Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

SHARING AND ADJACENT BAND COMPATIBILITY BETWEEN UMTS/IMT-2000 IN THE BAND 2500-2690 MHZ AND OTHER SERVICES

Granada, February 2004

INDEX TABLE

1 INTRODUCTION

WRC-2000 identified three different bands of additional spectrum for IMT-2000, including the band 2500 - 2690 MHz. For CEPT, this band has the highest priority. Therefore a first ECC Decision (02)06 on the designation of the band 2500 – 2690 MHz for UMTS/IMT-2000 concludes 1 January 2008 as the date when the band should be made available. The band 2500 – 2690 MHz is the only band available for IMT-2000 (in addition to the 2GHz core band) in many European countries within a realistic timeframe. ECC Decision (02)06 also calls for the development of an additional ECC Decision that details the spectrum arrangements for the band 2500 – 2690 MHz as well as the utilisation of the bands 2500 – 2520 MHz / 2670 – 2690 MHz by the end of 2004.

In Region 1 the band 2500 - 2690 MHz is currently allocated on a primary basis to the fixed service and the mobile service and parts of the band are also allocated to several space services. Based on the ERC Report 25, the following services and applications need to be considered for sharing and compatibility studies (see figure 1).

<table>
<tr><td colspan="7">2450 2483.5 2500 2520 2670 2690 2700 MHz</td></tr>
<tr><td colspan="2"></td><td>MSS</td><td>MSS(1)</td><td></td><td>MSS(1)</td><td rowspan="3">RA, EES, SR (passive services)</td></tr>
<tr><td></td><td colspan="2" rowspan="2">FS, MS, ISM, radiolocation</td><td colspan="3">MS (UMTS/IMT2000 terrestrial)</td></tr>
<tr><td></td><td colspan="3">FS(2), (3)</td></tr>
</table>

Figure 1 - European frequency plan for the 2.5 GHz band

(1) In the RR the allocation of the frequency bands 2 500-2 520 MHz / 2670 – 2690 MHz to the mobile-satellite service (space-to-Earth) becomes effective on 1 January 2005 and is subject to coordination under No. 9.11A of the RR.

(2)With the introduction of UMTS/IMT2000, the FS will become secondary in appropriate parts of the band in Europe. Therefore transitional arrangements for the FS may be considered.

(3) Within the band 2500-2670MHz, MMDS is used in certain European countries namely Iceland, Ireland, Latvia and Lithuania. In some of these countries operation within 2500-2520 MHz and 2670 – 2690 MHz will be phased out.

This report uses all relevant parameters needed in interference studies for UMTS, for MMDS (Multipoint Multimedia Distribution System) and the passive Services as identified in Figure 1, at the date of publication. It should be noted that the parameters assumed in this report for the IMT-2000 terrestrial system are those of UMTS; other terrestrial IMT-2000 radio interfaces have not been considered. The interference scenarios have been investigated by deterministic and statistical approaches.

This report gives recommendations and guidance on the necessary guard bands between UMTS and other services for the development of detailed the spectrum arrangements for UMTS in the band 2500 – 2690 MHz. However, since these recommendations are based on parameters correct at the date of publication, it should be noted that any changes in parameters, for example, in the terrestrial UMTS emission masks, would require the recommendations of this report to be re-considered.

2 SHARING AND ADJACENT BAND COMPATIBILITY STUDY METHODS

According to the allocation of Radio Services in and adjacent to the 2500 – 2690 MHz band various scenarios have to be considered. Table 1 gives an overview on these scenarios, which have been considered in detail in this report.

Bands	**Below 2500 MHz**	**2500 – 2520 MHz**	**2520 – 2670 MHz**	**2670 – 2690 MHz**	**Above 2690 MHz**
Allocated to ...	**MSS (DL)** **MS** **FIXED** **Radiolocation,**	**MS** **MSS DL**	**MS** **(FS)**	**MS** **MSS UL**	**RAS** **SR(p)** **EES(p)**[2]
Co-frequency band sharing		UMTS-T / MSS *UMTS-T/FS*	UMTS-T/MMDS	UMTS-T /MSS *UMTS-T/FS*	
Adjacent band compatibility (lower band edge)		*UMTS-T/MSS* *UMTS-T/Radiolocation* *UMTS-T /FS*	UMTS-T/MSS	UMTS-T /MSS *UMTS-S / FS*	
Adjacent band compatibility (upper band edge)		UMTS-T/MSS *UMTS-S / FS*	UMTS-T/MSS	UMTS-T/RAS UMTS-S / RAS *UMTS-T / SR(p)* *UMTS-T/EES(p)*	

Table 1: Sharing/compatibility scenarios considered

Note 1: The studies regarding IMT-2000 terrestrial intra-service compatibility are treated in other reports within the ECC or ITU-R.

Note 2: Footnote 5.340 applies to the band 2690-2700 MHz, which states: “all emissions are prohibited”.
Scenarios in italics have not been examined in this Report.

2.1 Interference mechanisms

2.1.1 Interference paths for UMTS-S / UMTS-T sharing and compatibility assessments

The various interference paths can be categorised in a number of ways. The approach selected is based on the wanted or interfering system and whether the interference path is the satellite component (including eventually terrestrial repeaters) or the terrestrial component. This approach was selected as the UMTS-S direction determines the approach to modelling. The result is four main interference paths, as shown in the table and figures below.

Interference Path	MSS DL at 2520MHz	MSS UL at 2670MHz
UMTS-T Wanted UMTS-S Interfering	A	B
UMTS-T Interfering UMTS-S Wanted	D	C

Table 2: Interference Paths

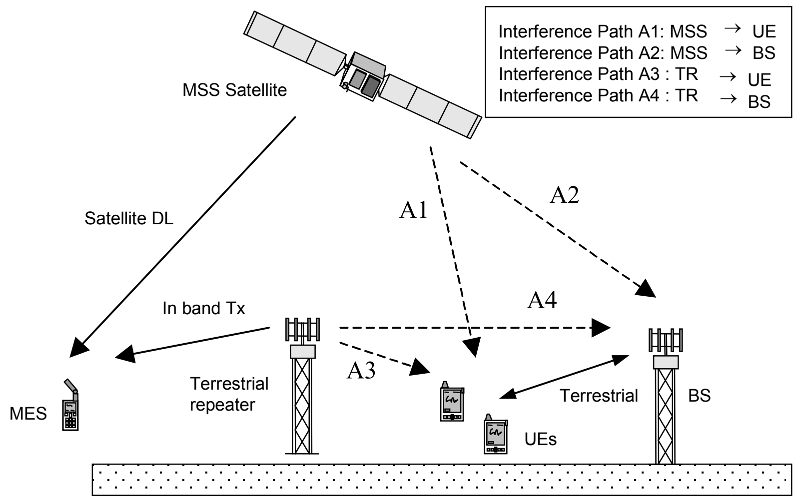


Figure 2: Interference Path A

2 500 - 2 520 MHz

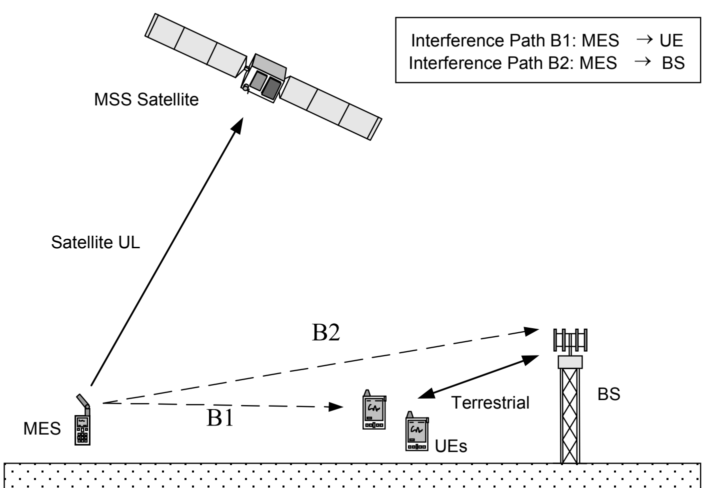


Figure 3: Interference Path B

2 670 - 2 690 MHz

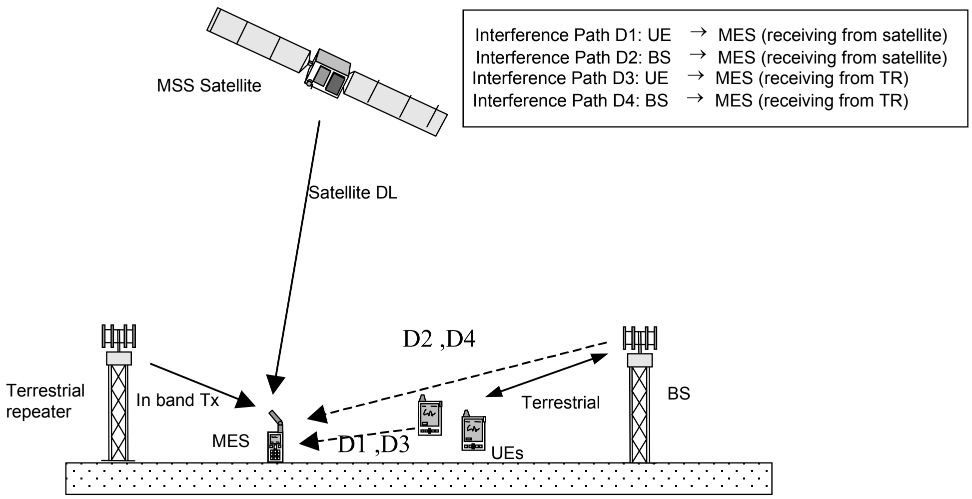


Figure 4: Interference Path C

2 670 - 2 690 MHz

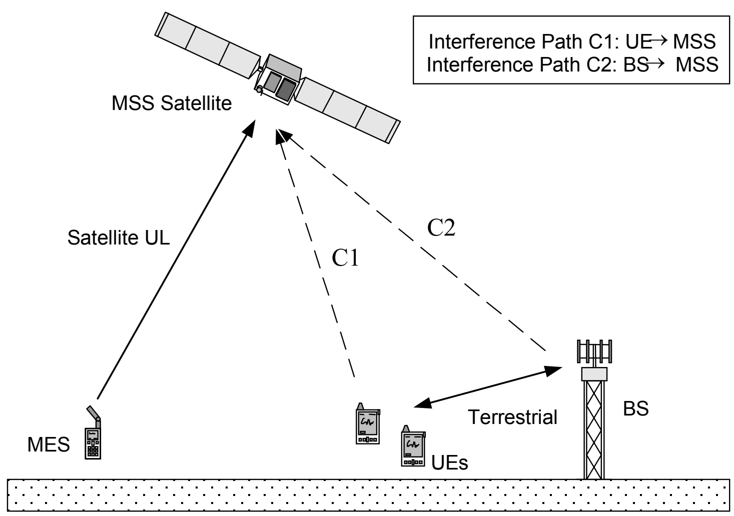


Figure 5: Interference Path D

2 500 - 2 520 MHz

2.1.2 Interference path for IMT-2000 system components/RAS compatibility assessments

UMTS-T base stations and UE as well as S-DMB MES and SRI-E MES can interfere with Radio Astronomy receiver stations as presented in the following Figure 6.

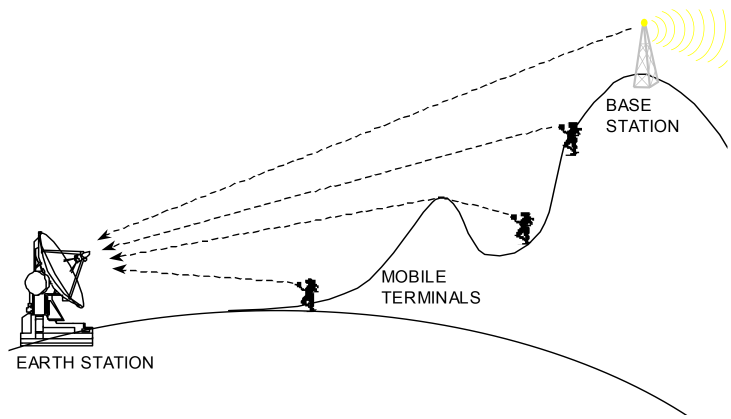


Figure 6: Interference path into RA stations

2.1.3 Interference paths for UMTS-T sharing and compatibility assessments for MMDS

The scenarios considered in these simulations are depicted in Figures 7 and 8 below. Figure 7 shows the interference paths from a terrestrial UMTS UE transmitter into an MMDS receiver (path E1) and from a UMTS base station transmitter into an MMDS receiver (path E2).

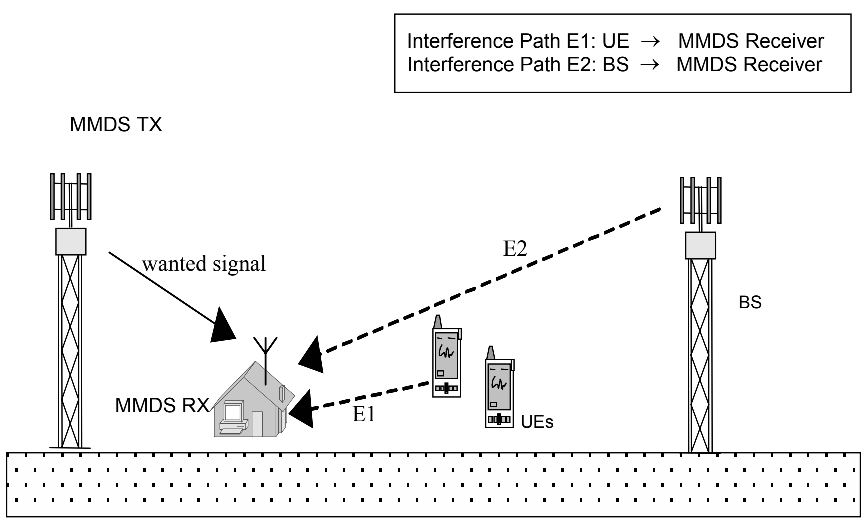


Figure 7: Interference path E

Figure 8 illustrates the interference paths from an MMDS transmitter into a UMTS base station receiver (path F1) and from an MMDS transmitter into a terrestrial UMTS UE. As the MMDS system is unidirectional there is no interference from the MMDS receiver into the UMTS system.

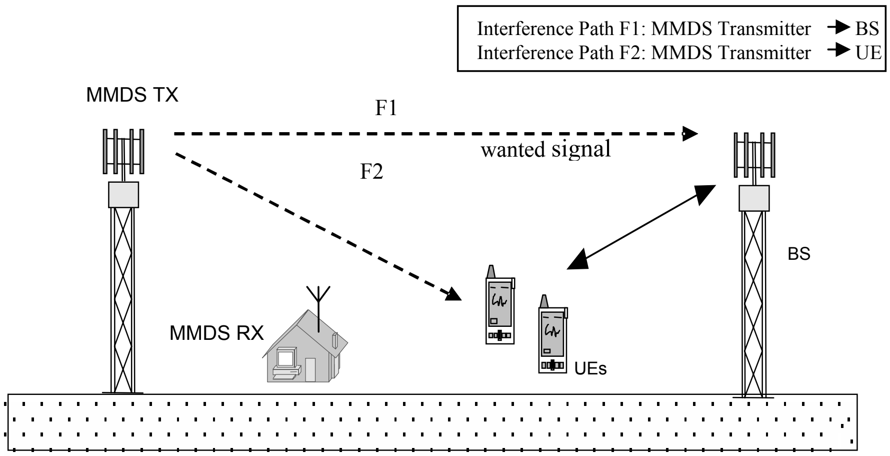


Figure 8: Interference path F

2.2 Minimum Coupling Loss (MCL) and Monte Carlo (MC) approaches

Within CEPT, two approaches have been used so far to assess interference between two systems.

The first one, the **Minimum Coupling Loss (MCL)**, allows computation, for a given system (a given set of transmitter and receiver parameters) of the minimum propagation loss (and hence derive the minimum separation distance) and/or the minimum adjacent band isolation (and hence derive the minimum guard band). For 3GPP compliant systems (terrestrial or satellite) operating with the same bandwidth, the adjacent band isolation is expressed by the ACIR, as explained below. It should be noted that the ACIR concept is useful when standard frequency carrier separations of 5, 10 or 15 MHz are envisaged. In the other cases, the use of Tx/Rx spectrum masks is necessary. The MCL between an interfering transmitter (Tx) and a victim receiver (Rx) is defined as :

$$MCL = T_x power(dBm/Ref.Bw) + T_x antenna\ gain(dBi) + R_x antenna\ gain(dBi)$$
$$- R_x \mathrm{int}erference\ threshold(dBm/Ref.Bw)$$

In case of minimum separation distance calculation ($D_{\min}$) :

$$MCL = Propagation\ model\ \ (D_{\min})$$

In case of minimum guard band calculation ($f_{separation}$):

$$MCL = Propagation\ model(D_{\min}) - ACIR(f_{separation})$$

The ACIR is defined as :

$$ACIR = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}} \text{ (in linear terms)}$$

ACLR is the Adjacent Channel Leakage Ratio of the interfering Transmitter (i.e. the out-of-band power ratio falling into the adjacent channel), and ACS is the Adjacent Channel Selectivity (i.e. the power received in the adjacent channel after input filter) of the victim receiver.

However, in UMTS systems, the interference usually results in loss of capacity and/or of coverage. The assessment of the impact of interference therefore requires in some cases a simulation over a large number of transmitters and receivers and MCL may not be adequate to investigate this loss. In addition, MCL does not model power control or dynamic situations, which may be determining for some scenarios as for example those involving User Terminals as a victim.

The second approach is the **Monte Carlo (MC)** simulation, which gives a probability of interference for the given set of parameters and a deployment and power control model.

The acceptable interference probability used in Monte-Carlo studies will depend on the scenario under consideration. For example, in the case of interference between MES and the terrestrial UE, the maximum acceptable interference probability for terrestrial W-CDMA is considered to be 2%.

Seamcat MC tool was used in most of the MC simulations presented in that report. The assumptions used in the Monte Carlo simulations are detailed in Annex B**,** and are based on work in ITU-R**.** Additional information is also included alongside the reported compatibility studies.

It is understood that only one of the approaches described above is not sufficient alone to describe in detail the interference problem, and to conclude on the problem of guard bands. The following points are relevant to the comparison of deterministic and statistical approaches:

- The MCL method is useful for an initial assessment of frequency sharing, and is suitable for fairly "static" interference situations (e.g. fixed links vs mobile base stations). It can however be pessimistic in some cases.
- The Monte-Carlo probabilistic method will generally give more realistic results. It is however complex to implement and will only give accurate results if the probability distributions of all the input parameters are well known.

