# PARAMETERS AND DEPLOYMENT CONSIDERATIONS

The following tables present the wireless broadband systems (WBS) system and deployment related parameters.

Table 1: WBS 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 | 50% |
| **User Terminal** | |
| UE height | 1.5 m |
| Indoor user terminal usage | 70% |
| Indoor user terminal penetration loss | Rec. ITU-R [P.2109-1](https://www.itu.int/rec/R-REC-P.2109/en) |
| UE density for terminals that are transmitting simultaneously | 3 UEs per sector |
| UE TDD activity factor | 25% |

Table 2: Antenna and power characteristics for WBS

| 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) | Incremental power: 5.5 (corresponding to a TRP = 24.6 dBm)  Medium power: 3.5 (corresponding to a TRP = 22.6 dBm) |
| Conducted power (before Ohmic loss) per antenna element for 4×4 AAS\*\* (dBm) (Note 2) | Incremental power: 17.5 (corresponding to a TRP = 30.6 dBm)  Medium power: 15.5 (corresponding to a TRP = 28.6 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) | Incremental power: 38 (51 dBm/100MHz)  Medium power: 36 (49 dBm/100MHz) |
| Maximum base station EIRP for 4×4 AAS (dBm/5MHz) |
| **Base station (non-AAS)** | |
| Antenna pattern | Refer to Recommendation [ITU-R F.1336](https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1336-5-201901-I!!PDF-E.pdf) |
| 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 polarization | Linear ±45º |
| Feeder Loss (dB) | 3 |
| Maximum non-AAS BS output power (before feeder loss) (dBm) | Medium power: 42  Low power: 28 |
| Maximum non-AAS BS antenna gain (dBi) | Medium power: 10  Low power: 6 |
| Mechanical downtilt (degrees) | 10 |
| Maximum base station EIRP for non-AAS (dBm/5MHz) | Medium power: 36 (49 dBm/100MHz)  Low power: 18 (31 dBm/100MHz) |
| **User Terminal** | |
| Typical antenna gain (dBi) | −4 |
| Body loss (dB) | 4 |
| Power control model | 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) |
| Maximum user terminal output power, PCMAX (dBm) | 23 |
| Power target value per RB, P0\_PUSCH (dBm) | −87.2 |
| Path loss compensation factor, α | 0.8 |
| Nite 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. | |

The FSS ES parameters considered in this study are based on the agreed technical, operational characteristics, and protection criteria of FSS systems provided by WP 4A (Document [5D/734](https://www.itu.int/md/R19-WP5D-C-0734/en)). Table 3 contains the FSS ES parameters used in this study and Table 4 contains the FSS protection criteria

Table 3: FSS ES Parameter

| Parameter | Value |
| --- | --- |
| Antenna diameter (m) | 3 |
| Peak antenna gain (dBi) | 39.5 |
| 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) |
| Antenna elevation angle (degrees) | 10 |
| Antenna height (m) | 10 |

Table 4: FSS ES Protection Criteria

| Frequency Ranges | Percentage of time for which the I/N value could be exceeded (%) | I/N Criteria  (dB) |
| --- | --- | --- |
| 3 600-3 800 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 WBS systems under WRC-23 assumptions 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 WBS positions). Thus, it may be appropriate to understand percentages as being in other domains, such as time, location, and probability.

## DEPLOYMENT

A FSS earth station (ES) located in Rambouillet Teleport site (48.549° N, 1.783° E) is assumed to perform this study. The WBS local network consists of a single base station (BS). In each snapshot of the Monte Carlo simulation, 3 user equipment (UE) with random azimuth angles are randomly located within each sector where both azimuth and location are uniformly distributed. It is noted that the WBS 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.

In this study we consider two cases, one case where the FSS ES and the WBS BS are pointing towards each other (Figure 1), and another case where the FSS ES is pointing towards the WBS BS but the WBS BS is pointing towards the opposite direction of the FSS ES (Figure 2). Figure 1 and Figure 2 show an exemplary deployment snapshot with a separation distance between the FSS ES and the WBS BS of 3 km.

