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Annex 26 to Joint Task Group 4-5-6-7 Chairman's Report

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT
ITU-R F.[IMT 1 350-1 530 MHz ADJACENT CHANNEL SHARING]

Adjacent channel/adjacent band coexistence between IMT systems and fixed service point-to-point links currently operating in 1 350-1 527 MHz

1 Introduction

This Report presents an interference analysis of the feasibility of adjacent channel / adjacent band coexistence between IMT systems and fixed service point-to-point links currently operating in 1 350-1 527 MHz.

2 Technical characteristics

The following table provides an overview of parameter values assumed for the interference analysis in this Annex.

TABLE 1

Modelling parameters for interference analysis

Parameter	Value	Notes
IMT transmitter		
Channel bandwidth	10 MHz	
Base station maximum ant gain	15 dBi	Including feeder losses
User equipment maximum ant gain	–3 dBi	Omnidirectional
Typical body loss	4 dB	
Base station height (a.g.l.)	30 m	
User equipment height (a.g.l.)	1.5 m	
Base station antenna downtilt	3 degrees	
Base station TX e.i.r.p.	58 dBm	[Ref: Document 4-5-6-7/242, Annex 2, Attachment 2, Appendix 1 Table C *Note Cannot be referred to in this manner in a DNR*]
User equipment TX e.i.r.p.	20 dBm	

Parameter	Value	Notes
Fixed link receiver		
Channel bandwidth	2 MHz	
Maximum ant gain	14 dBi	Including 3 dB feeder loss
Height (a.g.l.)	30 m	Antenna mast height above ground level
Height above terrain	100 m	1.4 GHz fixed links are largely deployed on top of hills
Polarization discrimination (for IMT base station interference)	3 dB	In general, FS links operate in V/H polarization while IMT links are slant polarized
Noise figure	4 dB	
Noise floor	−107 dBm	kTBNF
Interference criterion	−113 dBm to be exceeded for 20% of time	I/N = −6 dB

IMT base station transmitter antenna patterns

It is assumed that the base station azimuth and elevation patterns are based on Recommendation ITU-R F.1336. [In line with ITU-R Document 4-5-6-7/242, Annex 2, Attachment 2, Appendix 1 (where IMT reference parameter values for agenda item 1.1 are provided), *Note Cannot be referred to in this manner in a DNR*] it is further assumed that the horizontal beamwidth is 65 degrees and the factor ‘k’ is 0.7 for both peak and average sidelobes.

The assumed azimuth and elevation patterns are illustrated in the following figures for the peak and average sidelobes.

FIGURE 1

IMT base station azimuth patterns

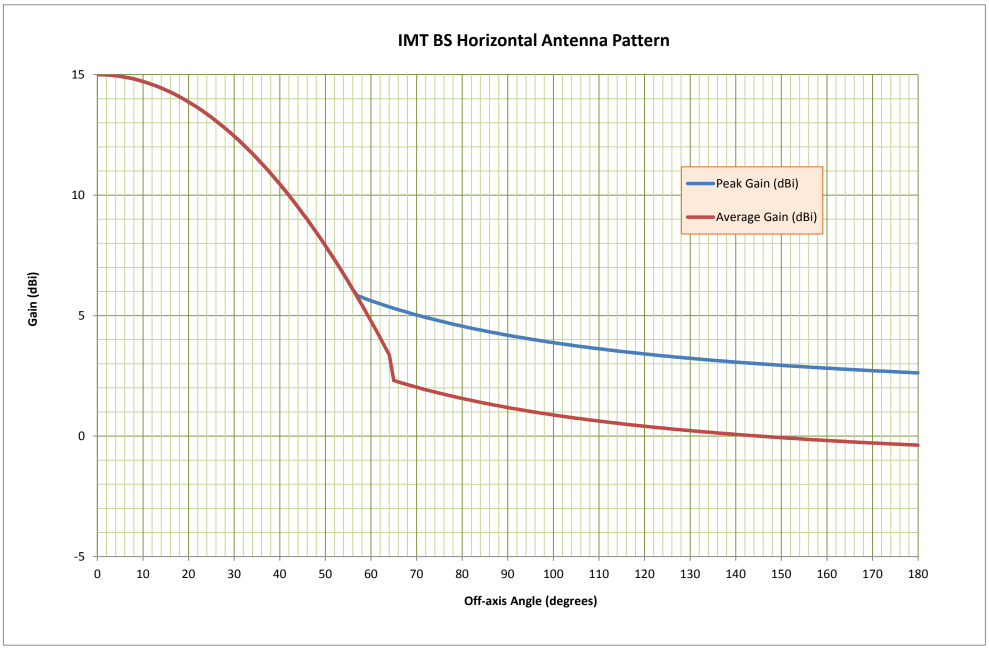
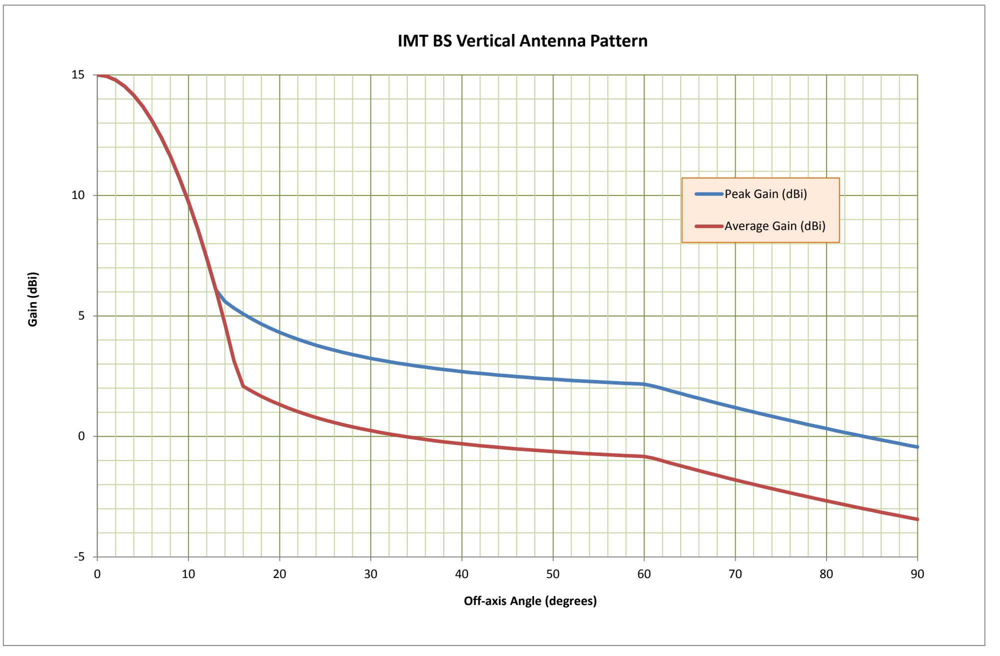