2.3 Propagation models

The propagation models to be used for deriving the separation distances with MCL as well as with Monte-Carlo approaches are the following :

For Space to Earth and Earth to space paths :
Free space path loss plus attenuation due to gaseous absorption as defined in ITU-R Rec. P.676-5 When a very high accuracy of the results is not required, the gaseous/rain attenuation can be neglected at frequencies below 3 GHz.

For Terrestrial paths :

- For distances < 20 km, the modified Hata-Cost 231 median loss model is used for MCL. Typically this is used for co-located systems e.g. for frequency separation studies. This model is also implemented in SEAMCAT, adding a lognormal fading factor.
- For distances > 20 km, ITU-R Rec. P.452-10 for smooth earth. Typically this is used for non-co-located systems, e.g. for geographic separation.

For the interference situation with RA stations, where the minimum coupling loss is huge, the model offered by Rec. P.452 is preferred when detailed terrain height and other required information is available (the use of P.452 is also in accordance with Recommendation M.1316). There are several propagation models that can be used considering humidity, forest, obstacles and other factors. It may be impossible to use them all when considering the antenna size (e.g. diameter of about 100 m in the case of the station in Germany). The morphological and the corresponding radio propagation conditions in the area around any RA station is a decisive factor for the necessary guard distance or guard band. The required geographical separation depends on the individual propagation conditions in the direction to a victim receiver.

3 CO-FREQUENCY SHARING CONCLUSIONS

3.1 Co-frequency sharing between MSS and terrestrial UMTS

When considering the sharing of the same frequency band between the Terrestrial component of IMT-2000 and MSS, the detailed analysis (see Annex B) shows that such sharing is not feasible within the same geographical area. This conclusion has been endorsed by ITU-R and CEPT.

Studies indicate that co-frequency co-coverage sharing of IMT-2000 and MSS is not feasible.

3.2 Co-frequency sharing between MMDS and terrestrial UMTS

Interference Path	Separation Distance Required (km)
UMTS UE→MMDS Rx	5
UMTS BS → MMDS Rx	5 pico cell, 25 micro cell, 70 macro cell
MMDS Tx → UMTS BS	5 pico cell, 25 micro cell, 70 macro cell
MMDS Tx → UMTS UE	5

The results show that co-frequency sharing between MMDS and UMTS/IMT-2000 services is feasible but only with relatively large separation distances (up to 70 km for macro cells) to minimise mutual interferences. The simulations indicate that co-frequency sharing may prove to be difficult due to the large separation distances required between the two services. Due to the high front-to-back ratio of MMDS receivers it may be possible to reduce the interference into MMDS receivers for co-channel sharing by ensuring that they are pointing away from UMTS service areas.

4 ADJACENT BAND COMPATIBILITY RESULTS AND CONCLUSIONS

4.1 Terrestrial and satellite IMT2000

The adjacent band compatibility results are summarised in the Table 3 below. The systems characteristics and study results are detailed in Annex A and B. In the following table results are given either in term of frequency carrier spacing or in term of frequency guard bands. A scenario is considered not feasible when guard bands exceed 15 MHz. Concerning TDD simulations, results are highly dependent on the deployment assumptions.

Scenario **Interferer → Victim**	**S-DMB**	**SRI-E**
1 (Path A1) Sat down → UE FDD down @2520 MHz	Feasible with standard 5 MHz carrier spacing	Feasible without any guard band.
2 (Path A1) Sat down → UE Rx TDD @2520 MHz	Feasible with standard 5 MHz carrier spacing	Feasible without any guard band[1]
3 (Path A2) Sat down → BS FDD up @2520 MHz	Feasible with a carrier spacing of 5.3 MHz (could be improved by optimized satellite filtering techniques)	Feasible without any guard band.
4 (Path A2) (Sat down → BS Rx TDD @2520 MHz	Feasible with a carrier spacing of 5.3 MHz (could be improved by optimized satellite filtering techniques)	Feasible without any guard band[1]
5 (Path A3) TR → FDD down @2520 MHz	Feasible with standard 5 MHz carrier spacing (No guard band required)	Not Applicable : No terrestrial repeaters with SRI-E
6 (Path A3) TR → MS Rx TDD @2520 MHz	Feasible with standard 5 MHz carrier spacing (No guard band required)	**Not Applicable :** No terrestrial repeaters with SRI-E
7 (Path A4) TR → FDD up @2520 MHz	Not feasible : required carrier spacing greater than 20 MHz	**Not Applicable:** No terrestrial repeaters with SRI-E
8 (Path A4) TR → BS Rx TDD @2520 MHz	required carrier spacing depends on TDD deployment. TDD/FDD coexistence studies results apply.	**Not Applicable :** No terrestrial repeaters with SRI-E
9 (Path B1) MES Sat up → UE FDD down @2670 MHz	The standard 5 MHz carrier spacing is appropriate.	Feasible : does not require frequency guard band
10 (Path B1) MES Sat up → UE Rx TDD @2670 MHz	The standard 5 MHz carrier spacing is appropriate.	Feasible : does not require frequency guard band

[1] The results for TDD scenarios have been derived from the results obtained for FDD in the same direction of transmission. In general, compatibility is facilitated when using TDD parameters with respect to using FDD parameters,

Scenario Interferer → Victim	**S-DMB**	**SRI-E**
11 (Path B2) MES Sat up → BS FDD up @2670 MHz	Feasible with standard 5 MHz carrier spacing for all S-DMB terminals, except for S-DMB Portable Terminals operating in rural cells, for which specific operating constraints apply: • a 10 MHz carrier spacing (5 MHz guard band) shall apply, or • the Portable S-DMB Terminal if forbidden to transmit to the satellite within terrestrial cells where the adjacent 5 MHz channel is operated. In this case, the standard 5 MHz carrier spacing is appropriate.	Feasible : does not require frequency guard band.
12 (Path B2) MES Sat up → BS Rx TDD @2670 MHz	Feasible with standard 5 MHz carrier spacing.	Feasible : does not require frequency guard band
13 (Path C1) UE FDD up → Sat up @2670 MHz	Feasible with a carrier spacing of 5 MHz (no guard band required)	Feasible with a 1 MHz guard band
14 (Path C1) UE Tx TDD → Sat up @2670 MHz	Feasible with a carrier spacing of 5 MHz (no guard band required)	Feasible : does not require frequency guard band
15 (Path C2) BS FDD down → Sat up @2670 MHz	Feasible with a carrier spacing of 5 MHz	Guardband exceeds 7 MHz. See also Annex (B.5) for sensitivity analysis
16 (Path C2) BS Tx TDD → Sat up @2670 MHz	Feasible with a carrier spacing of 5 MHz	Feasible : does not require frequency guard band
17 (Path D1) UE FDD up → MES down @2520 MHz	Not necessary to be studied: S-DMB terminals are dual mode and require a minimum duplex spacing of 20 MHz. Consequently, this is the most constraining assumption in this scenario	Pedestrian macro: not feasible irrespective of the guard band Vehicular macro: feasible without guard bands Rural: feasible without guard bands See also in annex (B.5) for sensitivity analysis.

Scenario Interferer → Victim	S-DMB	SRI-E
18 (Path D1) UE Tx TDD → MES down @2520 MHz	Not necessary to be studied if S-DMB terminals implement terrestrial TDD : S-DMB terminals are dual mode and require a minimum duplex spacing of 20 MHz between Tx and Rx bands. Otherwise, TDD/FDD coexistence studies results apply.	Suburban: guardband exceeds 8 MHz Urban: guardband exceeds 8 MHz See also Annex (B.5) for sensitivity analysis
19 (Path D2) BS FDD down → MES down (satellite reception mode) @2520 MHz	Feasible with standard 5 MHz carrier spacing.	Pedestrian-micro: 6 MHz guardband Vehicular-macro: > 8 MHz guardband Rural: 5 MHz guardband See also Annex (B.5) for sensitivity analysis

Table 3: Adjacent band compatibility results

4.1.1 Feasibility of adjacent band compatibility for SRI-E

For the downlink band (around 2 520 MHz), the compatibility results depend to a large extent on the environment in which the MESs will operate and the terrestrial systems are deployed:

- If TDD systems are deployed in the adjacent band, it would not be feasible to operate MESs in the same geographical areas.
- If FDD DL is deployed in the adjacent band, under the baseline assumptions a minimum guardband of 6 MHz would be needed for the pedestrian micro environment and 5 MHz for rural environment and it would not be possible to operate MES in macro vehicular environment However, if the MSS accepts some extra risk of interference, a guardband of 1 MHz would be sufficient in all environments based on the more optimistic assumptions, the appropriateness of which is not guaranteed or agreed.
- If FDD UL is deployed in the adjacent band, under the baseline assumptions, no guardband is needed for vehicular macro and rural environment and it may not be possible to operate MESs in the pedestrian-micro areas.

For the uplink band (around 2 670 MHz) the compatibility results are generally favourable:

- If TDD operates in the adjacent band, no guardband or a small guardband are necessary.
- If FDD DL operates in the adjacent band, under the baseline assumptions, the guardband exceeds 7 MHz. However, if the MSS operator accepts some extra risk of interference, a guardband of 1.5 MHz would be sufficient based on the more optimistic assumptions, the appropriateness of which is not guaranteed or agreed.
- If FDD UL operates in the adjacent band, a guardband of 1 MHz may be necessary.

4.1.2 Feasibility of adjacent band compatibility for S-DMB

Adjacent band compatibility with terrestrial FDD:

In the DL direction (around 2 520 MHz), the S-DMB system is able to operate in the MSS bands adjacent to IMT-2000 terrestrial allocation with a standard 5 MHz carrier frequency separation between an S-DMB carrier and a terrestrial IMT-2000 carrier, provided that these carriers are operated with the same frequency duplex direction. However, in the case when S-DMB portable terminals are used in rural cells, which leads to a 10 MHz carrier spacing, it is necessary to protect the IMT-2000 BS in rural areas, unless the portable terminals are disabled to transmit in rural terrestrial cells where the adjacent 5 MHz block is operated. In this latter case, the standard 5 MHz spacing is appropriate. If the frequency duplex directions are opposite in adjacent bands, at least

25 MHz carrier spacing would be needed because of the filtering constraints associated to the dual-mode nature of S-DMB terminals, and because of the interference from the terrestrial repeaters into the FDD base stations.

In the case where the satellite and terrestrial transmissions are aligned, it has to be noted that the co-location of the terrestrial repeaters with the base stations, although not necessary, enhances the compatibility situation.

In the UL direction (around 2 670 MHz), the S-DMB system is able to operate in the MSS band adjacent to the terrestrial system with a standard 5 MHz frequency carrier separation between a S-DMB carrier and a terrestrial IMT-2000 carrier, whichever the duplex direction chosen for the terrestrial IMT-2000 system.

Adjacent band compatibility with terrestrial TDD:

In the downlink direction (around 2 520 MHz):

i) If S-DMB terminals implement terrestrial TDD:
In general terms, dual-mode implementation issues within the S-DMB terminal will prevent adjacent band operation with TDD. As for FDD, a 20 MHz guard band will not be sufficient to solve this issue.

ii) If S-DMB terminals do not implement terrestrial TDD:
The compatibility (with 5 MHz carrier spacing) of TDD with respect to S-DMB operating in adjacent MSS downlink allocation is difficult: The TR-BS compatibility raises difficult implementation and planning issues, which highly depend on TDD deployment. The required carrier separation distance is likely to be the same as the one between TDD and FDD. The outcome of the TDD/FDD co-existence studies carried-out by ITU-R Study Group 8 may provide further guidance.
The adjacent band compatibility (with 5 MHz carrier spacing) of TDD with respect to S-DMB operating in adjacent MSS uplink allocation is possible without deployment constraints.

In the Uplink Direction (around 2 670 MHz):

The adjacent band compatibility between TDD/FDD with respect to S-DMB is possible with a standard carrier spacing of 5 MHz.

4.1.3 Summary results for satellite vs terrestrial IMT-2000

The following Table offers an overview of the impact of the sharing studies on systems compatibility considerations together with spectrum implementations contexts.

For each possible combination of FDD and TDD / MSS adjacent band sharing, the overall requirements in terms of the frequency carrier spacing or guard bands between these systems will need to ensure protection of both FDD/TDD and MSS victim stations in both systems, or compatible operation of these systems.

Table 4 below presents all possible combinations of FDD/TDD versus MSS adjacent band sharing. In order to keep to 2-dimensional reading of the tables and reflect that FDD/TDD versus S-DMB and FDD/TDD versus SRI-E compatibility results can be different due mainly to different implementation schemes[2]. Table 4 is split into sub-tables 4.a to 4.d (sub-tables 4.a + 4.b, and 4.c + 4.d present the overall compatibility assessment for FDD/TDD versus S-DMB and FDD/TDD versus SRI-E respectively).

The results have been grouped in these sub-tables, keeping in the first two lines the information related to each “victim” system involved. The last line is the overall compatibility study result, which combines the results referring to each “victim” system.

In some cases, the guardband is dependent on the environment in which the MSS service operates.

[2] For example, the S-DMB system uses terrestrial repeaters and the user terminals implement dual mode operation (terrestrial and satellite), which has impact on interference paths and also on several characteristics and criteria.

	TDD	**FDD down**	**FDD Up**
FDD/TDD victim	MSS↓→TDD MS&BS GB = the maximum value among 0.3 MHz and TDD/FDD results[3]	MSS↓→ FDD MS No GB[4]	MSS TR ↓→ FDD BS S-DMB Terrestrial Repeaters and FDD/TDD BS collocation remain difficult with carrier frequency spacing up to 15 MHz[5]
MSS victim	MS&BS→ MES Similar to TDD/ FDD results[6] if TDD mode is not implemented in S-DMB terminals[7]	FDD BS→ MES No GB	FDD MS→ MES Not necessary to be studied (minimum 20 MHz duplex spacing required by dual mode operation of S-DMB terminals is the most constraining assumption in this scenario)
Compatibility result combining lines 1 and 2	The maximum value among 0.3 MHz and TDD/ FDD results[1+2]) if TDD mode is not implemented in S-DMB terminals[3]	No GB	Carrier spacing = 25 MHz due to the need for 20 MHz guardband within S-DMB dual mode terminals. Moreover, BS-TR compatibility requires at least 10 MHz guardband

Table 4a: S-DMB Down @ 2 520 MHz and FDD/TDD above 2 520 MHz

[3] Possible combination of guard band and separation distances with regard to MS/terrestrial repeaters (see also IMT.COEX).
[4] No additional guard band between the two 5 MHz blocks. Since adjacent carriers are of 3.84 MHz, in 5 MHz blocks, a guard band already exists.
[5] Scenario A2 (S-DMB satellite down → T-UMTS FDD BS) would require 0.3 MHz guard band.
[6] Possible combination of guard band and separation distances with regard to MS/MES (see also Report ITU-R M.2030).
[7] If TDD mode was implemented in S-DMB terminals, a guard band greater than 20 MHz would be needed.

	TDD	**FDD down**	**FDD Up**
FDD/TDD victim	MES →TDD MS&BS No GB	MES → FDD MS No GB	MES → FDD BS No GB except for portable terminals that require a 5 MHz guardband in rural areas, unless the portable terminal is forbidden to transmit in terrestrial cells where the adjacent 5 MHz block is operated. In this latter case no GB is required
MSS victim	TDD MS&BS→ Sat No GB	FDD BS→ Sat No GB	FDD MS → Sat No GB
Compatibility result combining lines 1 and 2	No GB	No GB	No GB except for portable terminals that require a 5 MHz guardband in rural areas, unless the portable terminal is forbidden to transmit in terrestrial cells where the adjacent 5 MHz block is operated. In this latter case no GB is required

Table 4b: S-DMB up @ 2 670 MHz and FDD/TDD below 2 670 MHz

	TDD	**FDD down**	**FDD Up**
FDD/TDD victim	(Sat↓→TDD MS&BS) No GB	(Sat↓→ FDD MS) No GB	(Sat↓→ FDD BS) No GB
MSS victim	TDD MS&BS→ MES Not feasible if MESs and FDD/TDD operate in the same environment	FDD MS→ MES Not feasible for MESs in vehicular-macro environment. Minimum guardband of 6 MHz required for MESs pedestrian-micro environments and 5 MHz in rural	FDD MS→ MES Not feasible for MES in pedestrian-micro environment. For the other scenarios it is feasible with no GB (rural, vehicular macro)
Compatibility result combining lines 1 and 2	Not feasible if MESs and FDD/TDD operate in the same environment	Minimum guardband of 5 MHz required for MESs in rural and 6 MHz for pedestrian-micro environments. Not feasible for MESs in vehicular-macro environment	No guardband is needed for rural and vehicular macro environments. Not feasible for MES in pedestrian-micro environment

Table 4c: SRI-E (down) @ 2 520 MHz and FDD/TDD above 2 520 MHz

	TDD	FDD down	FDD Up
FDD/TDD victim	MES →TDD MS&BS No GB	MES →FDD MS No GB	MES →FDD BS No GB
MSS victim	TDD MS&BS →Sat No GB	FDD BS →Sat Guardband exceeds 7 MHz.	FDD MS →Sat GB 1 MHz
Compatibility result combining lines 1 and 2	No GB	Guardband exceeds 7 MHz	GB 1 MHz

Table 4d: SRI-E up @ 2 670 MHz and FDD/TDD below 2 670 MHz

All the results presented in the Tables 4a – 4d were obtained using the agreed baseline assumptions for MSS and FDD/TDD systems, as recorded in Annex A.

In order to refine the analysis of difficult compatibility study results for SRI-E downlink in Table 4c, and SRI-E uplink with regard to FDD downlink in Table 4d (due to a high sensitivity of the SRI-E MES to interference), some additional interference assessment of the related worst case scenarios involving SRI-E stations as a victim were undertaken with more optimistic assumptions than the baseline, mainly by a review of the FDD/TDD parameters (giving 6 to 12 dB relaxation: see Annex B5). These additional evaluations reveal a noticeable enhancement of the compatibility results in some cases. In the case of interference from the T-UTMS FDD Downlink into the SRI-E uplink, the guardbands reduce from greater than 7 MHz to 1.5 MHz. In the case of interference from the T-UTMS FDD downlink into the SRI-E downlink, compatibility becomes feasible in all environments with a guardband of 1 MHz. The appropriateness of these assumptions is not guaranteed nor agreed, and if they were proven to be over-optimistic, the MSS system may have to accept interference above the accepted interference criteria.

4.2 Radio Astronomy

The following table provides the required isolation between radio astronomy stations and IMT-2000 base, mobile and mobile earth stations under consideration in the studies :

Station type	Required isolation (MCL value in dB)
DS-CDMA FDD, BS (P=43dBm)*	190
DS-CDMA FDD, MS (P=24dBm)*	174
S-DMB, MES (P=24dBm)*	174
SRI-E, (worst case azimuth, assuming 25 degree elevation angle to satellite)	192
SRI-E, (best case azimuths, for off axis angles >90 degrees)	178

* the maximum OOB emissions were obtained with maximum BS/MS/MES transmit power, it can be noted that typical BS/MS tx power are below this value (see Annex A1).