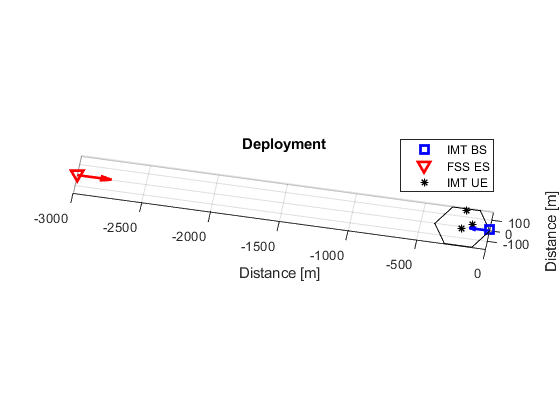


Figure 1: Deployment comprising a single FSS ES and a single WBS BS (case 1)

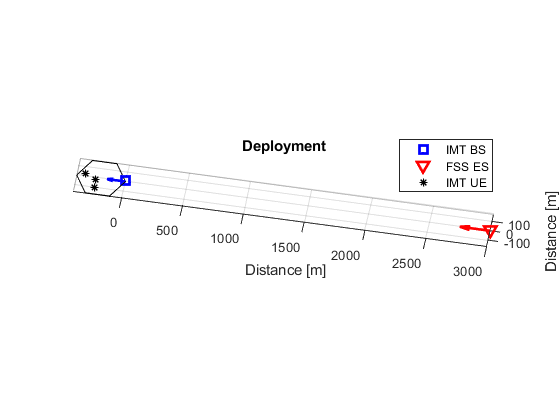


Figure 2: Deployment comprising a single FSS ES and a single WBS BS (case 2)

## ADDITIONAL CONSIDERATIONS

### Recommendation ITU-R P.2001 time percentage

The Rec. ITU-R P.2001 is used in this sharing study between stations on the surface of the Earth as specified by the ITU-R WPs 3K and 3M (document [5D/722](https://www.itu.int/md/R19-WP5D-C-0722/en)). For Monte Carlo simulations, this recommendation specifies that the time percentage (Tpc) in each snapshot should be randomly generated in the range 0-100%, thus we use a random variable with a uniform distribution for Tpc.

### Clutter loss

As elaborated in our contribution [PT1\_CG4G(22)007](https://www.cept.org/Documents/ecc-pt1/74015/ecc-pt1_cg4g-22-007_cg-38-42ghz-clutter-loss-considerationsdocx), 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 30% (resulting in a clutter loss of ~28.7 dB) on at least one of the ends of the propagation path. It is noted that this Recommendation indicates that statistical models are to be used when precise knowledge of the radio path is not known such as the width of streets, heights of buildings, and depth of vegetation.

# Monte carlo Study Results

### Intermediate results for medium power WBS with a 4×4 AAS (TRP = 28.6 dBm)

Assuming the deployment in Figure 1, the following intermediate results correspond to the case of a medium power WBS BS with 4×4 AAS.

Figure 3 shows the CDF curves of the FSS ES antenna gain towards the BS (left) and vice versa (right). The BS antenna gain includes the Ohmic losses. The BS highest gain towards the ES is 18.11 dB which is in line with the gain of an antenna array with 4x4 elements and an element gain of 6.4 dBi (6.4 + 10log10(16) = 18.4412 dBi).



Figure 3: CDF curves of the antenna gains from the FSS ES towards the BS and vice versa

Figure 4 shows the CDF curves of the FSS ES antenna gain towards the UEs (left) and vice versa (right). The UEs antenna gain has a value of -4 dBi for all snapshots.