FIGURE 2

IMT base station elevation patterns



IMT transmitter unwanted emission masks

In adjacent band scenarios the implications of unwanted emission masks need to be considered. 3GPP TS 36.104 (ETSI TS 136 104) and 3GPP TS 36.101 (ETSI TS 136 101) describe out-of-band and spurious emission limits for IMT base station and user equipment (UE) transmitters, respectively. 3GPP TS 36.104 suggests that the medium range base station transmit power is less than 38 dBm, whereas the representative IMT base station transmit power in this study is greater than 40 dBm. Generic Category B unwanted emission mask defined for wide area base stations has been therefore used in the modelling.

In order to consider the implications of practical unwanted emissions from IMT base station and UE transmitters, additional masks have been generated by suppressing the 3GPP IMT UE and Category B base station unwanted emission masks by 10 and 20 dB. These masks have also been used in the analysis. The possibility also exists to implement additional filtering at the base station in order to reduce the unwanted emissions further, which would further improve the compatibility results.

FIGURE 3

IMT base station unwanted emission masks

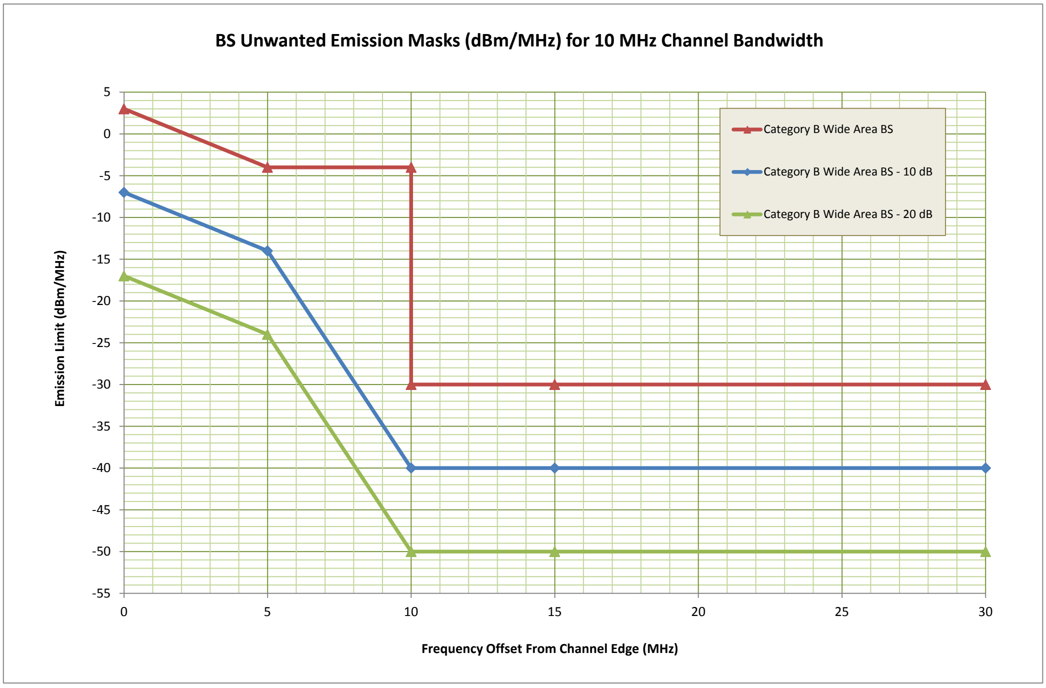
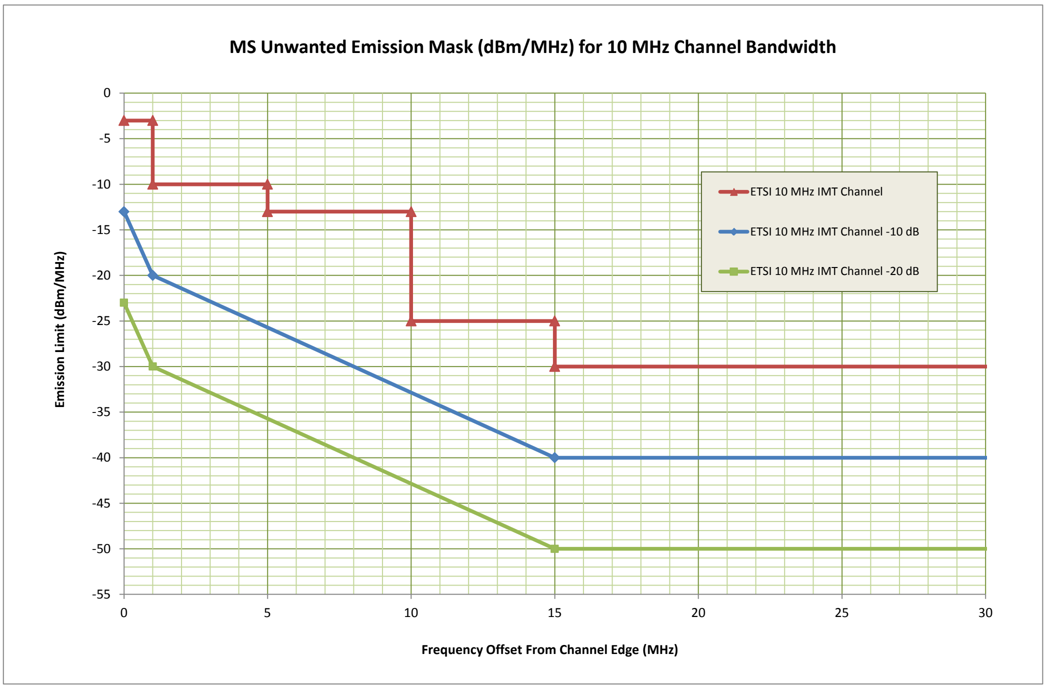


FIGURE 4

IMT UE unwanted emission masks

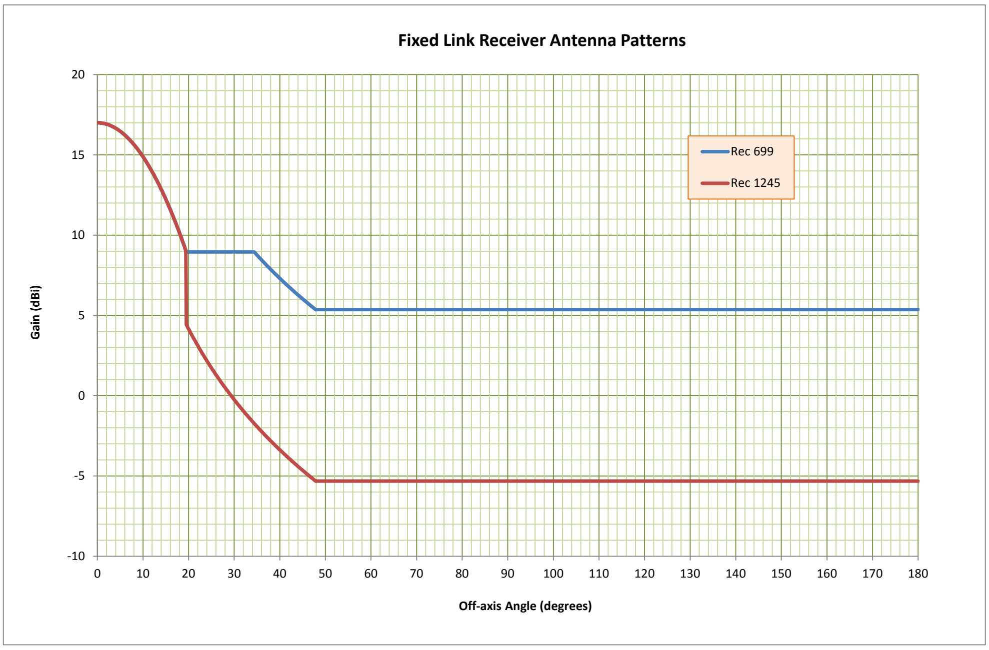


Fixed link receiver antenna patterns

Fixed link reference antenna patterns are defined in Recommendation ITU-R F.699 and Recommendation ITU-R F.1245. Recommendation ITU-R F.699 describes the peak envelope for the antenna sidelobes while Recommendation ITU-R F.1245 provides the average envelope of sidelobes. The following figure illustrates both patterns for an assumed maximum antenna gain of 17 dBi (which corresponds to an antenna diameter of approximately 60 cm at 1.4 GHz).