Table 4e : Required isolation between IMT-2000 system components and RA stations

For the case of MES and terrestrial MS, protection of radio astronomy stations can be ensured by definition of exclusion zones, where transmission is prohibited. For base stations co-ordination zones would be required:

a) The size of the exclusion zones may be determined by the appropriate national administration for MESs of each type of MSS system with respect to each individual radio astronomy station, taking into account local terrain information. The prohibition of MSS MES transmission could be accomplished in practice via features of the MSS system e.g. terminals implementing GPS / Galileo. The regulatory measures to ensure the implementation of such techniques would need to be addressed (e.g. in standards).

b) For terrestrial UMTS-BSs the MCL figures mentioned above could be used by the national administrations to calculate the relevant co-ordination zone. Each planned BS within this zone will need to be location / frequency coordinated with the radio astronomy stations.

c) For the terrestrial mobiles an exclusion zone will be accomplished as a consequence of coordinating the base stations, noting that mobiles implement "receive before transmit". These exclusion zones have to be defined depending on the local geographical situation.

d) The size of the co-ordination and exclusion zones will be site specific. The studies so far indicate typical coordination distances for BS in the range 60-100 km. For a single terrestrial mobile transmitting at maximum power the exclusion zone is between 30 – 50 km. For S-DMB MESs the distances are similar to that for the terrestrial mobile stations. For SRI-E the distances are slightly larger. Guard bands are not considered in calculating these distances.

e) Taking into account the location of the relevant RA sites, an assumption is that the required coordination or exclusion zone is expected to be entirely within a national boundary.

Base station filtering may provide an additional means of achieving required isolation. Additional filtering is not feasible for the mobiles as a mean of achieving additional isolation.

4.3 Adjacent band compatibility between MMDS and terrestrial UMTS

Interference Path	Frequency Separation Required (MHz)
UMTS UE→MMDS Rx	0
UMTS BS → MMDS Rx	20
MMDS Tx → UMTS BS	15
MMDS Tx → UMTS UE	10

Table 5

The results show that for adjacent channel operation between MMDS and terrestrial UMTS services operating in geographically separate locations a minimum frequency separation of 15 MHz will be necessary for macro and micro cell deployment of UMTS. For pico cell deployment no guard band is necessary. Due to the high front to back ratio of MMDS receivers it may be possible to reduce the interference into MMDS receivers for adjacent channel sharing by ensuring that they are pointing away from UMTS service areas.

5 GLOSSARY AND ABBREVIATIONS

CO-CHANNEL SHARING:
Co-channel sharing is the case where the terrestrial and the satellite components are operating on the same frequency, but separated geographically.

ADJACENT BAND COMPATIBILITY:
Adjacent band compatibility is the case where both system components are co-located or the terrestrial component is within the area covered by the satellite beam, but operate on adjacent frequencies.

ACI_{max}	maximum Adjacent Channel Interference
ACIR	Adjacent Channel Interference Ratio
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
BS	Base Station within terrestrial UMTS
CBD	Central Business District
DL	Downlink. In the case of terrestrial: BS transmit, UE receive
EES(p)	Earth exploration-satellite (passive)
EOC	Edge Of Coverage
FDD	Frequency Division Duplex
FDM	Frequency Division Multiplex
GB	Guard band
GSO	Geostationary Orbit
MC	Monte Carlo
MCL	Minimum Coupling Loss
MCS	Minimum Carrier Separation
MES	Mobile Earth Station within the satellite system
MMDS	Multipoint multimedia distribution system
MS	Mobile service
MSS	Mobile satellite service
OoB	Out-of-Band
RAS	Radio Astronomy Service
Sat	Satellite station
S-DMB	Satellite - Digital Multimedia Broadcasting
SR(p)	Space research (passive)
SRI-E	Satellite Radio Interface – E (as defined in ITU-R Recs M.1455 and M.1457)
TDD	Time Division Duplex
TR	Terrestrial Repeater
UE	User Equipment within terrestrial UMTS
UL	Uplink. In the case of terrestrial: UE transmit, BS receive
VLBI	Very Long Baseline Interferometry
WP8F	ITU-R Working Party 8F

ANNEX A: SYSTEM PARAMETERS

A.1 UMTS terrestrial system parameters

A.1.1 Base Station

The reference document for the parameters of terrestrial system components is Report ITU-R M.2039 [1].

Base Station as Wanted System:

Cell type	Rural
Antenna type	120 degree sector
Max antenna gain (dBi) including feeder loss	17
Downtilt angle (deg)	2.5
Antenna height (m)	30
Polarisation	Linear
Receiver Noise Figure (dB)	5
Receiver Thermal Noise (dB/W/MHz)	-139
Interference criteria (Isat/Nth) (dB)	-10
Adjacent Channel Selectivity	FDD : TS 25.104 [2] TDD : TS 25.105 [3]

Table A.1-1: IMT-2000 Base Station receive parameters

Base Station as Interfering System:

Cell type	Rural (FDD)	Vehicular-Macro (FDD)	Pedestrian-Micro (FDD)	Pico-CBD (FDD)	Suburban and Urban (TDD)
Cell size (km)	10	1	0.315	0.04	0.2
Maximum Transmit Power for a 5 MHz channel (dBm) (standards)	43	43	38	27	27
Typical Transmit power for a 5 MHz channel (dBm)	40	40	35	27	27[8]
Operating bandwidth (MHz)	5	5	5	5	5
Antenna type	120 deg sector	120 deg sector	120 deg sector	Omni-directional	Omni-directional
Max antenna gain (dBi) including feeder loss	17	17	5	0	0
Downtilt angle (deg)	2.5	2.5	0	0	0
Antenna height (m)	30	30	5	1.5	1.5
Polarization	Linear	Linear	Linear	Linear	Linear
ACLR	TS 25.104 [2]				25.105 [3]

Table A.1-2: IMT-2000 Base Station transmit parameters

[8] Depending on the type of services and the related level of asymmetry, a duty cycle from 0% to 100% has to be added to the typical transmit power when dealing with W-CDMA TDD mode. In the analysis, a 50% duty cycle is assumed, giving reduction in the typical transmitter power of 3 dB.

A.1.2 Mobile Station

Mobile station parameters, for all deployments, are given in the tables below.
Mobile Station as Wanted Station:

Antenna type	Isotropic
Max antenna gain (dBi)	0
Antenna feed loss (dB)	0
Antenna height (m)	1.5
Polarisation	Linear
Receiver Noise Figure (dB)	9
Receiver Thermal Noise (dB/W/MHz)	-135
Interference criteria (Isat/Nth) (dB)	-10
ACS	FDD : 25.101 [4] TDD : 25.102 [5]

Table A.1-3: IMT-2000 Mobile Station receive parameters

Mobile Station as Interfering Station:

Maximum Transmit power (dBm)	21 or 24			
Average Transmit Power (dBm) in FDD (from [6])	Rural	Vehicular-macro	Pedestrian-micro	Pico-CBD
	8.3dBm	7.5dBm	6.6dBm	-2.5dBm
Average Transmit Power (dBm) in TDD (from [7])	1.6dBm (including 50% activity factor)			
Operating bandwidth (MHz)	5			
Antenna type	Isotropic			
Max antenna gain (dBi)	0			
Antenna feed loss (dB)	0			
Antenna height (m)	1.5			
Polarisation	Linear			
ACLR	FDD : 25.101 [4] TDD : 25.102 [5]			

Table A.1-4: IMT-2000 Mobile Station transmit parameters

A.1.3 Traffic characteristics

Table 4 of [1] gives IMT-2000 Traffic Model Characteristics for a Mature deployment scenario. Some of these characteristics are key parameters when modelling interference from UMTS-T uplinks (MS transmitting) into UMTS-S systems. They are summarised in Table A.1-5 and Table A.1-6.

Average number of UE/cell	Macro – rural	0.3 users/cell
	Macro- vehicular	7 users/cell
	Micro-pedestrian	65 users/cell
	Pico – In-building	2 users/cell
Cell range	Macro – rural	10km
	Macro- vehicular	1km
	Micro-pedestrian	315m
	Pico – In-building	40m
Percentage of terrestrial surface	Macro – rural	57%
	Macro- vehicular	2%
	Micro-pedestrian	2%
	Pico – In-building	0.02%
	No coverage	38.98%

Table A.1-5: Terrestrial parameters in FDD

Coverage	Urban and suburban indoor
Average number of UE/cell	53.42 users/cell
Cell range	200m
Percentage of terrestrial surface	30% of urban and suburban, indoor deployment as described in Table A.1-5

Table A.1-6: Terrestrial parameters in TDD

A.2 Satellite Radio Interface e (SRI-E) system parameters

This section presents the parameters of a satellite system, based on SRI-E defined in ITU-R Rec. M1457-1. These parameters have been updated where necessary based on the following sources:

- IMT-2000 Satellite Radio Interface E Specifications in Recommendation ITU-R M.1455-2.
- IMT-2000 Satellite Radio Interface E Specifications in Recommendation ITU-R M.1457-2.

A.2.1 Satellite Station

The satellite parameters depend on the interference scenario under consideration, and hence vary depending on whether the satellite is the wanted or interfering system. The parameters needed to model each scenario are shown in the tables below. Where applicable, GSO longitudes of 54°W, 65°E and 109°E were used in the analysis.

Satellite as Wanted System:

Gain pattern (ITU-R S.672)	Ls=-25 dB
Max antenna gain (dBi)	43.1
Relative gain at EOC(dB)	-3
EOC Satellite G/T (dBK)	12
System Noise Temp (dB/K)	28.1
Receiver Noise Temp (°K)	638.3
Bandwidth (kHz)	200
Receiver Thermal Noise (dBW/MHz)	-140.6
Interference Criteria (dB) for purposes of this study	$\Delta T/T$ = 6% inband $\Delta T/T$ = 3% out-of-band

Table A.2-1: MSS satellite receive parameters

Satellite as Interfering System:

Gain pattern (ITU-R S.672)	Ls=-25 dB
Max antenna gain (dBi)	43.1
Beam pattern	Hexagonal
No. of active beams	19
Frequency re-use	7-beam clusters
EIRP per carrier (dBW)	43
Bandwidth (kHz)	200
Unwanted Emissions	Appendix 3 of the RR

Table A.2-2: MSS satellite transmit parameters

Satellite Beam Parameters:
The characteristics of the satellite beam pattern are shown in more detail in the table below.

Beam pattern	Hexagonal
Number of hexagon rings	11
Separation between hexagons	1.0°
Maximum satellite angle	8.9°
Total number of beams	295
Number of transmitting beams when satellite is interferer	19 (from Table A.2-2)
Beamwidth	1.2°
Peak gain	43.1 dBi (from Table A.2-2)
Roll-off (ITU-R S.672)	Ls=-25 dB (from Table A.2-2)

Table A.2-3: Satellite beam characteristics

A.2.2 Mobile Earth Station

The parameters of the UMTS-S MES are based on the Class 2 terminal described in ITU-R Rec. M.1455-2, configured for data use. This terminal is assumed to have a directional antenna with peak gain of 14 dBi and EIRP of 15 dBW.

The requirements for unwanted emissions are provided in ITU-R M.1480 for MES operating with geostationary satellites and from ITU-R M.1343 for MES operating with non-geostationary satellites.

For MESs with directional antennas Recommendation ITU-R M.1091 “Reference off-axis radiation patterns for mobile earth station antennas operating in the land mobile-satellite service in the frequency range 1 to 3 GHz” provides the reference radiation pattern.

A transportable or vehicle-mounted near-axis symmetric antenna should have the following radiation pattern:

Off axis angle (º)	Gain (dBi)	Off axis angle (º)	Gain (dBi)
0	14.0	50	1.5
5	13.8	55	0.5
10	13.1	60	-0.5
15	11.9	65	-1.3
20	10.3	70	-2.1
25	8.2	75	-2.9
30	5.7	80	-3.6
35	4.0	85	-4.2
40	4.0	90	-5.0
45	2.7	>90	-5.0

Table A.2-5: Antenna radiation pattern for SRI-E MESs

Recommendation ITU-R M.1091 indicates that the radiation pattern of antennas mounted to vehicular structures will be distorted significantly, particularly at low angles.

The MES parameters depend on the interference scenario under consideration, and hence vary depending on whether the UMTS-S component is the wanted or interfering system.

MES as Wanted System:

Gain pattern	ITU-R Rec. M.1091
Max antenna gain (dBi)	14
Antenna height (m)	1.5
Minimum elevation (deg)	10
Max MES G/T (dBK)	-13.5
System Noise Temp (dB/K)	27.5
Receiver Noise Temp (°K)	562.34
Bandwidth (kHz)	200
Receiver Thermal Noise (dBW/MHz)	-141.1
Interference Criteria (dB) for purposes of this study[9]	ΔT/T = 6% inband ΔT/T = 3% out-of-band (When used in Monte-Carlo methods, the criteria may be exceeded for up to 20% time or 20% MES locations)

Table A.2-6: MES receive parameters

MES as Interfering System:

Typical transmit power (dBW)	1
Operating bandwidth (kHz)	200
Gain pattern	ITU-R Rec. M.1091
Max antenna gain (dBi)	14
Max transmit EIRP (dBW)	15
Antenna height (m)	1.5
Polarisation	RHC
Unwanted Emissions	ITU-R M.1480

Table A.2-7: MES transmit parameters

A.2.2.1 OOB for MESs within GSO systems

The parameters for MES in geostationary satellite systems have been derived from Recommendation ITU-R M.1480 „Essential technical requirements of mobile earth stations of geostationary mobile-satellite systems that are implementing the global mobile personal communications by satellite (GMPCS) – Memorandum of understanding arrangements in parts of the frequency band 1-3 GHz" (MES operating within the band 1626.5-1662.5 MHz).

At the band edge, the requirements for (carrier-on) unwanted emissions are:

Offset from the edge of the band of nominated bandwidth (kHz)	Maximum e.i.r.p. (dBW/3kHz)	Corresponding maximum e.i.r.p. (dBm/Hz)
0 - 25	0 to -15	-4.8 to –19.8
25 - 125	-15 to -50	-19.8 to –54.8
125 - 425	-50	-54.8
425 - 1 500	-50 to -65	-54.8 to –69.8
1 500 - 36 000	-65	-69.8

Table A.2-8: Maximum unwanted emissions for MESs (GSO) with an e.i.r.p. less than or equal to 15 dBW (voice and data)

9 The sensitivity of these values is examined in Annex D.

A.2.3 User Density

The density of MES users can be derived from ITU-R Rec. M.1457 (using the proposed revision in ITU-R document 8D/397).

MSS Allocation	20 MHz / direction
Re-use between satellite beams	7
Carrier bandwidth	200 kHz
Beam separation	1°

Table A.2-9: User Density Key Parameters

From the MSS allocation and re-use factor, the average capacity per beam can be calculated as 20 MHz/7 = 2.86 MHz. With a carrier bandwidth of 200 kHz, this can be rounded to 14 carriers, total bandwidth 2.8 MHz.

Assuming an active data user occupies a single carrier[10], then this represents 14 users / beam. The highest user density in users / km^2 would be for the smallest beam, which would be for the one that is directly sub-satellite.
The geometry is shown in the figure below.

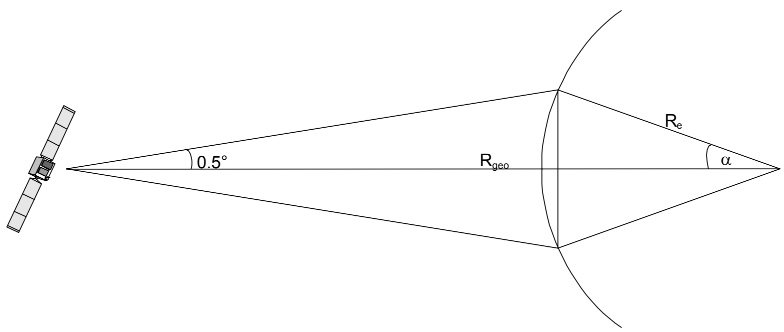


Figure A.2-1: Geometry to calculate area covered by beam

Using standard geometry, it can be calculated that angle α = 2.81°. The area can be calculated by integrating that part of a sphere, using:

$$A = 2\pi R^2 (1 - \cos\alpha)$$

Hence the area is 306,670 km^2, and the average area per user is 21,905 km^2, roughly a box with sides 148 km. In general it is not expected that users are located with uniform distribution across a service area, but will be grouped into clumps near traffic hot spots. One method that can be used to take account of this is to work out the area per user based upon the square of the number of users. In this case this would imply:

$$A_1 = \left(\frac{1}{14}\right)^2 A_{14} = 1{,}564.6 km^2$$

This equates to a box of side 40 km.

[10] It should be noted that the UMTS-S systems are proposing to use TDMA as an access method.. Therefore when modelling the aggregation from multiple users using Monte Carlo methods, if the carrier is being used to provide a voice service, there will still be only one user active per carrier at any one time.

A.3: SATELLITE DIGITAL MULTIMEDIA BROADCASTING (S-DMB) SYSTEM PARAMETERS

This section presents the parameters of S-DMB satellite system.

A.3.1 Satellite segment

The GSO reference system was selected for the S-DMB project. The architecture envisaged for the forward and the return link is depicted in the following figure.

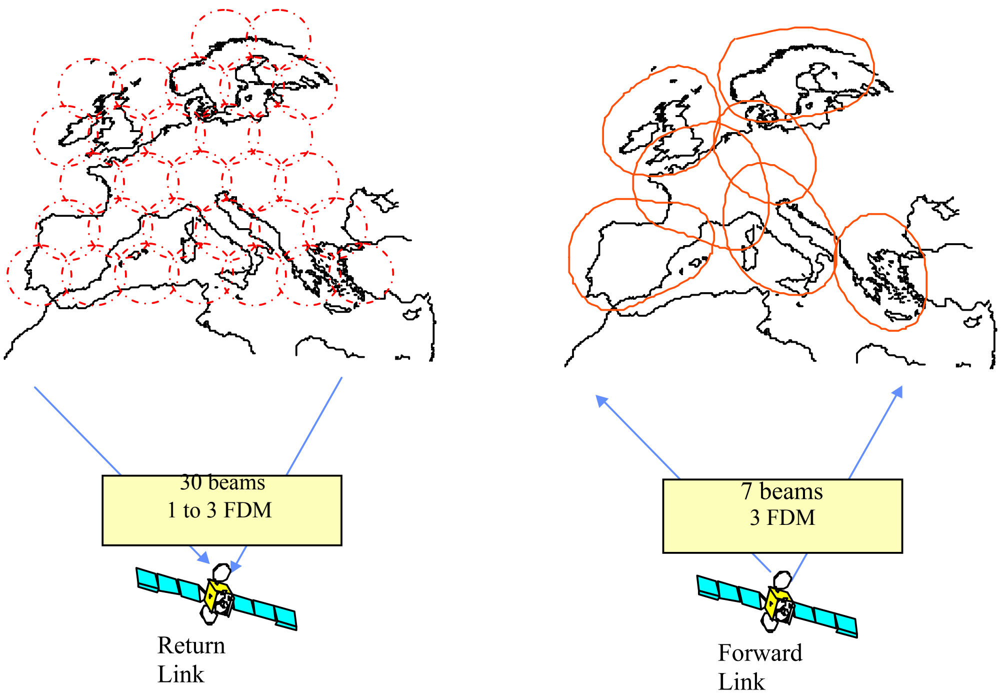


Figure A.3-1: S-DMB satellite configuration

The exact satellite longitudes are still to be determined. 10°E is a good candidate orbital position.

