# PARAMETERS AND DEPLOYMENT CONSIDERATIONS

The following tables present the relevant system and deployment related parameters used in this report.

Table 1: WBB system and deployment-related parameters

| Parameter | Value |
| --- | --- |
| **Base Station** | |
| Carrier frequency | 3.85 GHz |
| Channel bandwidth | 100 MHz |
| BS Antenna height | 10 m |
| Cell radius | 400 m |
| Sectorization | 1 sector |
| Frequency reuse | 1 |
| BS TDD activity factor | 75% |
| Network loading factor | 100% and 50% |
| **User Terminal** | |
| UE height | 1.5 m |
| UE density for terminals that are transmitting simultaneously | 3 UEs per sector |
| UE deployment | Uniform and Rayleigh distributions |

Table 2: Antenna and power characteristics for WBB systems

| Parameter | Value |
| --- | --- |
| **Base station (AAS)** | |
| Antenna pattern | Refer to 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) |
| Element gain (incl. Ohmic loss) (dBi) | 6.4 |
| Horizontal/vertical 3 dB beamwidth of single element (degree) | 90º for H  65º for V |
| Horizontal/vertical front to back ratio (dB) | 30 for both H/V |
| Antenna polarization | Linear ±45º |
| Antenna array configuration (Note 1)  (Row × Column) | 8×8 and 4×4 |
| Horizontal/Vertical radiating element spacing | 0.5 of wavelength for H  0.7 of wavelength for V |
| Array Ohmic loss (dB) | 2 |
| Conducted power (before Ohmic loss) per antenna element for 8×8 AAS (dBm) (Note 2) | 5.5 (corresponding to a TRP = 24.6 dBm) |
| Conducted power (before Ohmic loss) per antenna element for 4×4 AAS (dBm) (Note 2) | 17.5 (corresponding to a TRP = 30.6 dBm) |
| Base station maximum coverage angle in the horizontal plane (degrees) | ±60 |
| Base station vertical coverage range (degrees) (Note 3) | 90-120 |
| Mechanical downtilt (degrees) | 10 |
| Maximum base station EIRP for 8×8 AAS (dBm/5MHz) | 38 (51 dBm/100MHz) (Note 4) |
| Maximum base station EIRP for 4×4 AAS (dBm/5MHz) |
| Note 1: For the small/micro cell case, for example, 8×8 means there are 8 vertical and 8 horizontal radiating elements.  Note 2: For example, for an 8×8 AAS, the conducted power per element assumes 8×8×2 elements (i.e., power per H/V polarized element).  Note 3: The vertical coverage range includes the mechanical downtilt. 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 4: A 51 dBm/100MHz EIRP corresponds to WBB MP BS considering the incremental approach. | |

The FSS ES parameters considered in this study are based on the agreed technical, operational characteristics, and protection criteria of FSS systems. In addition, some additional parameters such as the antenna sizes and gain of the FSS earth stations (ESs) Fuchsstadt and DLR[[1]](#footnote-2) are also considered. Table 3 contains the FSS ES parameters used in this study and Table 4 contains the FSS protection criteria.

Table 3: FSS ES Parameters

| Parameter | Value |
| --- | --- |
| Antenna diameter (m) | 3, 4.8 (DLR), and 32 (Fuchsstadt) |
| Peak antenna gain (dBi) | 39.5, 44 (DLR), and 61 (Fuchsstadt) |
| Antenna pattern | Refer to Recommendation [ITU-R S.465](https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.465-6-201001-I!!PDF-E.pdf) |
| Receiving system noise temperature | 120 K for small antennas (1.2-3 m)  70 K for large antennas (4.5 metres and above) |
| Min. antenna elevation angle (degrees) | 10, 16.1 (DLR), and 8.4 (Fuchsstadt) |
| Antenna height (m) | 10, 14 (DLR), and 20 (Fuchsstadt) |

Table 4: FSS ES Protection Criteria

| Frequency Ranges | Percentage of time for which the I/N value could be exceeded (%) | I/N Criteria  (dB) |
| --- | --- | --- |
| 3 800-4 200 MHz (s-E) | 20%  0.005% | −10.5  −1.3 |

The protection criteria specified are related to the required availability of FSS links which is associated with time. However, Monte Carlo sharing studies conducted between FSS and WBB systems may involve other considerations based on additional variables which are not varying in the time domain (e.g., geographical locations in the space or deployment domain associated with WBB BS and UEs positions). Thus, it may be appropriate to understand percentages as being in other domains, such as time, location, and probability.