FIGURE 5

Fixed link receiver antenna patterns



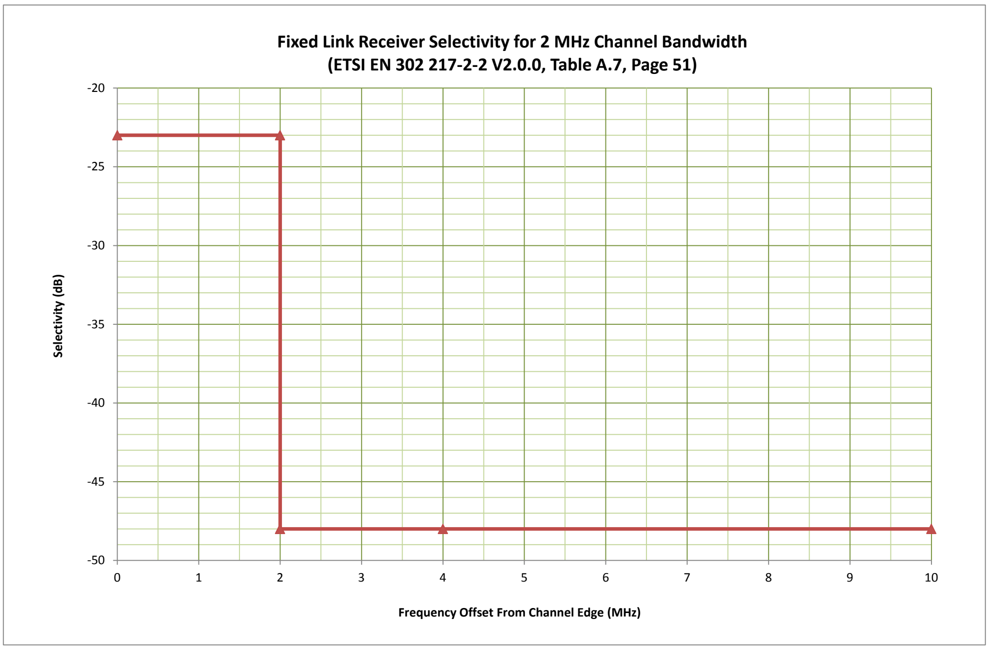
Fixed link receiver selectivity

ETSI standard EN 302 217-2-2 V2.0.0 (9/2012) describes fixed radio system characteristics for various frequency bands including the 1.4 GHz band. In Annex A of the standard, C/I ratios are provided for the co-channel, 1st adjacent channel and 2nd adjacent channel. It is noted that the C/I ratio given for the 2nd adjacent channel is also assumed to apply to adjacent channels beyond the 2nd adjacent channel in ETSI EN 300 630 V1.3.1 (2/2001) which defines fixed link characteristics for 1.4 GHz band only and is superseded by EN 302 217-2-2.

The following receiver selectivity has been assumed for the representative fixed link.

FIGURE 6

Fixed link receiver selectivity (ETSI EN 302 217-2-2)



3 Analysis

This section describes the analysis approach and provides the results obtained from the interference analysis.

3.1 Methodology

The analysis approach is based on deriving separation distances for different guard band assumptions. For a given guard band, the effective interfering emission power into the transmitter antenna resulting from the following two mechanisms has been considered:

– the IMT base station/UE unwanted emissions overlapping the fixed link receiver bandwidth. This is calculated by integrating the transmitter emission mask over the receiver bandwidth;

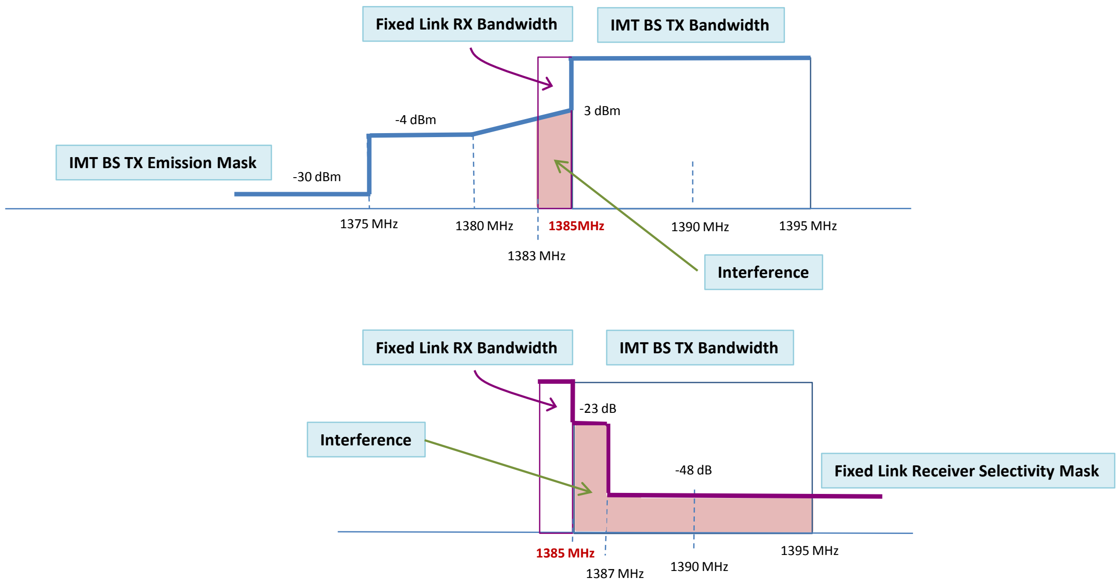
– the IMT base station/UE transmitter in-band power overlapping the fixed link receiver selectivity mask. This is calculated by integrating the receiver selectivity mask over the transmitter bandwidth.