A.3.2 S-DMB Forward Link

The satellite architecture provides an overall throughput of 6.2 Mb/s over Europe (i.e. 16 channel codes at 384 kbit/s shared among 7 beams).

A.3.2.1 RF performance

RF performance are summarised in the following table.

Downlink Frequency (satellite to S-DMB UE)	MHz	2170 – 2200 / 2500 – 2520
Downlink Polarisation		LHCP or RHCP
Number of spot beam (downlink)		7
EIRP Max	DBW	76 dBW
Useful Bandwidth	MHz	4.68 (3.84 Mc/s, 1.22 roll-off factor)

Table A.3-1: S-DMB Forward Link RF performance

A.3.2.2 Out of band emissions

The S-DMB payload has been simulated, and the resulting out-of-band emission mask is provided in Figure A.3-2 below. This mask takes into consideration:

- The payload thermal noise contribution
- The signal intermodulation products through the amplification chain
- The output filter: The performance of the assumed filter is below what the state-of-the-art permits. The choice of the filtering technique is the result of various trade-off which are not finalized at this stage.

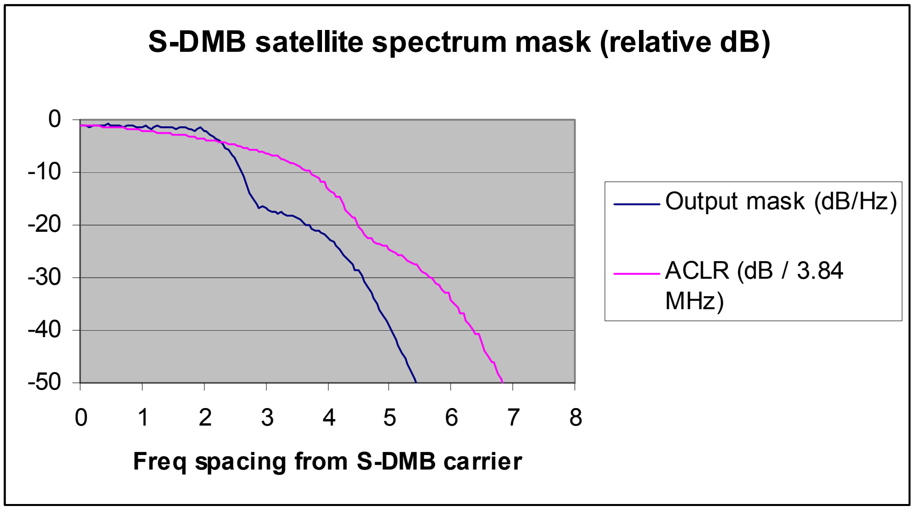


Figure A.3-2: S-DMB satellite spectrum mask

It should be noted that this mask is compliant with the ITU-R Recommendation SM.329-9 for spurious emissions, and with SM.1541 for Out-of-Band emissions.

Figure A.3-2 also shows the ACLR (Adjacent Channel Leakage Ratio) into an adjacent IMT-2000 channel, as a function of the channel spacing.

The resulting satellite ACLR figures for standard channel spacing are provided below:

	5 MHz channel spacing	10 MHz channel spacing
ACLR (dB)	24.6	> 50 dB

A.3.3 S-DMB Return link

The satellite will implement a spot-beam/frequency reuse pattern as shown in Figure A.3-1 .The satellite RF characteristics for the Return link is given in the Table A.3-2 below.

Useful Bandwidth per FDM	MHz	4.68 (3.84 Mc/s, 1.22 roll-off factor)
Protection requirement at the satellite receiver		DT/T<50%
System noise temperature	K	550

Table A.3-2: S-DMB Return Link RF performance

A.3.4 User terminal

S-DMB User Equipment (S-DMB UE) may be of several types, as figured below:

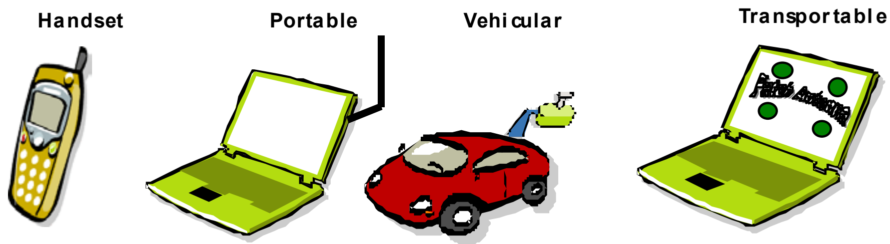


Figure A.3-3 –S-DMB UE configurations

<u>3G standardised handset:</u>

This type of terminal is composed of a single multi-mode 2G/3G handset able at the same time to receive the S-DMB broadcast signal (T-UMTS radio interface) and to establish point-to-point terrestrial connections for either the interactive S-DMB link or independent unicast services (voice, ???…). The additional point-to-point connection can use a GPRS mode. In this approach, specific S-DMB software modifications shall be implemented inside the multi-mode T-UMTS/GPRS handheld terminal including cache memory (already existing in some 2G commercial products).
This type of terminal could pertain to 3GPP power classes 1, 2 or 3.

<u>Portable:</u>

The portable configuration is built with a notebook PC to which an external antenna is attached.

<u>Vehicular:</u>

The vehicular configuration is obtained by installing on car roof a RF module connected to the S-DMB UE in the cockpit.

<u>Transportable:</u>

The transportable configuration is built with a notebook which cover contains flat patch antennas. This type of terminal is more dedicated to uses outside terrestrial coverage, and will offer higher bit rate return link capabilities.

For uplink transmissions, the terminals will use terrestrial capacity (2G or 3G), whenever possible. The return link via satellite will only be used outside terrestrial coverage, or when the terrestrial capacity is no longer available
(e.g. disaster situation).

The power and gain characteristics for the four S-DMB UE configurations are summarised in the table below :

S-DMB UE type	Maximum transmit power	Maximum Antenna Gain	Maximum EIRP
3G Handset Class 1 Class 2 Class 3	 2W (33 dBm) 500 mW (27 dBm) 250 mW (24 dBm)	 0 dBi 0 dBi 0 dBi	 3 dBW -3 dBW -6 dBW
Portable	2 W (33 dBm)	2 dBi	5 dBW
Vehicular	8 W (39 dBm)	4 dBi	13 dBW
Transportable	2 W (33 dBm)	14 dBi	17 dBW

Table A.3-3– S-DMB UE maximum transmit power, antenna gain and EIRP

The S-DMB UE RF performances are given in the table below :

Receive frequency (MHz)	2 170-2 200 / 2 500-2 520	
Transmit frequency	1980-2010 / 2670-2690	
Receive polarisation	Linear	
Transmit polarisation	Linear	
Noise figure	9 dB	
Receiver noise floor	-99 dBm	
Maximum output power	24/27/33/39 dBm	
Antenna gain	0/2/4/14 dBi	
Transmission mask	Compliant with the 3GPP UE requirements (see TS 25.101)	
ACLR (Adjacent Channel Leakage Ratio) as a function of carrier separation (from TS 25.101)	5 MHz	10 MHz
	33 dB	43 dB
ACS (Adjacent Channel Selectivity) as a function of carrier separation (compliant with UE requirements in [5])	5 MHz	10 MHz
	33 dB	43 dB

Table A.3-4– S-DMB UE RF performances

Protection requirements of S-DMB UE reception against external interference

Protection criteria are developed in this section with respect to two test services:

- 64 kbps : this is the multicasting bit rate at the beginning of the S-DMB deployment. With this bit rate, the reception of the multicasting signal by the S-DMB UE should be possible in most situations, including in indoor situation. This will allow to provide the S-DMB service while the terrestrial repeaters are not yet deployed
- 1 Mbps : this is the multicasting bit rate when the S-DMB system arrives at a mature deployment level, with a sufficient number of terrestrial repeaters. This bit rate is composed of three channels at 384 kbps using orthogonal codes.

The following table gives protection requirements in terms of C/(N+I) for test services to be used in sharing studies:

Test Service	Eb/Nt*	C/(N+I)**
64 kbps – outdoor	11.92 dB	-5.86 dB
1 Mbps (3*384 kbps) – outdoor	13.77 dB	3.77 dB
64 kbps – indoor	16.62 dB	-1.16 dB
1 Mbps (3*384 kbps) – indoor	17.77 dB	7.77 dB

Table A.3-5: Protection requirements for S-DMB UE

(*) Eb/Nt figures are extracted from 3GPP specifications 25.101, for pedestrian test environment (case 2), and indoor test environment (case 1). For the 1 Mb/s test service the Eb/Nt contains an additional provision of 1 dB due to the code orthogonality degradation due to the transmission through the satellite payload

(**) C/(N+I) = (Eb/Nt) – Processing Gain (dB).

It has to be noted that these protection criterions should be used for interference assessments when the S-DMB terminal receives the multicasting signal either directly from the satellite, or from the terrestrial repeaters.

A.3.5 Terrestrial repeaters segment

For the S-DMB system, it is expected that in rural and suburban areas a satellite could offer services with the required service availability simply by implementing a reasonable link budget margin. However in highly shadowed urban/suburban and indoor areas the satellite will not be able to provide services with the planned service availability alone. A solution to overcome this issue in dense urban areas is to retransmit the satellite signal thanks to terrestrial repeaters segment.

Two kinds of architectures can be envisaged :

- **"On-channel" repeaters** use the same band for signal reception and retransmission . These repeaters have a limited gain of around 80dB (to avoid self oscillation) and offer narrow coverage.
- **"Non on-channel" repeaters** use different frequency bands for signal reception and retransmission.

They enable to achieve wider coverage than on-channel repeaters, but require an additional frequency band for feeding (FSS Band). This type of repeaters has been selected for S-DMB. Within this category, different sub-categories are envisaged:

- **Simple frequency conversion repeaters:** Ka to S band.
- **NodeB repeaters:** the satellite-to-repeater feed link acts as a backhauling link, and connects to the repeater through a standard interface. This type of repeater allows a maximum reuse of standardised equipment.
- **Radio Network Subsystem Package:** In this configuration, there is a single satellite access point shared by several NodeB repeaters. The local distribution of the Broadcast/Multicast signal relies on the RNC. This architecture is interesting for connecting several indoor pico-cells, or local outdoor islands.

The repeaters are always uni-directional, i.e. operating in downlink direction only. For the S-DMB system, only "non on-channel repeaters" are envisaged to be widely deployed. "On-channel" repeaters might be used in very specific circumstances, similar to those conditions where Terrestrial IMT-2000 repeaters would be used (e.g. tunnel coverage).

The Rx antenna (receiving the signal from the satellite) associated with the terrestrial repeater is positioned in line of sight with the satellite. Terrestrial repeaters can be easily co-located to node B sites to provide the same coverage. They will be designed to reuse some node B subsystems (e.g. sectoral antennas) since frequency bands for both satellite and terrestrial components of IMT-2000 are adjacent.

Terrestrial repeaters' RF performance is summarised in the following table.

Receive frequency (MHz)	FSS Band		
Transmit frequency (MHz)	2 170-2 200 / 2 500-2 520		
Receive polarisation	Linear		
Transmit polarisation	Vertical		
Coverage area (°)	Up to 360° (i.e. 120° per sector)		
Terrestrial repeater classes	Wide area repeaters for macrocell application	Medium range repeaters for microcell	Local area repeaters for picocell
Assumed height of terrestrial repeaters (m)	30	6	6
Maximum output power (dBm)	43	30	24
Maximum Antenna gain (tx) (dBi)	15	6	0
Transmission mask	Compliant with the 3GPP requirements for Base Station in [4] as illustrated in Figure A.3-4.		
ACLR (Adjacent Channel Leakage ratio) as a function of carrier separation (compliant with BS requirements in [4])	5MHz	10MHz	15MHz
	45dB	50dB	67dB

Table A.3-6: S-DMB terrestrial repeater – RF performance

Terrestrial repeaters' transmission mask is shown in Figure A.3-4 below.

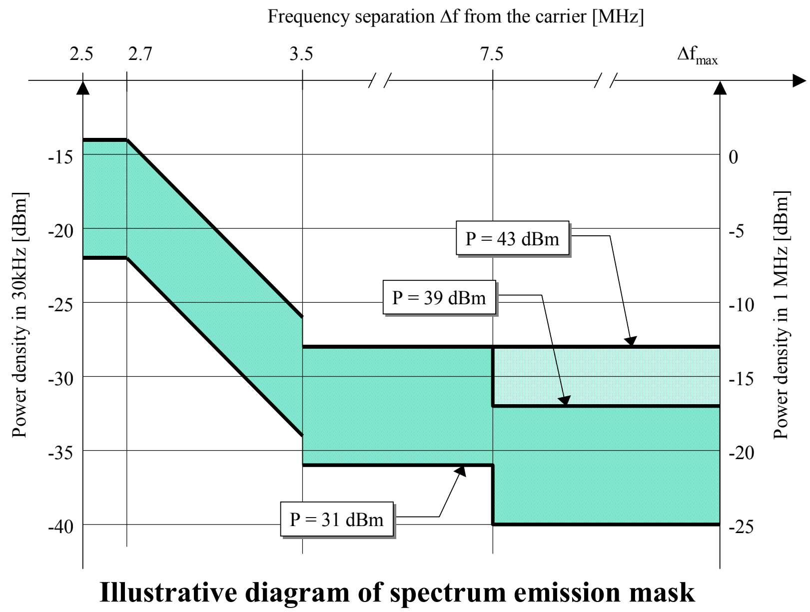


Figure A.3-4: Illustration of the terrestrial repeaters' transmission mask

Note : This mask is similar to the Base station transmission mask requirements in [2].

A.4 Radio Astronomy Service Parameters

A.4.1 RAS protection requirements

Recommendation ITU-R RA.769 provides the protection criteria for radio astronomical measurements. The appropriate value for the band 2690-2700 MHz is -207 dBW/10MHz or -177 dBm/10MHz, which applies to all systems operated in the adjacent band 2670-2690 MHz at, or near the location of the radio telescope.

A.4.2 Parameters for radio astronomy stations

The following table lists relevant parameters for the radio astronomy stations in Europe using the 2690-2700 MHz band (status 1 January 2004):

Country	**Place**	**Latitude N**	**Longitude E**	**Heigth above sea level (m)**	**Diameter (m)**	**Minimum elevation (°)**
Czech Republic	Ondrejov[1])	49°54'38"	14°47'01"	525	3 7,5	0 0
France	Nançay	47°23'26"	02°12'00"	180	200 x 40	3.6
Germany	Effelsberg	50°31'32"	06°53'00"	369	100	7
Netherlands	Westerbork	52°55'01"	06°36'15"	16	14 x 25	0
Russia	Kalyazin Pushchino Zelenchukskaya	57° 13'22" 54° 49'00" 43° 49'53"	37° 54'01" 37° 40'00" 41° 35'32"	195 200 1000	64 22 32	0 6 -5
Switzerland	Bleien[1])	47°22'36"	08°33'06"	469	7	5
United Kingdom	Cambridge	52°09'59"	00°02'20"	24	60 x 5	0
United Kingdom	Jodrell Bank	53°14'10"	-02°18'26"	78	76 32 13	-1 0 0
Typical maximum antenna gain: 69.0 dBi						

Note[1]): solar observations;

Table A.4-1: Location and parameters for RA stations

The Table A.4-1 shows the status as of 1 January 2004, but changes could be possible at a later stage. Therefore a generic conclusion on the compatibility issue between RAS in the band 2690-2700 MHz and IMT-2000 system components is developed in this report.

Typically, radio astronomy stations are located in rural areas. Radioastronomy sites are also chosen specifically to minimize interference from Earth based transmitters. The sites are usually at a considerable distance from the major fixed sources of terrestrial interference and may be screened by nearby high ground.

A.4.3 Some characteristics of RAS operations

During an observation, a radio astronomy telescope points towards a celestial radio source at a specific right ascension and declination, which corresponds to a specific azimuth and elevation at a certain moment in time. During an observation the pointing direction of the telescope continuously needs to be adjusted in order to compensate for the rotation of the Earth. The duration of an observation can range from milliseconds to several hours or longer, depending on the observing program. In practice, observations are often performed down to a very low elevation angle.

It should be noted that a radio telescope is an antenna with a very high main beam gain, typically 69 dBi for the 2690-2700 MHz band. If interference is received via the main lobe of the antenna pattern, this high gain should be taken into account. However, Recommendation ITU-R RA.769 assumes that the chance that the interference is received by the main lobe of the antenna is low, and therefore assumes in the calculation of the levels of detrimental interference that this is received in a sidelobe, i.e. at a level of 0 dBi at 19º from boresight (see also Recommendation ITU-R SA.509).

A.5 MMDS Ssystem Parameters

The system parameters for MMDS are listed in the table below

Transmitter power	52 dBm
Effective Tx antenna height	200 meters
Effective Rx antenna Height	20 meters
Tx antenna gain*	0 dBi
Rx antenna gain*	22 dBi
Cell Radius	16 km – 40 km
C/I	25 dB
Receiver Sensitivity	-77 dBm
Noise Floor	-102 dBm
Bandwidth	8000 kHz
Receiver Blocking Response	25 dB
Propagation Model	ITU.R 1546

Table A.4-1: MMDS Parameters

A.6 References in Annex A

[1] Report ITU-R M.2039 : Characteristics of terrestrial IMT2000 systems for frequency sharing / interference analyses, Geneva 2003.

[2] 3GPP 25.104 v530 : Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (FDD)

[3] 3GPP 25.105 v510 : Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (TDD)

[4] 3GPP 25.101 v530 : Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (FDD)

[5] 3GPP 25.102 v510 : Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (TDD)

[6] ECC Report 65 : Adjacent band compatibility between UMTS and other services in the 2GHz band

[7] Document ECC PT1(03)024: First results of sharing and adjacent band compatibility studies between the terrestrial and satellite components of IMT-2000 in the 2.5 GHz band

* All antennas omni-directional to provide for a worst case scenario.

ANNEX B: DETAILED ANALYSIS OF MOBILE SATELLITE SERVICE

B.1 Interference from MSS satellites into terrestrial FDD/TDD

This situation occurs around 2 520 MHz and corresponds to Path A.
In this configuration, the victim receiver is either a FDD/TDD BS or UE, which receives interference either from a S-IMT2000 satellite (SRI-E or S-DMB) or from a S-IMT2000 Terrestrial Repeater (S-DMB).