Figure 4: CDF curves of the antenna gains from the FSS ES towards the UEs and vice versa

To calculate the UE power control gain, Figure 5 shows the CDF curves of the UEs antenna gains towards the BS (left) and vice versa (right). The BS antenna gain includes the Ohmic losses. As expected, the BS highest gain value is almost 18.4412 dB and the UEs antenna gain has a value of -4 dBi always.



Figure 5: CDF curves of the antenna gains from the UEs towards the BSs and vice versa

Figure 6 shows the CDF curve of the coupling loss between the UEs and its BS (left) and the histogram of the UEs power control gain (right), namely, the UE power reduction assuming a power control with 3 dB steps.



Figure 6: CDF of the coupling loss between UEs-BS, and histogram of UL power control gain

The coupling loss is calculated as follows:

In Figure 6, the path losses are assumed to be free space path losses (FSPL), the clutter loss model is based on Rec. ITU-R P.2108 (random percentage of locations), and the additional losses include the building entry and body losses.

Figure 7 shows the CDF curves of the coupling loss between the BS and the FSS ES (left) and between the UEs and the FSS ES (right), where the path loss model is based on Rec. ITU-R P.2001 using a smooth terrain profile and the clutter loss model is based on Rec. ITU-R P.2108. No polarization losses are considered.

Figure 7: CDFs of the coupling loss between BS-FSS ES and UEs-FSS ES

For a separation distance of 13.5 km and 10.5 km between the FSS ES and the WBS BS, Figure 8 shows the CDF curves of the I/N from a medium power WBS BS with 4x4 and 8x8 AASs, respectively, and the aggregated I/N from the UEs. As can be seen, the long-term protection criterion is not exceeded by any of the curves. As expected, the interference is dominated by the BS and not the UEs.



Figure 8: CDF curves of the aggregated I/N from WBS BS and UEs

Note that the size of the AAS antenna changes very little the long-term criterion results.

### Summary of results (long-term criterion)

Assuming the deployment in Figure 1 (i.e., WBS BS and FSS ES pointing towards each other), in the next table are summarized the separation distances for the long-term protection criterion assuming clutter losses on one and on both ends of the propagation path[[1]](#footnote-2).

Table 5: Separation distances to prevent harmful interference to a FSS ES for the scenario in Fig. 1 (long-term criterion)

| Case | Corresponding maximum EIRP [dBm/100MHz] | Clutter losses on one end [km] | Clutter losses on both ends [km] |
| --- | --- | --- | --- |
| Incremental power with 8×8 AAS (TRP = 24.6 dBm) | 51 | ~11.5 | < 1 |
| Incremental power with 4×4 AAS (TRP = 30.6 dBm) | 51 | ~14.5 | ~1 |
| Medium power with 8×8 AAS (TRP = 22.6 dBm) | 49 | ~10.5 | < 1 |
| Medium power with 4×4 AAS (TRP = 28.6 dBm) | 49 | ~13.5 | < 1 |
| Medium power with non-AAS (Conducted power = 42 dBm) | 49 | ~16.5 | < 1.5 |
| Low power with non-AAS (Conducted power = 28 dBm) | 31 | ~4.5 | < 1 |

Assuming the deployment in Figure 2 (i.e., WBS BS pointing towards the opposite direction of the FSS ES), in the next table are summarized the separation distances for the long-term protection criterion assuming clutter losses on one and on both ends of the propagation path.