In addition, studies using these short-term protection criteria could be assessed on the basis that these values were put forward by the WP4A 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. Thus, short-term criterion is only assessed as sensitivity analysis.

## DEPLOYMENT

The WBB local network consists of a single base station (BS) which is always facing the FSS ES (worst-case). The BS beams direction are still randomised to point towards the UEs within the coverage area. Figure 1 shows an example of a WBB BS and a FSS ES when they are positioned facing each other with a separation distance of 3 km. In each snapshot of the Monte Carlo simulation, 3 user equipment (UE) are uniformly distributed within each BS sector as shown in Figure 2(a).

For sensitivity analyses, the 3 UE positions are randomly distributed with azimuth angles ranging from -60° to 60° following a uniform distribution, and their ground distances from the BS are randomly generated using a Rayleigh distribution as shown in Figure 2(b). This distribution 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.

The Rayleigh distribution describes the magnitude distribution of a two-dimensional random vector, where the coordinates consist of independent, identically distributed normal variables with a mean of 0. In this study, a standard deviation (σ) of 64 is employed for the normal variables to generate the Rayleigh distribution, with which occasional cell-edge UEs are deployed close to 400 m from the WBB BS. This distribution results in 99.99% of the UEs being deployed at a ground distance from the WBB BS of equal to or less than 300m as indicated in Table 5. Furthermore, this distribution was suggested for hotspots deployments by the ITU-R task group TG 5/1 towards WRC-19[[2]](#footnote-3). Hotspot deployments are assumed here to be similar to those for WBB MP networks.

Table 5: Rayleigh distribution statistics in this study

| Ground distance range (m) | Area of total cell | Share of UEs |
| --- | --- | --- |
| 0-100 | 6.3% | 70.5% |
| 100-200 | 18.8% | 28.7% |
| 200-300 | 31.3% | 0.75% |
| 300-400 | 43.8% | 0.0017% |

It is noted that the WBB BS transmit power is assumed to be split equally among its UEs, meaning that the transmit power for each UE is 10log10(1/3) = ‑4.77 dB lower than the total transmit power of the BS.

The FSS ESs in Table 3 are located in Rambouillet Teleport site (48.549° N, 1.783° E), DLR site (48.086° N, 11.281° E), and Fuchsstadt site (50.119° N, 9.924° E). For simplicity, a common latitude of 49° is used for all sites.