B.1.1 SRI-E

B.1.1.1 Methodology for path A

This interference path is between the S-IMT2000 DL interfering into the FDD/TDD, as shown in the Figure B.1-1 below.

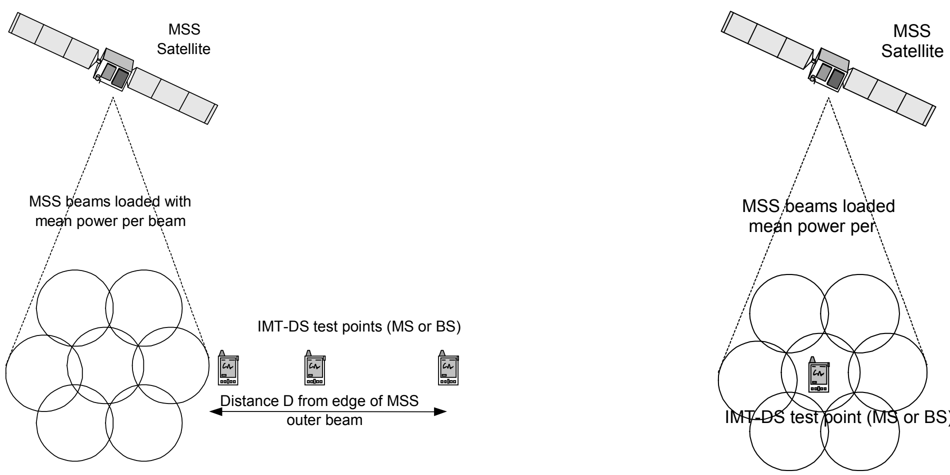


Figure B.1-1: Interference Path A: Geographic and Frequency separation

Interference into Mobile Stations
This aggregate interference to the mobile stations is a summation from all co-frequency transmitting beams of the interfering system. For interference path A these are the beams of the S-IMT2000 satellite. The traffic on each beam can be modelled in aggregate, using the average power per beam and the mean bandwidth per beam, rather than modelling each carrier in detail.

While a satellite can have hundreds of beams, not all will be active simultaneously - indeed power and frequency reuse constraints would make that infeasible.

Therefore a subset of beams was modelled, sufficient to cover a continent-wide area. For a GSO system with beams separated by 1°, this can result in a set of 19 active beams covering an area of around 5° sufficient to serve a continent sized hot-spot area, as shown in B.1-2 below. The beams were loaded such that the 20 MHz of spectrum allocated was fully utilized with traffic serving this region.

For the case of GSO systems the propagation models and traffic modelling are constant, and so the I/N at a single point is independent of time. Therefore it is feasible to locate a station at the edge of the coverage area and move it linearly in longitude to get a range of geographic separations.

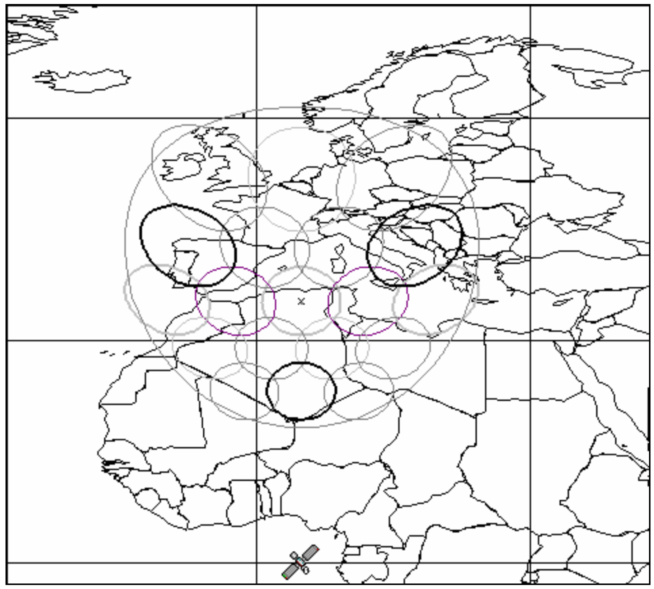


Figure B.1-2: Example GSO satellite beam pattern

Interference into Base Stations
Interference into base stations was modelled in a similar way to that for mobile stations as described above. In addition, it was necessary to consider the sectoral nature of the antenna and adjust the received I/N by a weighting factor so that it could be compared with the threshold.

Frequency Separation
This case was modelled taking into account out-of-band emissions. The FDD/TDD station location was fixed at the centre of the satellite beam, and the beams that operate on the two frequency blocks closest in frequency to the FDD/TDD were activated with OOB emission. The equivalent I/N was then calculated.
As the geometry and propagation model is fixed, the frequency was varied during the simulation to get the I/N as the guardband size is varied.

B.1.1.2 Co-frequency analysis (SRI-E, path A)

Co-frequency sharing considered the case where the S-IMT2000 and FDD/TDD systems were operating on the same frequency, 2.52 GHz, but were separated geographically. Two paths were considered, paths A and D. In each case there are two sub-paths depending upon whether the FDD/TDD was used for UL or DL.

For path A, different geometries were considered for each sub-path:

- for the MS RX (DL) the worst case was considered to be sub-satellite;
- for the BS RX (UL) the worst case was considered to be on the horizon.

In each case a set of active beams was steered away from the MS/BS to create a geographic separation between the beam edge and the FDD/TDD location. The I/N vs. distance plots are shown below.

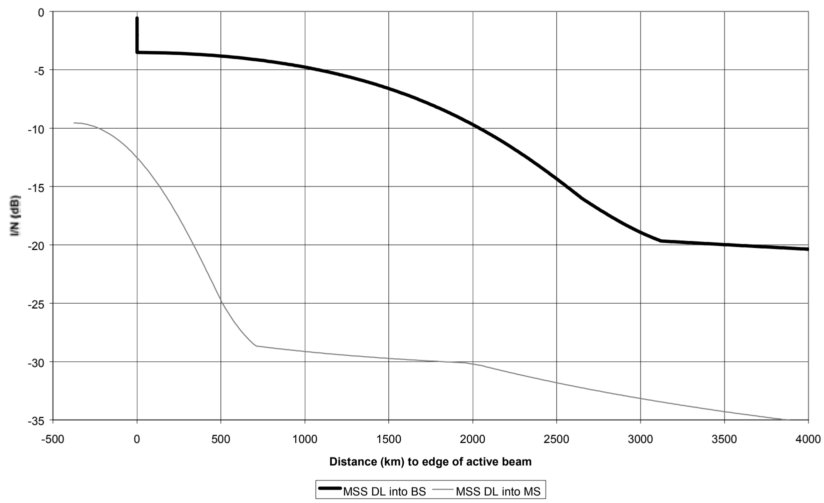


Figure B.1-3: Path A, geographic separation, I/N vs. distance

NOTE – Distances of less than zero are feasible for the MS case as it represents the MS within one of the outermost beams. This is not feasible for the other case as the BS is located at the edge of the satellite's field of view, and so the beam edge does not intersect the Earth. A 3 dB range of I/N values are plotted for BS distance = 0 case to represent the variation from boresight aimed at the BS to edge of beam co-incident with BS.
Interference was lower in the MS case than the BS case because the gain was lower (0 dBi rather than peak gain of 18 dBi) and noise higher (2 291 K rather than 912 K).

Further studies with updated parameters are required.

B.1.1.3 Adjacent band analysis (SRI-E, path A)

Co-located sharing considered the case where the S-IMT2000 and FDD/TDD systems were operating within the same geographic region but were separated in frequency.

For path A, the same two geometries as considered above were also used. However fewer beams were considered as only those two blocks of frequency nearest to the 2.52 GHz border were considered:

- for the MS RX (DL) the worst case was considered to be sub-satellite;
- for the BS RX (UL) the worst case was considered to be on the horizon.

The frequency of the FDD/TDD station was increased corresponding to operating just outside the 2.52 GHz boundary to having a guardband of 10 MHz. The resulting I/N plots are shown below.

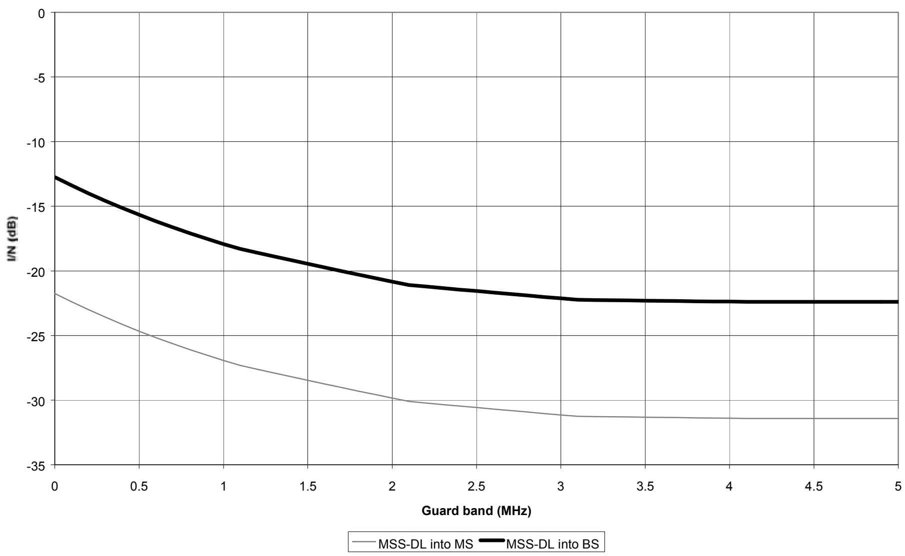


Figure B.1-4: Path A, frequency separation, I/N vs. guardband

B.1.2 Satellite Digital Multimedia Broadcasting (S-DMB)

B.1.2.1 Methodology for spacecraft interference (scenarios 1 to 4)

The interference assessment is conducted following a simple deterministic method, valid for TDD and FDD systems. The satellite interference level is evaluated on the basis of a link budget. For adjacent band compatibility, the satellite spectrum mask is applied. The interference level is then compared to the thermal noise of the 3G terrestrial receiver. The single entry level from a single satellite is only considered. Multiple satellite systems interference should not occur on a given geographical area, because satellite terminals use low directivity antennas. Co-frequency, co-coverage operation of multiple satellite systems is therefore operationally impossible.
The interference is deemed acceptable if:

$$\frac{I}{N} \leq -10dB$$

This criterion is applied for interference received by UEs or BSs, for any cell size. It should provide an adequate level of protection for Macro cells (see notes *xxi* and *xxxiv* of [1]). A less stringent criterion may in practice be adequate for Micro or Pico cells.

B.1.2.2 Co-Frequency analysis (S-DMB, Path A, scenario 1 to 4)

The table below shows a calculation of the impact in a co-frequency situation, of the satellite emissions into the MS or BS reception.

		MS	BS	
Terrestrial	Max Antenna gain	0,00	17,00	dB
	Feeder loss	0,00	1,00	dB
	Tilt angle	0,00	2,50	° down
	Antenna discrimination (Rec 1336, k=0.2, 10° elevation)		15,30	dB
	Rx Noise Figure	9,00	5,00	dB
	Rx Noise level	-134,98	-138,98	dBW/MHz
	Required I/N	-10,00	-10,00	dB
	Maximum tolerable ACI	-144,98	-148,98	dBW/MHz
Satellite	Satellite Altitude	36000,00	36000,00	km
	Frequency	2520,00	2520,00	MHz
	Path loss	191,60	191,60	dB
	Maximum tolerable satellite EIRP density	46,62	41,92	dBW/MHz
	Satellite EIRP	74,00	74,00	dBW
	Bandwidth	3,84	3,84	MHz
	Max in-band EIRP density	68,16	68,16	dBW/MHz
	Required attenuation	21,54	26,24	dB

Table B.1-1: Satellite downlink interference (co-frequency)

From these calculations, it seems that co-frequency sharing on the same coverage will be impossible. In some cases, mitigation factors may exist: better BS antenna discrimination for higher elevation angles, I/Nth criterion may be relaxed for small cells,

However, these factors will not permit to enhance the situation enough to make the co-frequency sharing possible in the same geographical area.

Co-frequency sharing in separate coverages could be possible provided that the satellite transmit antenna gain provides the necessary isolation, as indicated in the above Table.

Effect of satellite elevation angle

In the calculation shown in Table B.1-1, an elevation angle of 10° is assumed.

The satellite interference into the Base Station reception is highly dependent on the satellite elevation angle, when this angle is low (typically below 5°, including down-tilt).

The Figure below shows the 0, 5 and 10 degrees elevation contours, for a satellite located at 10°E longitude.

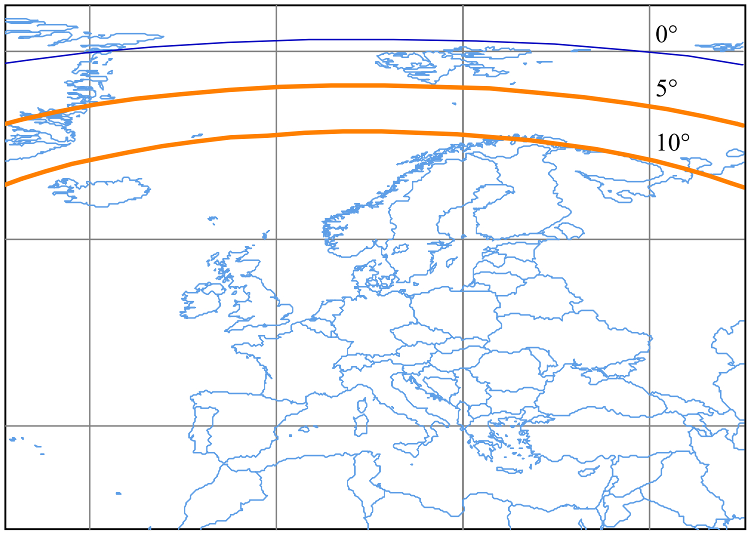


Figure B.1-5: Satellite elevation map

As illustrated in the above Figure, anywhere in Western Europe, the satellite signal will be seen with an incidence higher than 10°. This situation limits the interference to/from directional BSs.

B.1.2.3 Adjacent band compatibility (S-DMB, Path A, scenarios 1 to 4)

Figure A.3-2 in Annex A.3 shows the S-DMB payload ACLR (Adjacent Channel Leakage Ratio) into an adjacent IMT-2000 channel, as a function of channel spacing.

In order to meet the protection requirements of terrestrial 3G systems operating in adjacent band (see Table B.1-1), the required channel spacing is:

- 4.6 MHz for protecting Mobile Stations (FDD/TDD);
- 5.3 MHz for protecting Base Stations (FDD/TDD).

The use of optimized satellite payload filtering schemes should reduce the required spacing, in particular for protecting the BS reception. This latter case is however unlikely to happen, since satellite and terrestrial channel planning might be aligned, in order to facilitate network integration.

B.1.2.4 S-DMB Terrestrial Repeaters interfering T-IMT2000 networks : methodology and results (scenarios 5 to 8)

- **Scenarios 7 and 8: Interference from S-DMB Terrestrial Repeaters into FDD/TDD BS Rx (uplink)**

In this scenario both the victim receiver and the interfering transmitter are fixed. It is therefore appropriate to apply a static method to evaluate the feasibility of the compatibility.

The victim BS and interfering TR characteristics are summarized in the Tables below:

	FDD BS Macro	FDD BS Micro	FDD/TDD BS Pico
Antenna gain (dBi)	17	5	0
Propagation Environment	Suburban	Urban	Urban
Antenna height (m)	30	5	1.5
ACS (dB) at 5 MHz separation	46	46	46

Table B.1-2: Victim BS characteristics, as in [1]

Terrestrial repeater classes	Wide area repeaters for macrocell application	Medium range repeaters for microcell	Local area repeaters for picocell
Assumed height of terrestrial repeaters (m)	30	6	6
Maximum output power (dBm)	43	30	24
Maximum Antenna gain (tx) (dBi)	15	6	0
ACLR (dB) at 5 MHz separation	45	45	45

Table B.1-3: Interfering terrestrial repeaters characteristics, as in [2]

The minimum coupling loss requirement can be calculated as follows:

$$MCL= P_{TR} + G_{BS} +G_{TR}- ACIR - ACI_{max}$$

ACIR is calculated as:

$$ACIR = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}} \text{ (in linear terms)}$$

(ACLR, ACS) = (45, 46) dB implies that ACIR = 42.5 dB.
It is assumed that the ACI_{max} is similar as proposed in the Report ITU-R (IMT COEX): “Coexistence between IMT-2000 TDD and FDD radio interface technologies operating in adjacent bands and in the same geographical area”:

Cell type	Resulting max ACI_{ext} (dBm)
Macro rural	–114
Macro downtown	–100
Outdoor micro	–97
In-building pico	–85

For Macro cell repeaters (rural): MCL = 43 + 15 + 17 – 42.5 – (–114) = 146.5 dB.
For Macro cell repeaters (downtown): MCL = 43 + 15 + 17 – 42.5 – (–100) = 132.5 dB.
For Micro cell repeaters: MCL = 30 + 6 + 5 – 42.5 – (–97) = 95.5 dB.
For Pico cell repeaters: MCL = 24 + 6 + 0 – 42.5 – (–85) = 72.5 dB.
It can be noted that such MCL requirements forbid co-location of S-DMB terrestrial repeaters with base stations.
Using the Hata-COST 231 modified propagation model, from the MCL requirements it is also possible to derive the required separation distances between the TR and the BS (taking into account max TR and BS antenna gain):

	Wanted FDD BS Macro	Wanted FDD BS Micro	Wanted FDD/ TDD BS Pico
Interfering Macro TR Rural Propag	20700	2000	720
Interfering Macro TR Suburban Propag	7200	650	235
Interfering Micro TR Suburban Propag	411	78	58
Interfering Pico TR Urban Propag	123	50	43

Table B.1-4: Separation distances between interfering Terrestrial Repeater and Base Stations (meters)

Some conclusions can be drawn from the above Table:

- Macro terrestrial repeaters interfere BSs at such large distances, which will make the implementation of this type of repeaters impracticable.
- Micro/Pico terrestrial repeaters need to be separated from Micro BSs by a distance which is of the same order of magnitude as the coverage of the corresponding BS: This implies that the terrestrial repeater location will be highly constrained by prior BS deployment. Conversely, the presence of terrestrial repeaters at certain locations may constrain the posterior implementation of new BSs.

The scenarios involving wide cells are therefore the most critical, whereas the scenarios involving smaller cells are less difficult, but still very constraining. Also the ability to achieve co-siting of FDD base stations and S-DMB terrestrial repeaters is seen as essential for the S-DMB system deployment.

In the case of FDD base stations interfered by terrestrial repeaters, even with a frequency spacing of 15 MHz, the situation will not improve significantly to allow the compatibility in the wide cells, or for any type of cell in a co-sited situation.