Table 6: Separation distances to prevent harmful interference to a FSS ES for the scenario in Fig. 2 (long-term criterion)

| Case | Corresponding maximum EIRP [dBm/100MHz] | Clutter losses on one end [km] | Clutter losses on both ends [km] |
| --- | --- | --- | --- |
| Incremental power with 8×8 AAS (TRP = 24.6 dBm) | 51 | < 1 | < 1 |
| Incremental power with 4×4 AAS (TRP = 30.6 dBm) | 51 | < 1 | < 1 |
| Medium power with 8×8 AAS (TRP = 22.6 dBm) | 49 | < 1 | < 1 |
| Medium power with 4×4 AAS (TRP = 28.6 dBm) | 49 | < 1 | < 1 |
| Medium power with non-AAS (Conducted power = 42 dBm) | 49 | < 1 | < 1 |
| Low power with non-AAS (Conducted power = 28 dBm) | 31 | < 1 | < 1 |

### Summary of results (long-term criterion with fixed time percentage for Rec. ITU-R P.2001 propagation model)

We compare the preceding results with additional methodologies to determine the validity of these results. For this purpose, we consider the methodology where a fixed time percentage (Tpc) is used for the Recommendation ITU-R P.2001. In this case, for long-term results we use the exemplary Tpc value of 20%. We consider only clutter losses on one end of the propagation path and again a fixed percentage of locations equal to 30% for the Recommendation ITU-R P.2108. For a set of different separation distances, Figures 9 and 10 show the CDF curves of the I/N for incremental and medium power WBS BS with 4x4 and 8x8 AASs for the scenario in Fig. 1.

|  |  |
| --- | --- |
| (a) | (b) |

Figure 9: I/N CDF curves with fixed Tpc and clutter fixed percentage of locations for incremental power WBS BS with AAS (a) 8x8 and (b) 4x4 array configurations

|  |  |
| --- | --- |
| (a) | (b) |

Figure 10: I/N CDF curves with fixed Tpc and clutter fixed percentage of locations for medium power WBS BS with AAS (a) 8x8 and (b) 4x4 array configurations

The results attained with this methodology align very well with the results in Table 5 (for clutter losses on one end). It can be seen that the separation distances difference between methodologies is less than 1 km for all tested cases.

### Sensitivity analysis (short-term criterion)

We provide the separation distances for the short-term criterion for WBS with AAS and with clutter losses only on one end of the propagation path. However, it is noted that this criterion has not been completed in the expert group ITU-R WP4A as indicated in the Document 5D/734, thus these results are not representative in sharing studies and should not determine overall resolutions.

Additionally, note that these probabilities are not directly comparable with percentages of the FSS protection criteria since those are percentages of time while the probabilities calculated in this study are not entirely in the time domain. Table 7 contains the summary of results and, for the scenario in Fig. 1, Figure 11 shows the CDF curves of the I/N from incremental power WBS BS with 4x4 and 8x8 AASs for separations distances of 22.5 km and 20 km respectively.

Table 7: Separation distances between WBS and FSS ES (short-term criterion)

| Case | Corresponding maximum EIRP [dBm/100MHz] | Scenario Fig. 1 [km] | Scenario Fig. 2 [km] |
| --- | --- | --- | --- |
| Incremental power with 8×8 AAS (TRP = 24.6 dBm) | 51 | < 20 | < 1.5 |
| Incremental power with 4×4 AAS (TRP = 30.6 dBm) | 51 | < 22.5 | < 1.5 |



Figure 11: Short-term protection criterion I/N CDF curves for incremental power WBS BS with AAS 8x8 and 4x4 array configurations (Scenario Fig. 1)

# Concluding remarks

Based on the set of assumptions taken in this study, separations distances ranging from less than 1 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 assuming the WBS base station and the FSS earth station are pointing towards each other (Figure 1), results indicate that the longest separation distance is ~16.5 km for medium power WBS base stations with non-AASs (corresponding to a maximum EIRP = 49 dBm/5MHz). For this case, 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 WBS base station is pointing in the opposite direction of the FSS earth station (Figure 2), 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 WBS base station, separation distances can be decreased to just few kilometres to prevent harmful interference to FSS earth stations for a wide range of WBS base station antenna configurations and EIRP levels.

1. Ofcom, [UK Spectrum Co-ordination](https://www.ofcom.org.uk/__data/assets/pdf_file/0027/85086/coordination_processes.pdf), 2008 [↑](#footnote-ref-2)