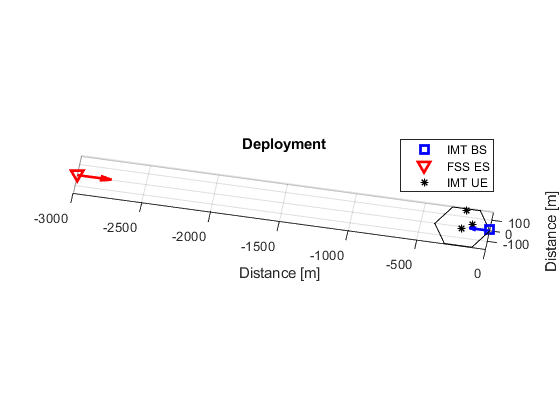


Figure 1: Deployment comprising a single FSS ES and a single WBB BS

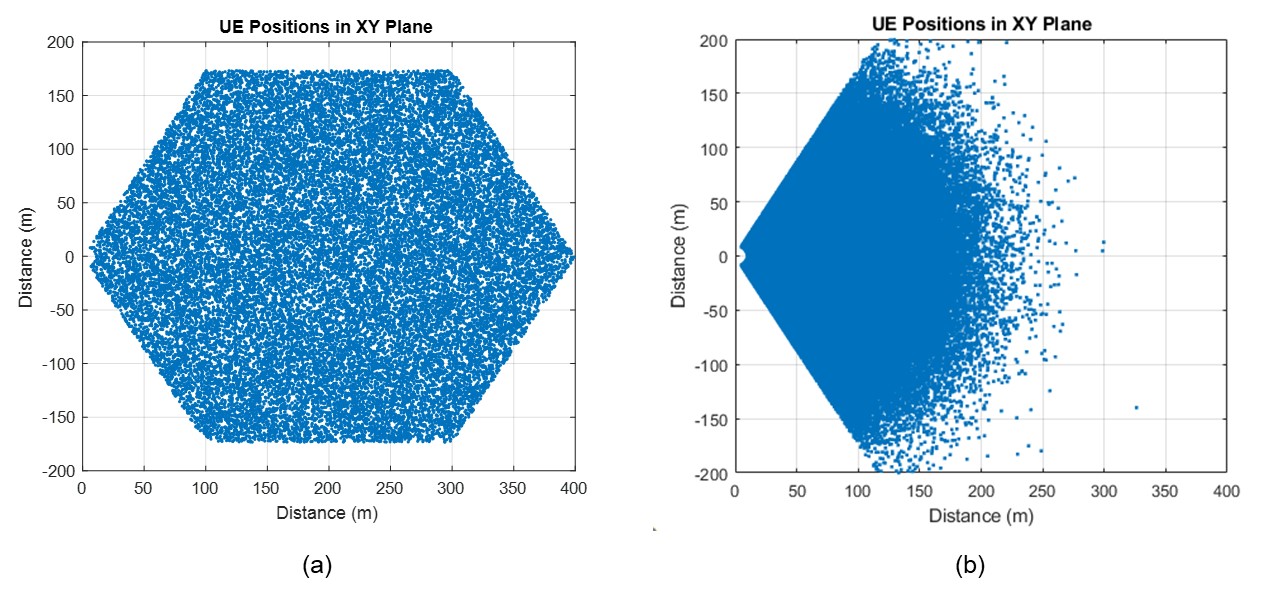


Figure 2: UE deployment: (a) uniform distribution and (b) Rayleigh distribution

## ADDITIONAL CONSIDERATIONS

### Recommendation ITU-R P.452-17 time percentage

The Recommendation ITU-R P.452-17 is used in this sharing study between stations on the surface of the Earth as specified by the ITU-R working parties (WPs) 3K and 3M (document [5D/722](https://www.itu.int/md/R19-WP5D-C-0722/en)). A smooth earth surface is assumed. Furthermore, to extend ITU-R P.452 model time percentage (Tpc) range to 0-100%, the ITU-R study group 3 (SG3) guidance (document [6A/198](https://www.itu.int/md/R12-WP6A-C-0198/en)) is that for Tpc > 50% the basic transmission losses are equal to the case Tpc = 50, thus, we use a random variable with a uniform distribution for Tpc between 0-100% applying the previous condition.

### Clutter loss

Due to the lack of exact information regarding vegetation/forest areas and other obstacles along the propagation path, the use of the clutter loss model in Rec. ITU-R P.2108 is a good compromise to account for the additional attenuation due to vegetation and/or other objects. In this study, the clutter losses for terrestrial paths are calculated in accordance with Rec. ITU-R P.2108-1 using a fixed percentage of locations equal to 50% on at least one end of the propagation path (resulting in a clutter loss of ~30.78 dB when the separation distance is larger than ~3km, in line with the characterization of the clutter in urban scenario). It is noted that this Recommendation indicates that statistical models can be applied for urban and suburban clutter loss modelling, so they cannot be applied for the rural scenario. These models should be used when the characteristics of the radio path, such as the height of buildings and the depth of vegetation, are not well known.

### TDD and Network loading factors

To incorporate these factors into the single-entry simulations, we first conduct Monte Carlo simulations, assuming the WBB BS is always transmitting in every snapshot, i.e., a 100% activity factor. Subsequently, once the interference results of all Monte Carlo snapshots are available in vector form, we extend this vector with empty snapshots (*-Inf* dB), so the following ratio corresponds to the overall activity factor:

Thus, the empty elements in the vector account for the assumed inactivity of the WBB BS. For instance, if the number of empty snapshots is 0, the activity factor is 100%. Conversely, if the number of empty snapshots is significantly greater than that of the active ones, the activity factor will tend to zero.