The case of TDD base stations interfered by terrestrial repeaters is similar to the case of TDD base stations interfered by FDD base stations. The separation distances for this case are given in Table 25 of [3], and vary a lot according to the TDD deployment assumptions, and frequency separation (5, 10 or 15 MHz). As this is the most problematic case for FDD/TDD coexistence, it can be assumed that the frequency separation which will be implemented between TDD and FDD (due to the BS-BS scenario), will also apply to the TR – BS (TDD) case.

It should be noted that in this scenario, the S-DMB terminal Rx band in the MSS allocation is neighbouring the S-DMB Tx band in the MS allocation. As explained in § B.4.2.1 of this document, the dual mode nature of the S-DMB terminal will impose a carrier frequency separation of 20-30 MHz with terrestrial FDD uplink. This constraint needs to be considered in combination with the constraint arising from the TR-BS scenario.

- **Scenarios 5 and 6: Interference from S-DMB Terrestrial Repeaters into FDD/TDD Downlink**

As already mentioned, the terrestrial repeaters are similar to FDD base stations, when considering interference issues. Their deployment is environment-dependent, and the requirements in terms of power, antenna height and antenna gain, are the same as for base stations.

Another factor increases the similarity between BS and TRs: it is desirable in order to decrease the cost of the TR segment, and facilitate the integration, to reuse to the maximum extent possible 3GPP standardized equipment. This results, inter alia, in identical spectrum masks for TRs and BSs.

These similarities allow to reuse available studies, which have been developed by 3GPP for assessing FDD/FDD coexistence in the downlink direction.

The following Figures are extracted from 3GPP 25.942.v500 [3], and provide an estimate of the capacity loss of a FDD macro urban networks due to operation in the adjacent 5 MHz channel of a identical network, as a function of ACIR (Adjacent Channel Interference Ratio).

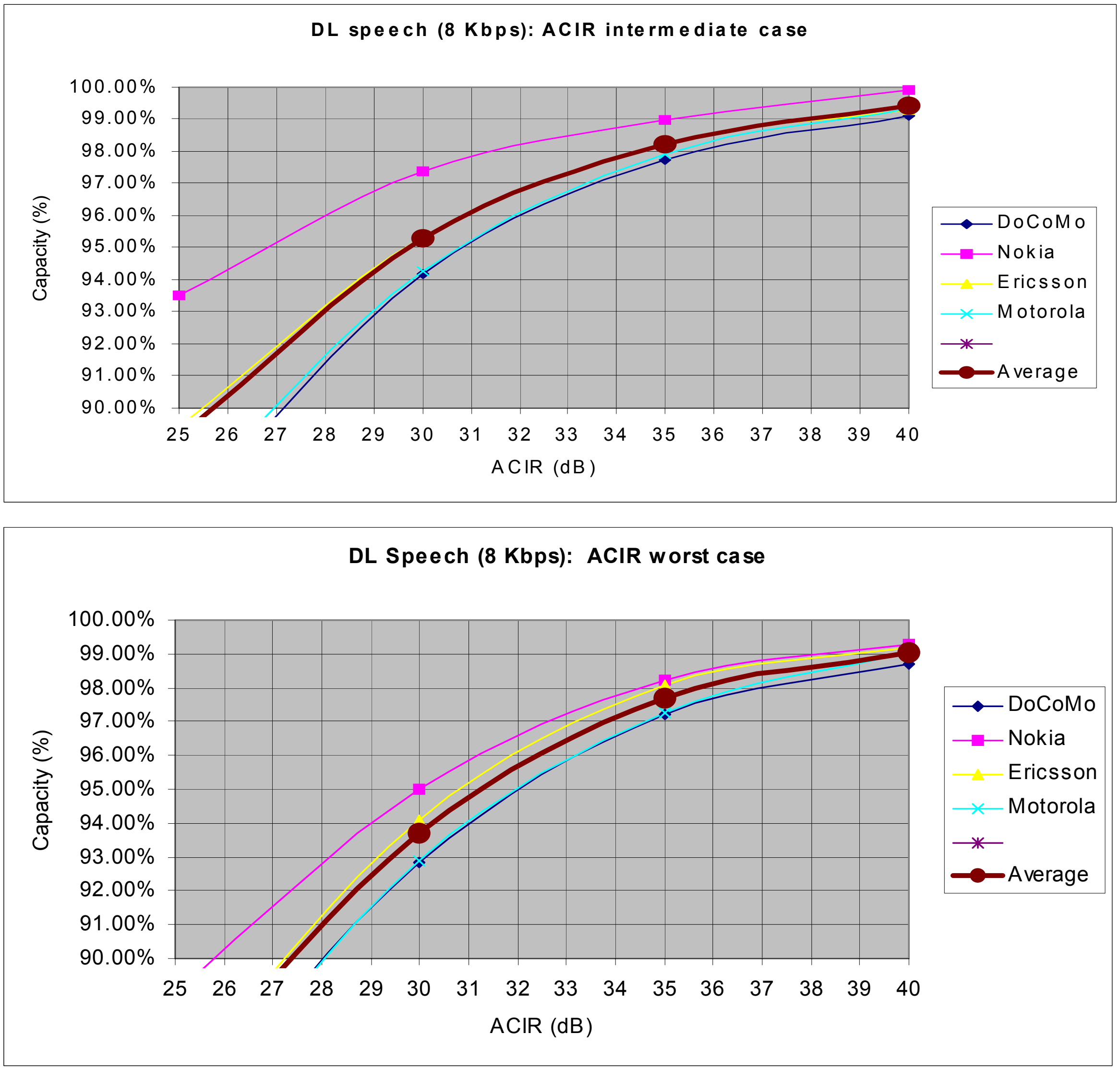
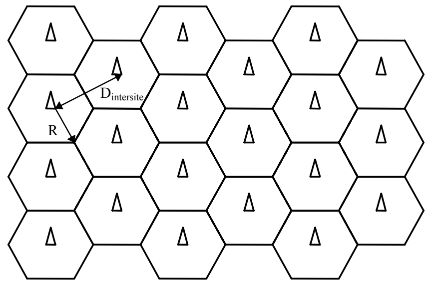


Figure B.1-6: Capacity vs. ACIR for FDD/FDD coexistence (DL speech)

Within one network, the BSs are placed at the centre of an hexagonal grid:



The worst case co-existence scenario corresponds to the case where the 2 networks are shifted by a cell radius (577m in the 3GPP simulation). The intermediate case scenario corresponds to a half cell radius shift. The co-located case (best case) is not considered in the 25.942 study.

Extrapolation of results for Terrestrial Repeaters
In the 25.942 simulation for FDD/FDD coexistence, the impact is assessed in terms of loss of maximum number of users. The base stations of the wanted and interfering terrestrial network are assumed to operate close to their assigned maximum power. If the BSs of the interfering network are replaced by S-DMB terrestrial repeaters with equivalent characteristics, the interference seen by the wanted network remains the same. Therefore the findings of the FDD/FDD coexistence studies, are also applicable to FDD/terrestrial repeater coexistence.

In the scenario studied in this section, the FDD downlink is in the lower part of the 2.5 GHz band. The 5 MHz carriers would be organized as follows:

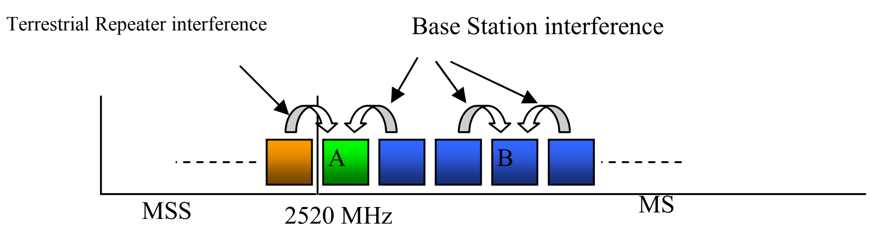


Figure B.1-7: Illustration of downlink adjacent channel interference

In the above Figure, it can be seen that the interference experienced from adjacent blocks is equivalent for block A and for block B, provided that S-DMB Terrestrial Repeaters and Base Stations have similar deployment and RF characteristics.

Therefore the operation of terrestrial repeaters in the upper 5 MHz block of the 2 500-2 520 MHz MSS allocation will not create additional constraints to the lower 5 MHz FDD downlink carrier of a T-IMT-2000 network, compared to a terrestrial 5 MHz FDD downlink carrier which would be located at upper frequencies in the T-IMT-2000 downlink allocation. **A standard 5 MHz carrier spacing is therefore appropriate for this scenario.**

It can be noted that conclusions on compatibility between TR and TDD UE Rx (downlink) are similar to those regarding FDD UE Rx (downlink). However, the main compatibility issue for TDD arises from TDD BS Rx protection from TR interference, see above paragraph.

B.2 Interference from MSS MES into terrestrial FDD/TDD

This situation occurs around 2670 MHz and corresponds to Path B.

B.2.1 SRI-E

B.2.1.1 SRI-E (method 1)

B.2.1.1.1 Methodology (SRI-E, path B, scenarios 9 to 12)

This interference path is between the S-IMT2000 uplink interfering into the FDD/TDD, as shown in the Figures below.

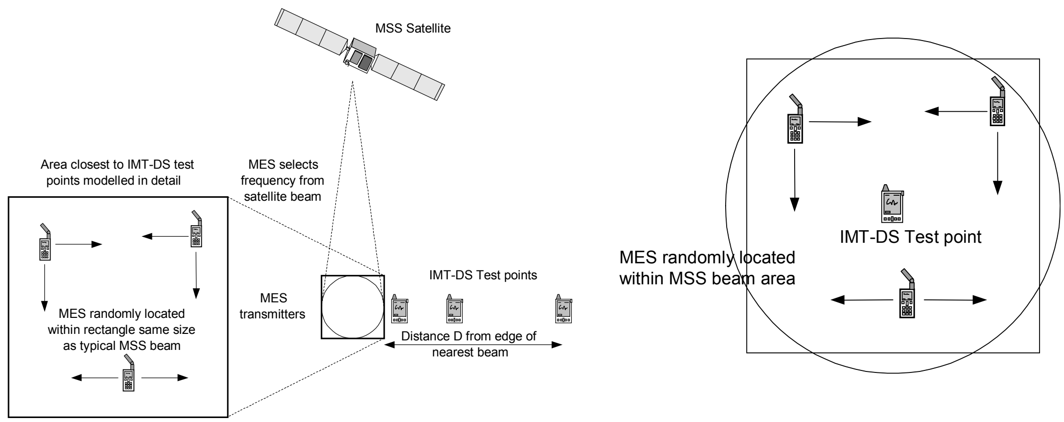


Figure B.2-1: Interference Path B: Geographic and Frequency separation

Interference into Mobile Stations
In this case the interference is the summation of interference from multiple Mobile Earth Stations. It was assumed that the MES in the satellite beam nearest to the FDD/TDD deployment was operating co-frequency, as this is likely to be the worst case. The adjacent beams are therefore likely to be both further away and non-co-frequency, and so will result in much lower levels of interference, and were not considered further.

Therefore this summation is from all MES within one satellite beam, that nearest to the FDD/TDD deployment. Each MES was modelled as transmitting on mean power over a single S-IMT2000 carrier bandwidth.

There were two random elements to the simulation:

- the MESs were assumed to have a uniform user density across the beam, and so were modelled as randomized within that area;
- the distances to be considered were in general greater than 20 km, and so the propagation model used was ITU-R Recommendation P.452, which includes a random element. As each MES is likely to be separated by a significant distance, it can be assumed that there are different propagation conditions for each interfering path. Hence a different percentage of time was used in the Recommendation P.452 calculation for each MES.

For a given FDD/TDD location, these two distributions must be convolved together to produce an I/N distribution. A set of test FDD/TDD stations was therefore located at a set of distances from the edge of the S-IMT2000 satellite beam, and the probability that the threshold is exceeded calculated.

Interference into Base Stations
Interference into base stations was modelled in a similar way to that for mobile stations as described above. Two additional factors had to be considered, the calculation of the aggregate I/N and the pointing of the BS antenna. The BS was configured with one sector pointing towards the S-IMT-2000 satellite beam, and the other two separated in azimuth by ±120°.

Frequency Separation
With frequency separation the FDD/TDD station location was fixed at the centre of the S-IMT-2000 satellite beam, experiencing interference from adjacent band S-IMT-2000 user terminals. The worse case is when the beam that covers the location of the FDD/TDD station is nearest in frequency, as there will be minimal out-of-band attenuation and geographic separation. Further beams would have addition geographic and frequency separation, and so were not considered further. Therefore the summation over beams is simply over those MES within the single beam into the FDD/TDD station, and so there is a single A(OOB) term rather than a summation.

While the satellite beam would contain multiple MES, only one need be modelled if it is the one both closest in distance and frequency as others would have minimal impact.

B.2.1.1.2 Co-frequency analysis (SRI-E, path B, scenarios 9 to 12)

Co-frequency sharing considered the case where the S-IMT2000 and FDD/*TDD* systems were operating on the same frequency, 2.67 GHz, but were separated geographically.

For path B, interference is considered from a single transmitting MES (S-IMT2000 UL) into the FDD/TDD DL (MS Rx) or UL (BS Rx) for a range of separation distances from 20 km to 2 000 km. The resulting distribution of I/N against distance is shown in Figure B.2-2.

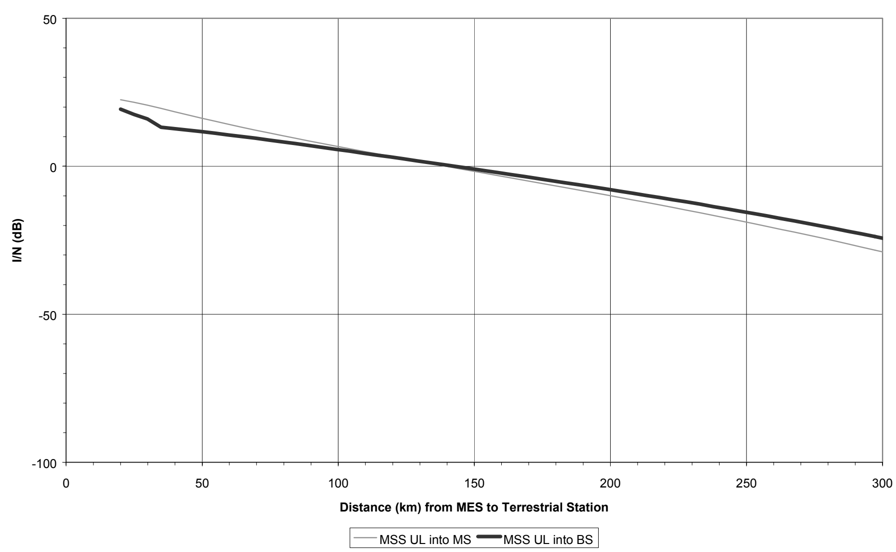


Figure B.2-2: Path B: geographic separation, I/N versus distance

Further studies with updated parameters are required.

B.2.1.1.3 Adjacent band analysis (SRI-E, path B, scenarios 9 to 12)

Co-located sharing considered the case where the S-IMT2000 and FDD/TDD systems were operating within the same geographic region, but were separated in frequency. For path B, interference was considered from a single MES (S-IMT2000 UL) interfering into either the FDD/TDD DL (MS Rx) or UL (BS Rx) direction. The geographic region was defined as box of size 20 × 20 km within which the MES was located at random at each time step in the simulation. The FDD/TDD MS or BS was located at the centre of the box and interference calculated using the Hata propagation model. The simulation was repeated for 100,000 samples to obtain a distribution of %-samples the I/N criteria was exceeded for different guardbands from 0 to 2.5 MHz.

The results are shown in Figure B.2-3.

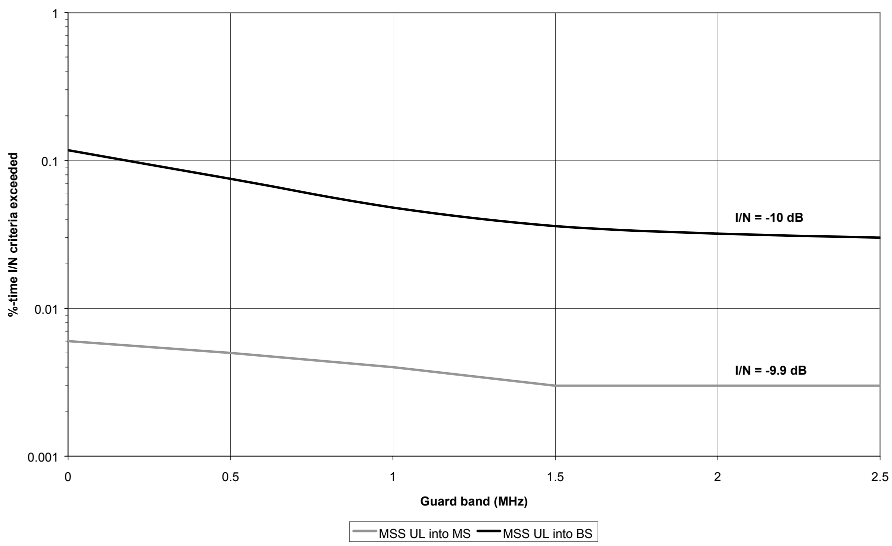


Figure B.2-3: Path B: frequency separation, %-time I/N criteria exceeded vs. guardband

NOTE – Only those values below 1% are shown in the Figure.

B.2.1.2 SRI-E (method 2)

B.2.1.2.1 Methodology (SRI-E, path B, scenarios 9 to 12)

Results are calculated with CEPT tool SEAMCAT. The functional specifications of the SEAMCAT software are defined in the ERC Report 68 and are available from www.ero.dk/seamcat . The tool can estimate the interference probability on one victim link depending on the density of interferers in the same area, or the minimum separation distance between the interfering transmitter and the victim receiver. These calculations can be made for different frequency carrier separations. Hence, the guardband efficiency can be estimated.
When considering FDD/TDD simulation, a level around 2 per cent of probability of interference is required to ensure the agreed 5 per cent of outage.

SEAMCAT considers three different interference sources:

- out of band emissions;
- blocking effects;
- intermodulation products effects.

Simulation calculation made in this Report take into account only two adjacent carriers to estimate interference from each system. As intermodulation products solely affect further frequencies than the adjacent one, this interference mechanism will be only considered if the receiver bandwidth of the victim receiver includes either (2*f1+/–f2) or (2*f2+/–f1)[11]. Otherwise, we can reduce the interference mechanisms to only out-of-band emissions and potential desensitization of a receiver by an interferer in an adjacent channel.

Out-of-band emissions by a mobile of one technology on one carrier can impact the receiver of the other technology on another carrier by raising the noise floor in the receiver (see Fig. B.2-4).