The effective interfering emission power into the transmitter antenna has been translated into separation distances by taking account of antenna gains, propagation loss and receiver interference criterion. The assumptions used are generally pessimistic, and the separation distances calculated are more like coordination distances than minimum separation distances that would be required to avoid interference in reality.

The following figure provides an illustration of adjacent channel interference for an example scenario where the IMT base station transmitter and fixed link receiver operate in adjacent channels with 0 MHz guard band.

FIGURE 7

Adjacent band interference illustration



3.2 Results - IMT base station interference

Effective interfering emission power

The table below shows power levels calculated for both interference mechanisms by assuming 0 MHz, 2 MHz (which is equal to one fixed link channel) and 10 MHz (which is equal to one IMT channel) guard bands for IMT base station transmitters.

TABLE 2

Effective interfering emission power levels

(IMT base station Transmitter)

Scenario	Power due to unwanted emissions overlapping receiver bandwidth (dBm)	Power due to in-band transmitted power overlapping receiver selectivity mask (dBm)	Effective interfering emission power into transmitter antenna (dBm)	Notes
IMT base station interferer with 3GPP mask, 0 MHz guard band	4.685	13.049	13.64	Receiver selectivity dominates.
IMT base station interferer with 3GPP mask – 10 dB, 0 MHz guard band	−5.315		13.112	
IMT base station interferer with 3GPP mask – 20 dB, 0 MHz guard band	−15.315		13.056	
IMT base station interferer with 3GPP mask, 2 MHz guard band	1.885	−5	2.695	Unwanted emissions dominate.
IMT base station interferer with 3GPP mask – 10 dB, 2 MHz guard band	−8.115		−3.274	Both mechanisms are important.
IMT base station interferer with 3GPP mask – 20 dB, 2 MHz guard band	−18.115		−4.793	Receiver selectivity dominates.
IMT base station interferer with 3GPP mask, 10 MHz guard band	−26.99	−5	−4.973	Receiver selectivity dominates.
IMT base station interferer with 3GPP mask – 10 dB, 10 MHz guard band	−36.99		−4.997	
IMT base station interferer with 3GPP mask – 20 dB, 10 MHz guard band	−46.99		−5	

As can be seen, the adjacent channel / adjacent band coexistence with IMT base station transmitters is largely dominated by the selectivity of the fixed link receiver when the guard band is 0 MHz and 10 MHz. It is worth noting that, for guard bands greater than 10 MHz, no additional discrimination is available in the calculations as the assumed transmitter and receiver masks do not vary beyond this point. In practice, the transmitter and receiver masks may show variation with guard bands greater than 10 MHz. In particular, the receiver selectivity which is the dominant factor when the guard band is 10 MHz can be improved with additional filtering.

Separation distances

Based on the effective interfering emission power levels shown in Table 2, separation distances have been calculated under the pessimistic assumptions used in this analysis.

It is assumed that IMT base station transmitter is pointing at the fixed link receiver at regular azimuth offsets relative to the fixed link receiver pointing direction. At each azimuth offset, the required separation is calculated by using the effective interfering emission power (shown in Table 2), transmitter antenna gain, fixed link receiver antenna off-axis gain and interference path loss which is assumed to be represented by Recommendation ITU-R P.1546.

The Recommendation ITU-R P.1546 propagation loss curve is obtained from the interpolation of standard loss curves given in the recommendation to accommodate the operating frequency (assumed to be 1 400 MHz), the fixed link receiver antenna height above terrain (100 metres) and the propagation percentage time (20%). Recommendation ITU-R P.1546 is valid for path lengths greater than or equal to one kilometre. For paths less than 1 kilometre, it is assumed that the path loss follows the Hata model up to 100 metres and an interpolation is applied for distances between 100 metres and one kilometre. Calculated loss values are compared against the free space path loss to make sure that they do not fall below the free space path loss.

As an example, the following figure shows the variation of the separation distances when a 2 MHz guard band is assumed. The separation distances are calculated for both Recommendation ITU-R F.699 and Recommendation ITU-R F.1245 fixed link receiver antenna pattern. The IMT base station transmitter is assumed to be 3-degrees downtilted and the emissions are assumed to follow the 3GPP mask.