# Monte carlo Study Results

In this study, for different ground distances between the WBB BS and FSS ES, we assume that the WBB BS is always facing the FSS ES around it (worst-case). Additionally, it is reasonable to assume that the 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.

## Long-term criterion

In this section, we provide the separation distances for the long-term criterion for WBB BS with AAS and clutter losses only on one end of the propagation path. The next table summarizes the separation distances assuming baseline parameters for the instances where the BS is facing the main-lobe (i.e., aligned in azimuth with the FSS ES) and facing the back-lobe of the FSS ES:

Table 6: Separation distances using baseline parameters and UE uniform distribution

| WBB BS | FSS ES | Maximum EIRP (dBm/100MHz) | FSS ES Pattern | Activity factor | Main-lobe (km) | Back-lobe (km) |
| --- | --- | --- | --- | --- | --- | --- |
| 8×8 AAS | 3m diameter | 51 | S.465 | 75% | < 12.8 | < 2.2 |
| 8×8 AAS | 3m diameter | 51 | S.465 | 37.5% | < 7.6 | < 1.2 |
| 8×8 AAS | DLR | 51 | S.465 | 75% | < 10.8 | < 2.8 |
| 8×8 AAS | DLR | 51 | S.465 | 37.5% | < 5.6 | < 1.4 |
| 8×8 AAS | Fuchsstadt | 51 | S.465 | 75% | < 19.6 | < 2.8 |
| 8×8 AAS | Fuchsstadt | 51 | S.465 | 37.5% | < 12.8 | < 1.4 |
| 4×4 AAS | 3m diameter | 51 | S.465 | 75% | < 15.6 | < 3.6 |
| 4×4 AAS | 3m diameter | 51 | S.465 | 37.5% | < 14.2 | < 2.8 |
| 4×4 AAS | DLR | 51 | S.465 | 75% | < 15.8 | < 4.6 |
| 4×4 AAS | DLR | 51 | S.465 | 37.5% | < 14.6 | < 3.8 |
| 4×4 AAS | Fuchsstadt | 51 | S.465 | 75% | < 23 | < 4.6 |
| 4×4 AAS | Fuchsstadt | 51 | S.465 | 37.5% | < 21.4 | < 3.8 |

Note that the separation distances change depending on the activity factors assumed, thus it is important to account for this parameter.

Figure 3 shows the I/N values for a probability of 20% around the DLR earth station with an equivalent activity factor of 37.5% for the case of a BS with an 8x8 array size. The darkened area corresponds to locations where the I/N protection criterion is exceeded.



Figure 3: (a) I/N around DLR earth station and (b) I/N CDF at 5.6 km from FSS ES (facing main-lobe)

Figure 4 shows the I/N values for a probability of 20% around the Fuchsstadt earth station with an equivalent activity factor of 37.5% for the case of a BS with an 8x8 array size.



Figure 4: (a) I/N around Fuchsstadt earth station and (b) I/N CDF at 12.8 km from FSS ES (facing main-lobe)

## Long-term criterion (sensitivity analysis)

In this section, as sensitivity analysis, we provide the separation distances for the long-term criterion for WBB BS with AAS and clutter losses only on one end of the propagation path using additional assumptions on the user terminal (UE) deployments. The next table summarizes the separation distances assuming a UE Rayleigh distribution for the instances where the BS is facing the main-lobe (i.e., aligned in azimuth with the FSS ES) and facing the back-lobe of the FSS ES.