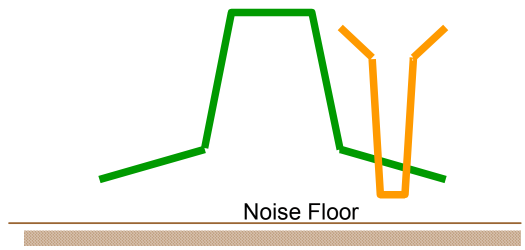


Figure B.2-4: Out-of-band emissions impacting receiver of another technology

The result of such interference will be an effective reduction in the usable receiver sensitivity, which results in a reduced link budget margin. A receiver normally cannot do anything about this unwanted noise, however it is possible to reduce sideband emissions at the transmitter source through the use of filters. It is also possible to accommodate this kind of interference in the system design by adjusting powers or by changing the link budget margin requirements.

The second type of interference concerns the potential desensitization of a receiver by a strong interferer in an adjacent channel (Fig. B.2-5). The interferer can be strong enough to impact the RF front end, gain controls or impact the IF performance if enough signal slips past the IF filters.

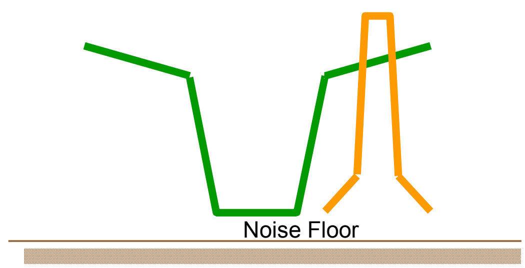


Figure B.2-5: Desensitization of a receiver by an interferer in an adjacent channel

The result of such interference is a reduction in receiver sensitivity through quieting (de-sense) thus preventing reception of desired signals at low levels. It is possible to reduce this kind of interference through the use of filters at the receiver or by changing the system design parameters to ensure the desired signal levels are sufficiently strong enough to overcome any receiver de-sense. To simulate the blocking effects in the SEAMCAT software tool, it is possible either to enter the filtering mask of the victim receiver, or to use as an input parameter a constant blocking value defined in the systems standards. For this simulation, we will implement the receiver mask.

B.2.1.2.2 Results

Internal interferences in FDD network
In order to model intra-cell and inter-cell interferences in a cellular network, 1 dB noise rise is added to the noise floor level in rural areas and 3 dB in urban areas. This assumption is also applied to the user equipment even if the noise rise depends on its position in the cell.

[11] Practical experience shows that intermodulation is very difficult to predict theoretically and is generally a problem to be solved on a case by case basis by appropriate site engineering mitigation techniques.

Scenario 9: effects of MES on FDD MS in 2 670-2 690 MHz

Results in urban areas with 315 m micro cell radius
The victim is the FDD/TDD UE, which receives voice services and the interferer is MES UE for data services ($C/N + I = -19$ B). One interferer per cell in urban areas is a worst case as explained in the active MES density section. One interferer per cell corresponds to 3.2 interferers per km^2.

Interferer density (1/km^2)	1.8 10^{-4}	3.2
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	0.76%
2.8 (200 kHz Guardband)	0%	0.7%

Table B.2-1: Scenario 9 results (315 m radius, $C/N + I = -19$ dB)

The victim is FDD/*TDD* UE which receives voice services and the interferer is MES UE for data services ($C/N + I = -11$ dB in urban).

Interferer density (1/km^2)	1.8 10^{-4}	3.2
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	1.8%
2.8 (200 kHz guardband)	0%	1.8%

Table B.2-2: Scenario 9 results (315 m radius, $C/N + I = -11$ dB)

The victim is FDD/*TDD* UE which receives data services and the interferer is MES UE for data services ($C/N + I = -19$ dB in urban).

Results in rural areas with 10 km cell radius
The victim is FDD/*TDD* UE which receives voice services and the interferer is MES UE for data services ($C/N + I = -19$ dB). One interferer per cell in rural areas is considered here. One interferer per cell corresponds to 3.2.10^{-3} interferers per km^2.

Interferer density (1/km^2)	1.8.10^{-4}	3.18.10^{-3}
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	0%
2.8 (200 kHz Guardband)	0%	0%

Table B.2-3: Scenario 9 results (10 km radius, $C/N + I = -19$ dB)

The victim is FDD/TDD UE, which receives voice services and the interferer is MES UE for data services ($C/N + I = -11$ dB in rural).

Interferer density (1/km^2)	1.8.10^{-4}	3.18.10^{-3}
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	0.002%
2.8 (200 kHz Guardband)	0%	0%

Table B.2-4: Scenario 9 results (10 km radius, $C/N + I = -11$ dB)

Scenario 11: effects of MES on FDD BS in 2 670-2 690 MHz

Results in urban areas in micro cell radius
The victim is FDD/TDD BS with 5 dBi gain and which receives data services ($C/N + I = -21$ dB in rural) and the interferer is MES UE for data services.

Interferer density (1/km^2)	1.8 10^{-4}	3.2
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	1.6%
3.6 (1 MHz guardband)	0%	0.7%

Table B.2-5: Scenario 11 results (315 meters radius, $C/N + I = -21$ dB)

The victim is FDD/*TDD* BS with 5 dBi gain and which receives voice services ($C/N + I = -12$ dB) and the interferer is MES UE for data services.

Interferer density (1/km^2)	1.8 10^{-4}	3.2
Frequency carrier separation (MHz)		
2.6 (no guardband)	0%	2.2%
3.6 (1 MHz guardband)	0%	1.5%

Table B.2-6: Scenario 11 result (315 metres radius, $C/N + I = -12$ dB)

Results in rural areas with 10 km cell radius
The victim is FDD/TDD BS with 15 dBi gain and which receives data services ($C/N + I = -21$ dB) and the interferer is MES UE for data services.

Interferer density (1/km^2)	$1.8.10^{-4}$	$3.18.10^{-3}$
Frequency carrier separation (MHz)		
2.6 (no guardband)	0.03%	0.44%
2.8 (200 kHz guardband)	0%	0.38%

Table B.2-7: Scenario 11 results (10 km radius, $C/N + I = -21$ dB)

The victim is FDD/TDD BS with 15 dBi gain, and which receives voice services ($C/N + I = -12$ dB) and the interferer is MES UE for data services.

Interferer density (1/km^2)	$1.8.10^{-4}$	$3.18.10^{-3}$
Frequency carrier separation (MHz)		
2.6 (no guardband)	0.13%	0.002%
2.8 (200 kHz Guardband)	0.1%	0%

Table B.2-8: Scenario 11 results (10 km radius, C/N + I = –12 dB)

B.2.2 S-DMB

B.2.2.1 Methodology and evaluation (S-DMB, Path B, scenarios 9 to 12)

These scenarios were studied using SEAMCAT. The interfering S-DMB terminals are assumed to be uniformly spread across the simulation area. Their density is calculated from the maximum assumed uplink capacity, and the satellite beam footprint area. The S-DMB terminals will be able to use terrestrial capacity (GSM/3G) for their uplink transmissions when it is available. Therefore, two situations have to be examined:

- The S-DMB terminal uplinks to the satellite whatever its location, and including in the victim terrestrial cell.
- The S-DMB terminal uplinks to the satellite except when located in the victim terrestrial cell because it uses the terrestrial capacity available in this cell.

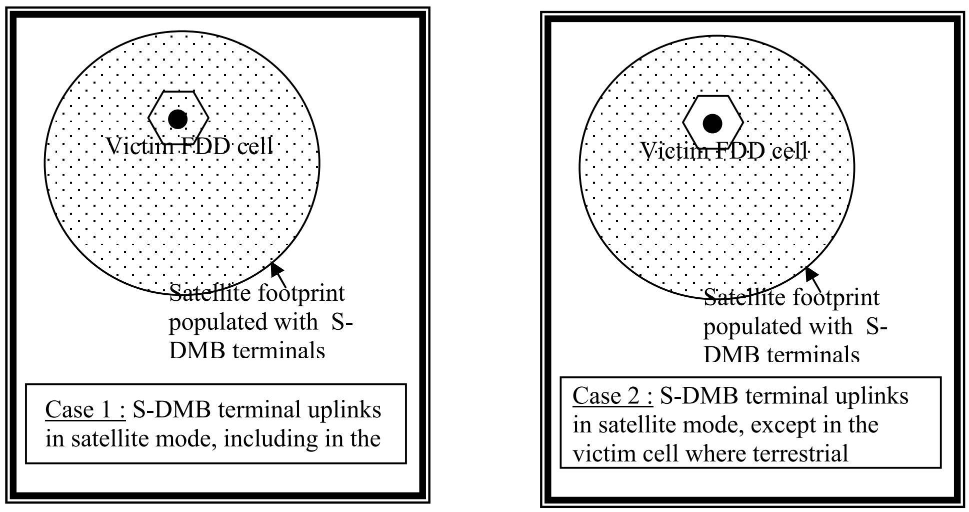


Figure B.2-6: S-DMB Terminal uplink interference configurations

For all cases developed in this section, the S-DMB terminal RF and deployment characteristics are assumed as follows:

	Handheld	Vehicular	Portable
Max. Power (dBm) No uplink power control	24	33	39
Antenna max gain (dBi)	0	4	2
Antenna gain towards victim BS, UE (dBi)	0	2	0
S-DMB Terminal ACLR (dB), in first adjacent channel	33	33	33
Number of simultaneous transmitting S-DMB terminals per satellite beam	250	100	100

Table B.2-9: Interfering S-DMB Terminal characteristics

The satellite beam diameter is about 700 km, and the S-DMB terminals are assumed to be uniformly distributed across the satellite footprint.

Victim terrestrial systems characteristics (as in Att. 7.2 to ITU-R Doc. 8F/827, referred in [1]) are shown in the following Table:

	FDD BS Rural Macro	FDD UE Rural Macro	FDD BS Suburban Macro	FDD UE Suburban Macro	TDD BS Urban Pico	TDD UE Urban Pico
Noise Floor (dBm)	–103	–99	–103	–99	–103	–99
I/N threshold (dB)	–10	–10	–10	–10	–10	–10
Antenna gain (dBi)	17	0	17	0	0	0
Propagation Environment	Rural	Rural	Suburban	Suburban	Urban-outdoor	Urban-outdoor
Antenna height (m)	30	1.5	30	1.5	1.5	1.5
Cell radius (km)	10	10	1	1	0.04	0.04

Table B.2-10: Victim terrestrial system characteristics

The SEAMCAT simulations resulted in the following interference probabilities, for a standard 5 MHz spacing between the S-DMB and FDD/TDD carriers:

	FDD BS Rural Macro	FDD UE Rural Macro	FDD BS Suburban Macro	FDD UE Suburban Macro	TDD BS Urban Pico	TDD UE Urban Pico
Handheld	2.85%	0.02%	0.26%	0	0	0
Vehicular	4.25%	0.03%	0.42%	0	0	0
Portable	7.05%	0.03%	0.55%	0	0	0

Table B.2-11: Case 1 results: S-DMB emissions authorized in the FDD/TDD coverage

	FDD BS Rural Macro	FDD UE Rural Macro	FDD BS Suburban Macro	FDD UE Suburban Macro	TDD BS Urban Pico	TDD UE Urban Pico
Handheld	0.03%	0	0.02%	0	0	0
Vehicular	0.39%	0	0.18%	0	0	0
Portable	1.04%	0	0.2%	0	0	0

Table B.2-12: Case 2 results: S-DMB emissions not authorized in the victim cell

Comments on results
The probabilities of interference are for most scenarios rather low. The reason for this is the very low density of S-DMB terminals. E.g. there is only one handheld terminal per area of 1 500 sq km on average. Nevertheless, when considering only the areas in the vicinity of S-DMB terminal, the probability of interference would be significantly higher. It is therefore of interest if there is a correlation between the locations where S-DMB terminals are used and the locations of FDD/TDD receivers. In general, the areas where S-DMB terminals would transmit are expected to be somewhat separated from the areas of dense FDD/TDD deployments.

The worst results correspond to the case where Portable S-DMB terminals transmit in the vicinity of rural cell and affects the BS reception. In that case the probability that the I/N exceeds –10 dB is around 7% if the S-DMB terminals are allowed to transmit even though there is a terrestrial coverage (i.e. in the victim cell), and around 1% if S-DMB transmissions in the MSS uplink band are avoided within the victim cell.

Other factors influencing the interference probability are identified:

- Island effect: The values of Table B.2-12 correspond to the case where the rural victim cell is isolated and in an environment where S-DMB terminals may uplink to the satellite. In the study, the rural cell is assumed to be geographically separated from the rest of the terrestrial coverage. In a real world situation, such isolated rural cell may represent exceptional cases. The most affected cells are the ones located at the border of the terrestrial coverage constituted by a juxtaposition of cells. The "border" cells will experience interference only from those S-DMB emissions originating from the outer side of the terrestrial coverage. Rural cells located in the inner part of the terrestrial coverage should not experience interference, thanks to terrestrial path isolation between the T-IMT-2000 receiver (BS or MS) and the interfering MES, which is located outside the terrestrial coverage. This assumes that MES transmissions are prohibited inside terrestrial coverage.
- Protection criterion: a generic I/N criterion of - 10 dB has been used, for calculating the probabilities in Tables B.2-11 and B.2-12. Since the interference will be experienced by a limited number of cells, a criterion of –6 dB could have been used (see note v of [1]).
- Mixture of terminals types: Table B.2-11 shows that the interference probability into Rural macro cells vary a lot according to the type of terminals which is considered. It is likely that the population of S-DMB terminals will be a mix of the different existing categories, and therefore the actual interference probability will be between the extreme values obtained respectively for handheld and portable terminals.

In conclusion, the most difficult case is the protection of isolated rural cells from S-DMB portable terminals uplink interference (~7% interference probability with a 5 MHz spacing). With 10 MHz carrier spacing, the probability of interference of portable S-DMB terminals into Rural Base Stations is 2.6%. If the S-DMB portable terminal does not transmit in the MSS band within the victim cell, the interference probability is evaluated to be 1.04%, which is acceptable (provided the criterion is 2%). In all other cases (other terrestrial environments, other S-DMB terminals), the interference probability is not significant.

B.3 Interference from terrestrial FDD/TDD into MSS satellites

This situation occurs around 2 670 MHz and corresponds to Path C.

B.3.1 SRI-E

B.3.1.1 SRI-E (method 1)

B.3.1.1.1 Methodology (SRI-E, path C, scenarios 13 to 16)

This interference path is between the FDD/TDD (either BS or MS TX) interfering into the S-IMT2000 uplink, as shown in the Figure below.

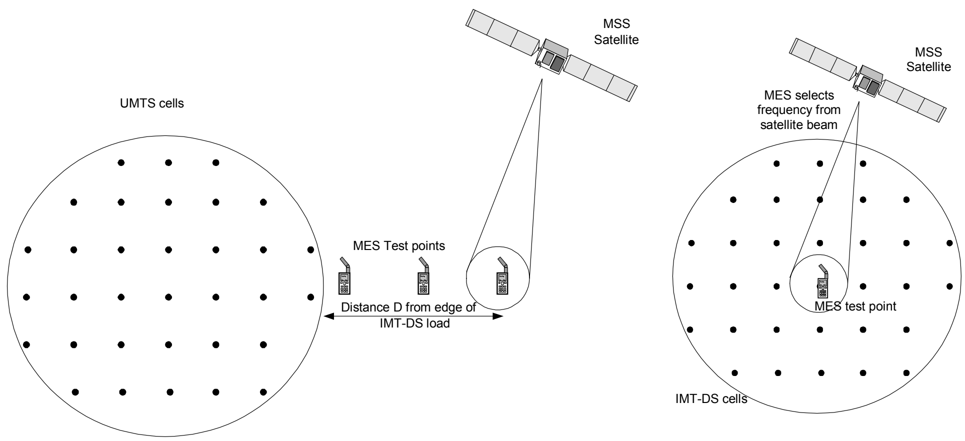


Figure B.3-1: Interference Path C: Geographic and Frequency separation

Interference from Mobile Stations

This scenario involves interference from large numbers of FDD/TDD transmitters into the satellite uplink. As it is not feasible to model each one individually, all transmitters within a defined area were represented by a single test point, with its transmit power scaled accordingly. The test point was located at the centre of the area that it represents.

For transmissions from the mobile case the total power per test point can be calculated from:

$$P_a = \sum_{environment} \frac{A_t}{A_c} \frac{p}{100} \left(P_v N_v + P_D N_D \right)$$

where all units are in absolute scale, not dB, and where:

P_a = total power from all transmitters represented by test point

$\sum_{environment}$ = sum over all environments

A_t = total area represented by test point

A_c = area of cell of this environment

p = percentage of area covered by this environment

P_v = mean transmit power of voice users for this environment

N_v = mean number of voice users in cell for this environment

P_D = mean transmit power of data users for this environment

N_D = mean number of data users in cell for this environment.

For the case where the transmit power of voice and data users is the same for all environments, this reduces to:

$$P_a = PNA_t \sum_{environment} \frac{p}{100 A_c}$$

where:

P = mean transmit power of user

N = mean number of users in cell

The total e.i.r.p. for an omnidirectional antenna with zero dB gain is then

$$\text{e.i.r.p.} = 10\log10(P_a)$$

These test points are then distributed separated in distance by $\sqrt{A_t}$.

The aggregate interference from all test points into a satellite uplink pointing at a mobile earth station geographically separated from the FDD/TDD deployment can then be calculated.
For the case of GSO systems the propagation models and traffic modelling are constant, and so the I/N into a single beam is independent of time. Therefore it is feasible to point a beam at a station located at the edge of the FDD/TDD deployment area and move it linearly in longitude to get the I/N for a range of geographic separations.

Interference from Base Stations
A similar approach was used to calculate aggregate interference from FDD/TDD base stations into satellite uplinks. However the aggregate e.i.r.p. per test point has to take account of the variation in antenna characteristics between environments. In the simulations each test point was therefore modelled with 9 antennas (3 antennas per environment, each with 3 sectors):

1) 3 antennas for rural environment;
2) 3 antennas for suburban-macro environment;
3) 3 antennas for urban-micro environment.

The first antenna of each environment was pointed at random, and then the other two with boresight azimuth offset by ±120°. Over a large area the BS azimuths can be expected to have a nearly random distribution, and therefore no specific pointing is required.

If the input is the total power per cell, P_c, then the aggregate power per antenna at the test point is:

$$P_a = \frac{P_c}{3}\frac{A_t}{A_c}\frac{p}{100}$$

where:

P_a = total power from all base stations of specified environment into each antenna
P_c = mean transmit power of base stations of specified environment
A_t = total area represented by test point
A_c = area of cell of this environment
p = percentage of area covered by this environment.

As before the units are absolute, not dB, and the test points are distributed separated in distance by $\sqrt{A_t}$.

As above, the aggregate interference from all test points into a satellite uplink pointing at a mobile earth station, geographically separated from the *FDD*/*TDD* deployment, can then be calculated. A GSO satellite beam was pointed at a station located at the edge of the *FDD*/*TDD* deployment area and the I/N for a range of geographic separations was calculated.