FIGURE 8

Adjacent band separation distances for an IMT base station interferer

(3GPP mask, 2 MHz guard band)

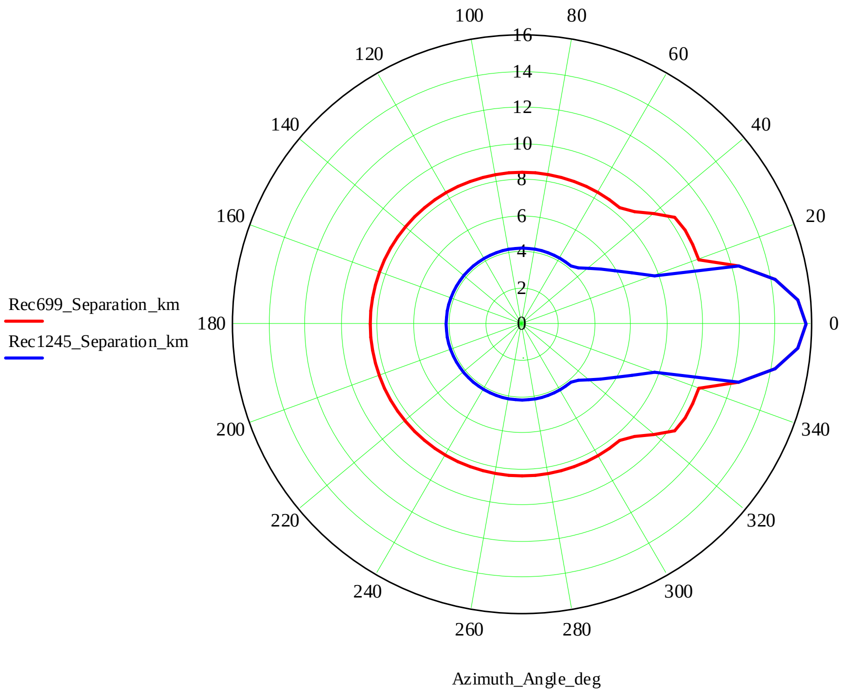


Table 3 below provides a summary of calculated separation distances for the scenarios given in Table 2.

TABLE 3

Calculated separation distances (IMT base station Interferer)

Scenario	**Separation distance (km)**	
	F.699	**F.1245**
IMT base station interferer with 3GPP mask, 0 MHz guard band	15.2 – 25.9	8.6 – 25.9
IMT base station interferer with 3GPP mask – 10 dB,	14.8 – 25.3	8.3 – 25.3

0 MHz guard band		
IMT base station interferer with 3GPP mask – 20 dB, 0 MHz guard band	14.8 – 25.2	8.3 – 25.2
IMT base station interferer with 3GPP mask, 2 MHz guard band	8.4 – 15.7	4.2 – 15.7
IMT base station interferer with 3GPP mask – 10 dB, 2 MHz guard band	5.8 – 11.6	2.7 – 11.6
IMT base station interferer with 3GPP mask – 20 dB, 2 MHz guard band	5.2 – 10.7	2.4 – 10.7
IMT base station interferer with 3GPP mask, 10 MHz guard band	5.1 – 10.6	2.4 – 10.6
IMT base station interferer with 3GPP mask – 10 dB, 10 MHz guard band	5.1 – 10.6	2.4 – 10.6
IMT base station interferer with 3GPP mask – 20 dB, 10 MHz guard band	5.1 – 10.6	2.4 – 10.6

The results indicate that the required separation is between 2.4 kilometres and 25.9 kilometres for the scenarios examined and under the assumptions used.

Sensitivity analysis

The analysis presented in the preceding section assumes that the IMT base station transmitter is pointing at the fixed link receiver. If it is assumed that the IMT base station transmitter is pointing away from the fixed link receiver and there is an additional 12 dB discrimination available at the transmitter antenna (in line with the Recommendation ITU-R F.1336 peak horizontal antenna pattern shown in Figure 1) the separation distances calculated are between 0.9 and 14.9 kilometres for the scenarios shown Table 3.

The analysis presented in the preceding section also assumes that the maximum interference threshold is 6 dB below the fixed link receiver noise floor. This is equal to 1 dB loss in the fixed link fade margin. If it can be assumed that the fixed link can tolerate 3 dB loss in its fade margin due to IMT base station interference (which implies that the maximum interference threshold is equal to the fixed link receiver noise floor) the separation distances vary between 1.5 and 19.8 kilometres for the scenarios shown in Table [8].

The combined effect of the IMT base station transmitter pointing away from the receiver and the interference threshold equal to the receiver noise floor translates into separation distances between 0.5 and 11 kilometres for the scenarios shown in Table [8].

If it can be assumed that an IMT base station transmitter is deployed in a cluttered urban area and the transmitter power is reduced by 10 dB together with an additional 20 dB clutter loss on the interference path the separation distances that are calculated vary between 0.15 and 6.5 kilometres for the scenarios shown in Table [8].

3.3 Results – IMT user equipment interference

Effective interfering emission power

IMT UE effective interfering emission power levels calculated for the two interference mechanisms mentioned earlier are shown in the following table for the assumed 0 MHz, 2 MHz and 10 MHz guard bands.

