAS (4x8)  15m height | FSS ES |
| 4  Rural WBB MP | Outdoor WBB MP  vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 49 dBm/100MHz  AAS (4x8)  15m height | FSS ES |
| 5  Rural WBB MP | Outdoor WBB MP vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 49 dBm/100MHz  AAS (4x8)  15m height | FSS ES with 48 degrees elevation |

#### Results of the studies (interference potential from outdoor AAS WBB LMP BS into FSS ES)



Figure 1: AAS WBB LMP BS into FSS ES

# Conclusions

In summary, the results of the separation distances we observed from the simulations are shown in Table 6

Table 6: Summary of results of the simulation scenarios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario No. | Scenario type | Clutter assumption | Interference from | Interference to | Separation distance |
| 1  Urban WBB LP | Outdoor WBB LP vs  FSS ES | 50% applied at WBB LP BS side  30% applied at FSS ES side | Outdoor WBB LP BS  EIRP = 31dBm/100MHz  Non-AAS  10m height | FSS ES | ~850m |
| 2  Rural WBB LP | Outdoor WBB LP vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB LP BS  EIRP = 31dBm/100MHz  Non-AAS  10m height | FSS ES | ~4km |
| 3  Rural WBB MP | Outdoor WBB MP  vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 51dBm/100MHz  AAS (4x8)  15m height | FSS ES | ~16km |
| 4  Rural WBB MP | Outdoor WBB MP  vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 49dBm/100MHz  AAS (4x8)  15m height | FSS ES | ~12.5km |
| 5  Rural WBB MP | Outdoor WBB MP  vs  FSS ES | 30% applied only at FSS ES side | Outdoor WBB MP BS  EIRP = 49dBm/100MHz  AAS (4x8)  15m height | FSS ES with 48 degrees elevation | ~2.5km |

As mentioned in the methodology section of this document, the simulations assume that the initial separation distance between WBB LMPs and FSS ES was 250m. For the scenarios which assumed clutter at both sides, clutter only at one side was applied for the Monte Carlo steps between 250m-750m and clutter at both sides was applied for the rest of the simulation steps from 1000m onwards.

From the above results, we can observe that when clutter was applied at the WBB LP side, the separation distance requirement to satisfy the long-term I/N protection criterion of FSS ES was approximately 850m, while when clutter was not applied to the WBB LP side, a separation distance of approximately 4km was found to be required to satisfy the I/N long-term protection criterion of FSS ES. When considering WBB MP BSs, we have not assumed clutter at all at their side. The results indicate that the required separation distance is approximately 12.5 km and 16 km for outdoor AAS MP BS with EIRPs 49dBm/100MHz and 51dBm/100MHz respectively. When simulating the coexistence of AAS MP BS with EIRP 49dBm/100MHz with an FSS ES with a 48 degrees antenna elevation, the separation distance observed was approximately 2.5km.

In the assessment of the above results, it is worth highlighting the following assumptions that were taken into consideration:

* The assumption of 10 degrees elevation angle is the most conservative assumption expected for the elevation angle of the FSS ES (worst case)
* The consideration of 100% network loading factor represents a conservative assumption
* No polarisation loss was considered in the simulations
* The antenna gain of the non-ASS omni WBB LP BS antenna was assumed to be 12dBi