Table 7: Separation distances using sensitivity analysis parameters and UE Rayleigh distribution

| WBB BS | FSS ES | Maximum EIRP (dBm/100MHz) | FSS ES Pattern | Activity factor | Main-lobe (km) | Back-lobe (km) |
| --- | --- | --- | --- | --- | --- | --- |
| 8×8 AAS | 3m diameter | 51 | S.465 | 75% | < 5 | < 0.8 |
| 8×8 AAS | 3m diameter | 51 | S.465 | 37.5% | < 2.4 | < 0.6 |
| 8×8 AAS | DLR | 51 | S.465 | 75% | < 3.6 | < 1 |
| 8×8 AAS | DLR | 51 | S.465 | 37.5% | < 1.8 | < 0.6 |
| 8×8 AAS | Fuchsstadt | 51 | S.465 | 75% | < 8.2 | < 0.8 |
| 8×8 AAS | Fuchsstadt | 51 | S.465 | 37.5% | < 3.8 | < 0.6 |
| 4×4 AAS | 3m diameter | 51 | S.465 | 75% | < 13.8 | < 2.6 |
| 4×4 AAS | 3m diameter | 51 | S.465 | 37.5% | < 12 | < 1.8 |
| 4×4 AAS | DLR | 51 | S.465 | 75% | < 13.4 | < 3.4 |
| 4×4 AAS | DLR | 51 | S.465 | 37.5% | < 8.8 | < 2.2 |
| 4×4 AAS | Fuchsstadt | 51 | S.465 | 75% | < 21 | < 3.4 |
| 4×4 AAS | Fuchsstadt | 51 | S.465 | 37.5% | < 18.6 | < 2.4 |

## Short-term criterion (sensitivity analysis)

We provide the separation distances for the short-term criterion for WBB BS with AAS, the DLR FSS ES, and clutter losses only on one end of the propagation path. Table 8 summarizes the separation distances for the instances where the BS is facing the main-lobe (i.e., aligned in azimuth with the FSS ES) and facing the back-lobe of the FSS ES.

Table 8: Separation distances using baseline and sensitivity analysis parameters and UE uniform distribution

| WBB BS | FSS ES | Maximum EIRP (dBm/100MHz) | FSS ES Pattern | Activity factor | Main-lobe (km) | Back-lobe (km) |
| --- | --- | --- | --- | --- | --- | --- |
| 8×8 AAS | DLR | 51 | S.465 | 75% | < 7.8 | < 1.8 |
| 8×8 AAS | DLR | 51 | S.465 | 37.5% | < 7.4 | < 1.8 |
| 4×4 AAS | DLR | 51 | S.465 | 75% | < 11.4 | < 2.4 |
| 4×4 AAS | DLR | 51 | S.465 | 37.5% | < 11 | < 2.4 |

Figure 5 shows the I/N values for a probability of 0.005% around the DLR earth station with an equivalent activity factor of 37.5% for the case of a BS with an 8x8 array size, UE uniform distribution, and FSS ES S.465 pattern. The darkened area corresponds to locations where the I/N protection criterion is exceeded.



Figure 5: Sensitivity analysis with UE uniform distribution, AAS 8x8, and FSS ES S.465 pattern: (a) I/N around DLR earth station and (b) I/N CDF at 7.4 km from FSS ES (facing main-lobe)

Figure 6 shows the I/N values for a probability of 0.005% around the DLR earth station with an equivalent activity factor of 37.5% for the case of a BS with an 4x4 array size, UE uniform distribution, and FSS ES S.465 pattern.



Figure 6: Sensitivity analysis with UE uniform distribution, AAS 4x4, and FSS ES S.465 pattern: (a) I/N around DLR earth station and (b) I/N CDF at 11 km from FSS ES (facing main-lobe)

# Concluding remarks

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 Rec. ITU-R P.2108, with fixed percentage of locations equal to 50% (in line with the characterization 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 Rec. ITU-R P.452, with a random time percentage,

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 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 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 our results can be improved if local clutter data is used instead of statistical clutter assumptions.

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

1. DLR (“Deutsches Zentrum für Luft- und Raumfahrt”, German Aerospace Centre). [↑](#footnote-ref-2)
2. ITU-R, [Annex 1 to Task Group 5/1 Chairman’s Report](https://www.itu.int/dms_ties/itu-r/md/15/tg5.1/c/R15-TG5.1-C-0478!N01!MSW-E.docx), System parameters and propagation models to be used in sharing and compatibility studies, 2018. [↑](#footnote-ref-3)