TABLE 4

Effective interfering emission power levels (IMT MS transmitter)

<table>
<tr><th>Scenario</th><th>Power due to unwanted emissions overlapping receiver bandwidth
(dBm)</th><th>Power due to in-band transmitted power overlapping receiver selectivity mask (dBm)</th><th>Effective interfering emission power into transmitter antenna
(dBm)</th><th>Notes</th></tr>
<tr><td>IMT UE interferer with 3GPP mask, 0 MHz guard band</td><td>−2.21</td><td rowspan="3">−6.951</td><td>−0.953</td><td>Both mechanisms are important.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 10 dB,
0 MHz guard band</td><td>−14.761</td><td>−6.285</td><td rowspan="2">Receiver selectivity dominates.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 20 dB,
0 MHz guard band</td><td>−24.761</td><td>−6.879</td></tr>
<tr><td>IMT UE interferer with 3GPP mask, 2 MHz guard band</td><td>−6.99</td><td rowspan="3">−25</td><td>−6.922</td><td rowspan="2">Unwanted emissions dominate.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 10 dB,
2 MHz guard band</td><td>−19.769</td><td>−18.63</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 20 dB,
2 MHz guard band</td><td>−29.769</td><td>−23.75</td><td>Both mechanisms are important.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask, 10 MHz guard band</td><td>−21.99</td><td rowspan="3">−25</td><td>−20.229</td><td>Both mechanisms are important.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 10 dB,
10 MHz guard band</td><td>−31.197</td><td>−24.066</td><td rowspan="2">Receiver selectivity dominates.</td></tr>
<tr><td>IMT UE interferer with 3GPP mask – 20 dB,
10 MHz guard band</td><td>−41.197</td><td>−24.897</td></tr>
</table>

Separation distances

Based on the effective interfering emission power levels shown in Table 4 and other assumptions used in this Report, separation distances have been calculated using Recommendation ITU-R P.1546-4 path loss model. Recommendation ITU-R P.1546-4 path-loss curves refer to signal strength at a local clutter level, therefore when mobile terminals are considered an additional loss needs to be introduced as these terminals are likely to be located below the clutter. In this modelling, an additional loss of 10 dB has been added to reflect the height loss. The range of calculated separation distances is provided in the following table. The minimum separation distance is assumed to be 10 metres.

TABLE 5

Calculated separation distances (IMT UE interferer)

Scenario	**Separation distance (km)**	
	F.699	**F.1245**
IMT UE interferer with 3GPP mask, 0 MHz guard band	0.79 – 1.97	0.34 – 1.97
IMT UE interferer with 3GPP mask – 10 dB, 0 MHz guard band	0.52 – 1.29	0.23 – 1.29
IMT UE interferer with 3GPP mask – 20 dB, 0 MHz guard band	0.5 – 1.24	0.22 – 1.24
IMT UE interferer with 3GPP mask, 2 MHz guard band	0.5 – 1.23	0.22 – 1.23
IMT UE interferer with 3GPP mask – 10 dB, 2 MHz guard band	0.2 – 0.49	0.07 – 0.49
IMT UE interferer with 3GPP mask – 20 dB, 2 MHz guard band	0.14 – 0.33	0.01 – 0.33
IMT UE interferer with 3GPP mask, 10 MHz guard band	0.18 – 0.44	0.06 – 0.44
IMT UE interferer with 3GPP mask – 10 dB, 10 MHz guard band	0.13 – 0.32	0.01 – 0.32
IMT UE interferer with 3GPP mask – 20 dB, 10 MHz guard band	0.12 – 0.3	0.01 – 0.3

Table 5 indicates that the separation distance remains below 1.97 kilometres for the scenarios investigated and is generally only a few hundred metres.

Sensitivity analysis

The separation distances calculated in the preceding sub-section are based on the interference criterion of 1 dB fade margin loss in the fixed link. If it can be assumed that the fixed link can tolerate 3 dB loss in its fade margin due to interference from an IMT UE transmitter the separation distances remain below 1.23 kilometres for the scenarios shown in Table 5.

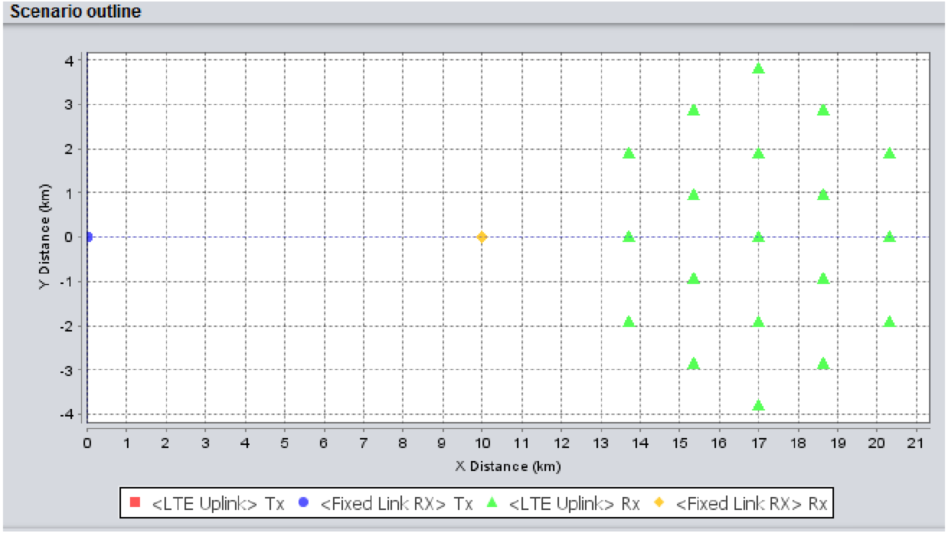
Monte Carlo analysis

Interference from a population of IMT UE transmitters has been analysed using the SEAMCAT OFDMA module. It is assumed that each sector in a 19 site / 57 sector cluster is populated by 5 outdoor IMT UE transmitters. The interference path loss is based on SEAMCAT Recommendation ITU-R P.1546 model where the propagation variations are enabled and the min/max path loss percentage times are set to 20%.

The first scenario in Table has been examined as an example to investigate the implications of interference.

FIGURE 9

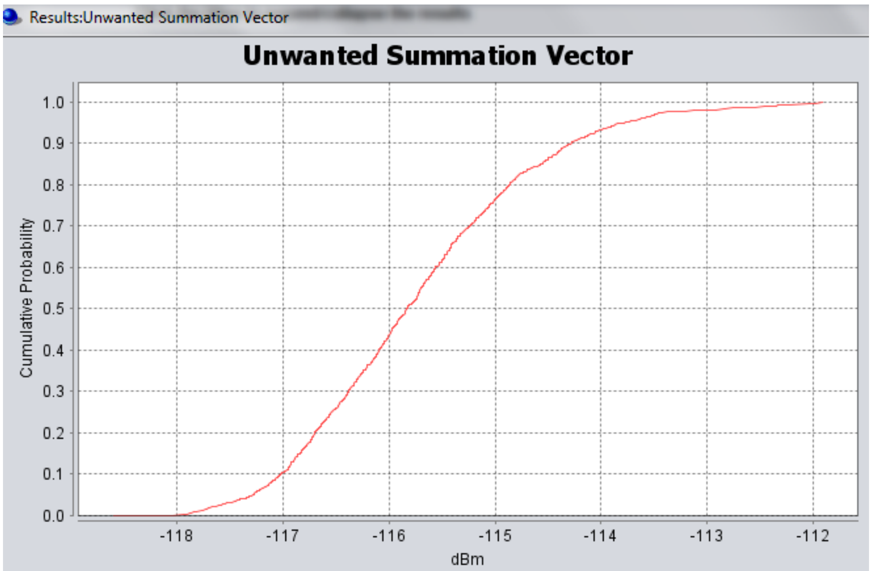
SEAMCAT simulation outline



The following figure illustrates the interference CDF for the scenario shown in the figure above where the victim fixed-link receiver is pointing towards the IMT cell cluster and located approximately 2 kilometres away from the edge of the cluster.

FIGURE 10

SEAMCAT simulation result



The results indicate that, for the assumed separation from the edge of IMT cell cluster, the interference threshold (−113 dBm) is satisfied in almost all Monte Carlo trials. The required separation from the edge of the IMT cluster is therefore similar to the corresponding separation distances calculated for the single-entry IMT UE interference.

4 Summary

– With no guard band, separation distances in the range 8.3 to 25.9 kilometres (depending on the assumed IMT base station emission mask and fixed link receiver antenna pointing and antenna pattern) have been calculated to satisfy the fixed link interference criterion for an IMT base station. This is reduced to 2.4 to 15.7 kilometres when 2 MHz guard band (which is equal to the fixed link receiver bandwidth) is assumed and 2.4 to 10.6 km when 10 MHz guard band (which is equal to the IMT base station transmitter bandwidth) is assumed.

– These calculated separations are based on pessimistic assumptions where it is assumed that the interfering IMT base station transmitter is pointing towards the fixed link receiver, the maximum interference threshold is limited to 1 dB loss in the fixed link fade margin and the IMT base station transmitter is deployed for a wide area coverage.

– Depending on the assumed IMT base station emission mask and fixed link antenna pointing and antenna pattern, the calculated separation distance is between 0.9 and 14.9 kilometres when the IMT base station transmitter is assumed to point away from the fixed link receiver. Similarly the separation is between 1.5 and 19.8 kilometres when the fixed link margin loss due to IMT base station interference is 3 dB. If IMT base station transmitters are deployed in cluttered urban area the separation is between 0.15 and 6.5 kilometres.

– To facilitate adjacent channel sharing, IMT base station transmitters may have to be coordinated with fixed link receivers. Depending on the specific deployment scenario, guard bands may be used to decrease separation distance requirements and account may also be taken of the base station e.i.r.p. in determining the required coordination distance. Further improvements may be obtained from terrain/clutter losses and by deploying additional filtering at IMT base station transmitters and/or fixed link receivers.

– The required separation is less than 2 kilometres when interference from IMT UE transmitters is considered. Depending on the assumed guard band, interference alignment and IMT UE emission mask, the required distance is reduced to a few hundred metres.

– Adjacent channel sharing between IMT UE transmitters and fixed link receivers could therefore be realized providing that fixed link receivers are not close to population centres or busy transport infrastructure links where mobiles could be operating in close proximity.