Frequency Separation
Similar approaches were used for the frequency separation case, except the S-IMT200*0* beam was pointed at a test MES located in the centre of the FDD/TDD deployment. The two FDD/TDD carriers nearest in frequency were then included in the summation.

B.3.1.1.2 Co-frequency analysis (SRI-E, path C, scenarios 13 to 16)

Co-frequency sharing considered the case where the S-IMT2000 and FDD/TDD systems were operating on the same frequency, 2.67 GHz, but were separated geographically.

- For path C, interference was considered from a widescale deployment of FDD/TDD transmitters (either MS or BS) into the S-IMT2000 UL. The geometry varied depending on the sub-path considered:
- for the MS Tx (UL) the worst case was considered to be sub-satellite;
- for the BS Tx (DL) the worst case was considered to be when the MES is on the horizon.

The aggregate interference was calculated based upon the Recommendation ITU-R P.676 propagation model. The resulting distribution was a graph of ΔT/T against distance from FDD/TDD deployment to the edge of active beam, as shown in the Figure below.

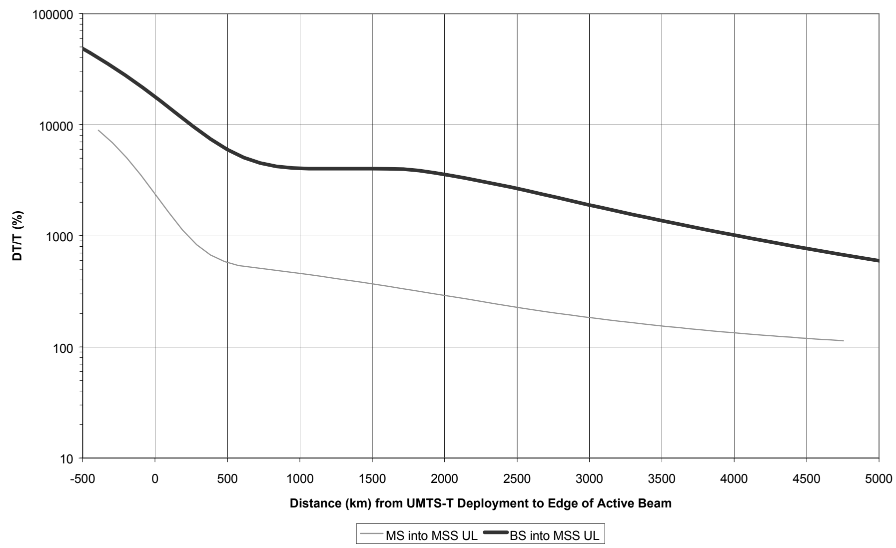


Figure B.3-2: Path C: geographic separation, ΔT/T vs. distance from FDD/TDD deployment

Further studies with updated parameters are required.

B.3.1.1.3 Adjacent band analysis (SRI-E, path C, scenarios 13 to 16)

Co-located sharing considered the case where the S-IMT2000 and FDD/TDD systems were operating within the same geographic region but were separated in frequency:

- Similarly to the co-frequency case, for path C the geometry varied depending on the sub-path:
- for the MS Tx (UL) the worst case was considered to be sub-satellite;
- for the BS Tx (DL) the worst case was considered to be when the BS deployment and MES are on the horizon.

The results for scenario 15 are shown in the Figure below. The Figure show two examples: one where the minimum elevation of the MSS beam is 5º, and the other where the minimum elevation of the MSS beam is 20º.

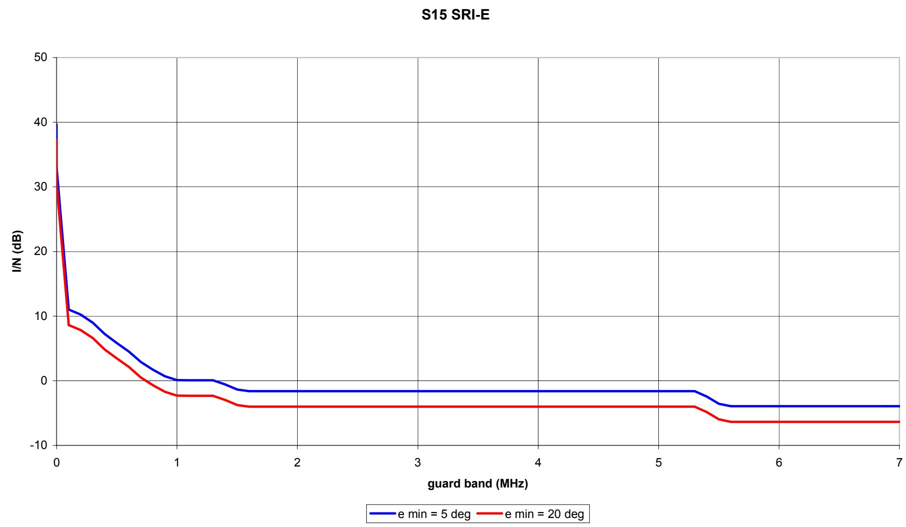


Figure B.3-3: Results for scenario 15 (I/N versus guardband)

The interference criterion (corresponding to I/N = –15 dB) is exceeded irrespective of the guardband. This scenario is examined further in section B.5.

B.3.1.2 SRI-E (method 2)

B.3.1.2.1 Methodology (SRI-E, Path C, scenario 13 to 16)

The methodology is the same as the one used with S-DMB system and described in B.3.2.1. This methodology aggregates the interference power falling into a satellite beam from all the terrestrial cells in the satellite's field-of-view. Noting that a key assumption of the methodology is uniform terrestrial cellular coverage over the satellite field-of-view, the calculations can be simplified considerably by examining only interference from terrestrial cells in the 3 dB beamwidth of the satellite's spot beam, which corresponds to 1.2º aperture angle with SRI-E system. This angle is used by SRI-E to define its spot beam radius.

Outside the beam, we will use a different antenna gain for BS and another value for losses due to buildings.

B.3.1.2.2 Results with adjacent band compatibility issues

Concerning the methodology for assessing interference to MSS space segment, the total interference at the satellite is calculated by summing up the contributions from each terrestrial visible cell following the ERC Report 65 method. In the calculations, vertical radiation pattern of base station antennas come from Recommendation ITU-R F.1336-1 with k = 0.2 and are used to derive BS antenna attenuation in the aggregate budget links. The satellite noise power is –169 dBm/Hz and the maximum tolerated level of external interferences is around 3% of the noise level.

The following Table gives the simulation results in adjacent band:

Sat. Beam boresight	Interferences without guardbands	Interferences with 1 MHz guardband	Interferences with 2 MHz guardbands	Interferences with 6 MHz guardbands
10°E; 40°N	–181 (18% of ΔT/T)	–181.9 (14% of ΔT/T)	–183 (11.3% of ΔT/T)	–183 (11.3% of ΔT/T)
10°E; 50°N	–182.2	–183.1	–184.2	–184.2
10°E; 60°N	–183.3	–185.2	–185.3	–185.3

Table B.3-1: Out of band interfering power density at satellite receiver (dBm/Hz) to compare to –173.55 dBm/Hz (ΔT/T = 50%) and –185.78 dBm/Hz (ΔT/T = 3%)

The criteria of ΔT/T of 3% is exceeded whatever the guardband proposed. This scenario is examined further in section B.5.

B.3.2 S-DMB

B.3.2.1 Methodology (S-DMB, Path C, scenarios 13 to 16)

The methodology described in the ERC Report 65 (§ 3.2.1 and Annex B) has been used, in order to evaluate the aggregate interference seen by the satellite receiver, from the terrestrial 3G networks which are visible from the satellite.

This methodology consists in aggregating across the satellite footprint, the average interfering e.i.r.p. per cell arising either from BSs, or from all the UEs transmitting within the average cell. The determination of the "average cell" parameters is derived from deployment assumptions given in Annex A.

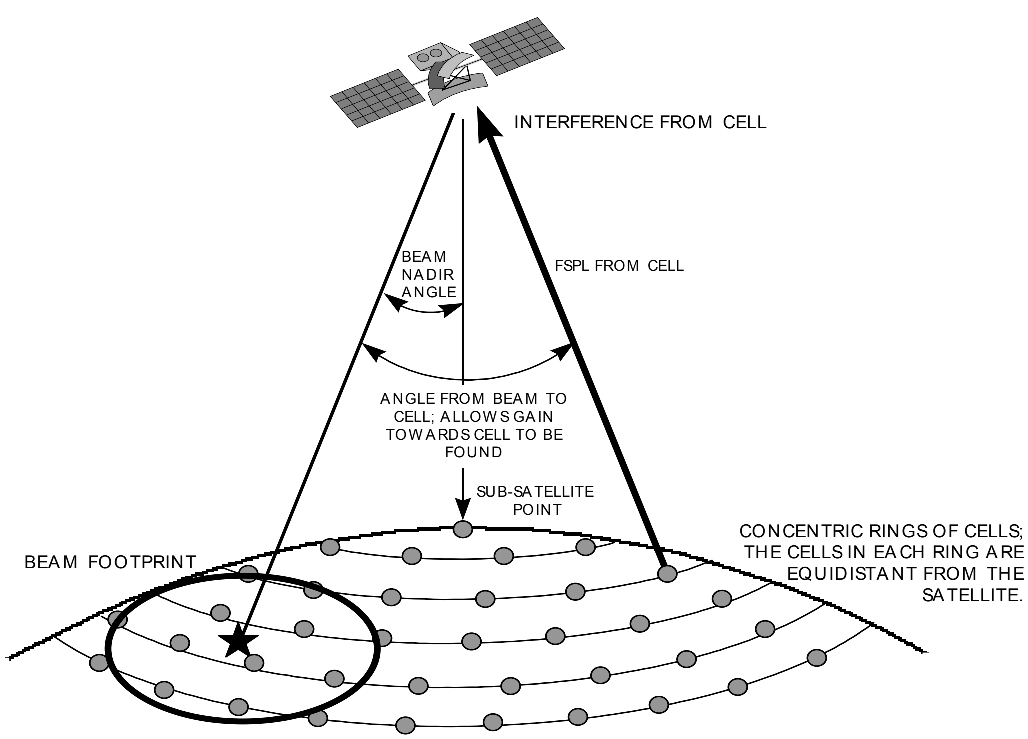


Figure B.3-4: ERC Report 65 methodology for evaluating interference into satellite reception

Based on the methodology described above and in [3], the average MS e.i.r.p. per cell, and the average BS power per cell are calculated, for both TDD and FDD modes.

The resulting terrestrial 3G average parameters are given below:

	FDD	**TDD**
Average cell radius (km)	1.98	0.2
Average MS e.i.r.p. per cell (dBm)	20.83	15.86
Average BS power per cell (dBm)	32.10	13.3

In order to evaluate the cumulative BS emission level at the satellite, an average BS maximum gain of 13 dBi is assumed for *FDD*, and 5 dBi for TDD. The BS gain towards the satellite is derived from the satellite elevation angle, and the BS max gain. The BS gain pattern obeys to ITU-R Recommendation M.1336, assuming k = 0.2, and a downtilt angle of 2.5°.

In a first instance, the in-band interference is calculated. The spectrum mask in then applied to MS and BS, as applicable, in order to determine the necessary guardbands. The spectrum masks are derived from the applicable 3GPP specifications (see [2, 4, 5, 6]).

The interference level is compared to the satellite receiver thermal noise. The interference is acceptable if it represents a fractional part of the thermal noise. If the interference is below 50% of the thermal noise level, it should be acceptable.

B.3.2.2 Co-frequency analysis (S-DMB, Path C, scenarios 13 to 16)

The calculated in-band interfering power density at the satellite receiver is given in the Table below:

	Interfering system		
Sat. Beam boresight	**FDD Ues**	**FDD BSs**	**TDD (UE and BS)**
10°E; 40°N	–144.5	–135.8	–178.5
10°E; 50°N	–143.0	–131.5	–176.6
10°E; 60°N	–141.9	–126.4	–174.6

Table B.3-2: In-band interfering power density at satellite receiver (dBm/Hz)

For FDD, the above values are typically 25 to 40 dB above the satellite thermal noise level, which means that co-frequency sharing is not possible on the same coverage. Co-frequency operation over separate coverages would be possible if the satellite Rx antenna provides the necessary isolation.

With the assumptions taken for TDD (indoor deployment only), the interference level is of the same order of magnitude as the satellite receiver thermal noise. In these conditions, sharing seems difficult to achieve, and would highly depend on TDD deployment. The sharing with TDD, when deployed outdoors, would not be feasible.

B.3.2.3 Adjacent band analysis (S-DMB, Path C, scenarios 13 to 16)

Taking into account the applicable ACLR requirements for 5 MHz channel spacing, the interference level seen by the satellite is given in Table below. The equivalent percentage of the satellite thermal noise is given in parenthesis:

	Interfering system		
Sat. Beam boresight	**FDD UEs**	**FDD BSs**	**TDD (UE and BS)**
10°E; 40°N	–177.5 (23.4% of Nth)	–180.8 (11.0% of Nth)	–218.1 (29.5% of Nth)
10°E; 50°N	–176.0 (33.5% of Nth)	–176.5 (29.8% of Nth)	–215.8 (45.7% of Nth)
10°E; 60°N	–174.9 (43.1% of Nth)	–171.4 (95.4% of Nth)	–214.5 (64.6% of Nth)

Table B.3-3: Adjacent channel interfering power density at satellite receiver (dBm/Hz)

Assuming a standard 5 MHz channel spacing, the satellite reception is adequately protected from FDD mobile emissions. The same conclusion is applicable for interference coming from FDD base stations, when located at low/medium latitudes. It should be noted that the satellite experiences more interference when the beam covers Northern latitudes. In a real situation, the interference should be significantly lower, since the population density is lower in northern countries, than in other areas of Europe for which the traffic assumptions were made. No adjacent channel compatibility issues with TDD are anticipated. If there was a limited outdoor deployment of TDD, the adjacent band compatibility would certainly still be feasible, due to the very high available margin.

B.4 Interference from terrestrial FDD/TDD into MSS MES

This situation occurs around 2 520 MHz and corresponds to Path D.

B.4.1 SRI-E

B.4.1.1 Methodology (SRI-E, Path D, scenario 17 to 20)

This interference path is between the FDD/TDD (either BS or MS TX) interfering into the S-IMT2000 downlink, as shown in the Figure below.

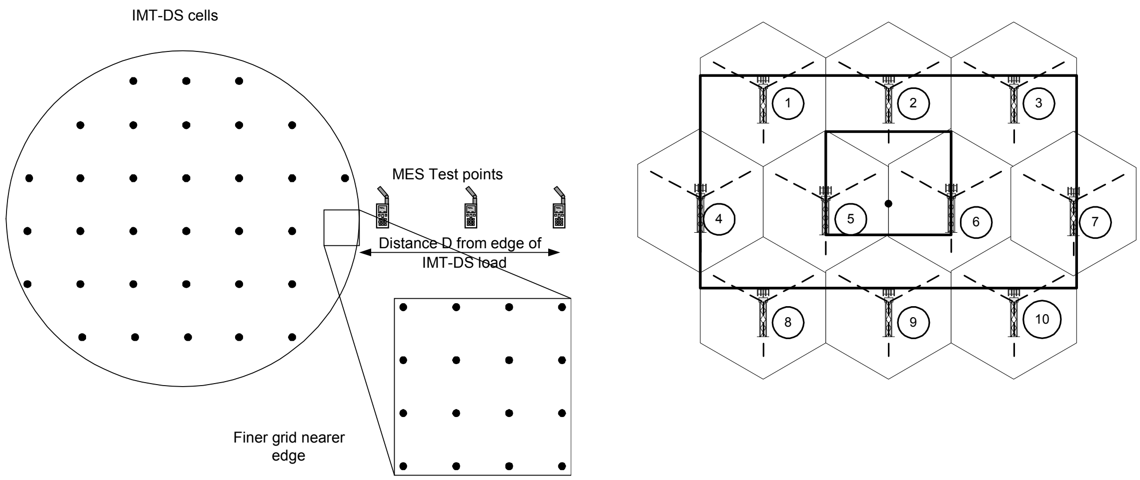


Figure B.4-1: Interference Path D: Geographic and Frequency separation

Interference from Mobile Stations
In a similar approach to interference path C, test points were used to represent all transmissions within an area, and the aggregate interference to the MES is determined by the summation of interference each test point.

Two grids were used - one near the edge of FDD/TDD deployment and one further away. The total power at each test point was calculated using the same method as for path C.

The interference into a set of MESs separated by a set of distances from the edge of the FDD/TDD deployment area was then calculated. The propagation used in this case was Recommendation ITU-R P.452 for smooth earth with, as before, a separate percentage of time for each interference path.

The propagation model in Recommendation ITU-R P.452 is based upon predicting the path loss that can be expected to be exceeded for a specified percentage of time. It is therefore necessary to define for each interference path a percentage of time using a pseudo-random number generator. To be consistent with the values used in the Recommendation, any percentages above 50% or below 0.001% must be truncated to that range.

Within Recommendation ITU-R P.452 there is no guidance as to how to model the correlation of propagation paths from large numbers of geographically separate transmitters. The approach used was to assume that the propagation environments for all transmitters within a specified geographic area were fully correlated, but between disparate geographic areas they would be statistically independent. Therefore the interference path from each test point was assigned its own random percentage, which was then used in the model in Recommendation ITU-R P.452 to determine the relevant propagation loss.

The total interference was computed by aggregating the received signals from all of these paths:

- Two alternatives were considered:
- a separate percentage of time for each of the test points on the coarse and fine grids (as in Fig. B.4-1);
- a separate percentage of time for each of the test points on the coarse grid and the same percentage of time used by all the test points on the fine grid.

This calculation of aggregate interference was repeated 100 000 times to produce a cumulative distribution function of received aggregate interference against percentage of time for which interference would be exceeded.

Interference from Base Stations
As for the mobile station and for interference path C, a set of test points was used with antennas representing each environment, and transmit power calculated as above. Similarly two grids were used, with different powers/environment/test point.

Frequency Separation
When studying frequency separated, co-located operation, the MES was located within an area populated by FDD/TDD systems. A Monte-carlo method was used to determine the percentage of locations for which the MES interference criterion was exceeded. Each of the outdoor scenarios (“Rural”, “Vehicular-Macro” and “Pedestrian-Micro”) were analysed separately.

B.4.1.2 Co-frequency analysis (SRI-E, Path D, scenarios 17 to 20)

Co-frequency sharing considered the case where the S-IMT-2000 and *FDD*/*TDD* systems were operating on the same frequency, 2.52 GHz, but were separated geographically.

The result after 100,000 samples was CDFs of ΔT/T vs. % time ΔT/T exceeded. These were used to determine the % time for which the threshold of ΔT/T = 6% was exceeded for various distances, as shown in the Figure below.

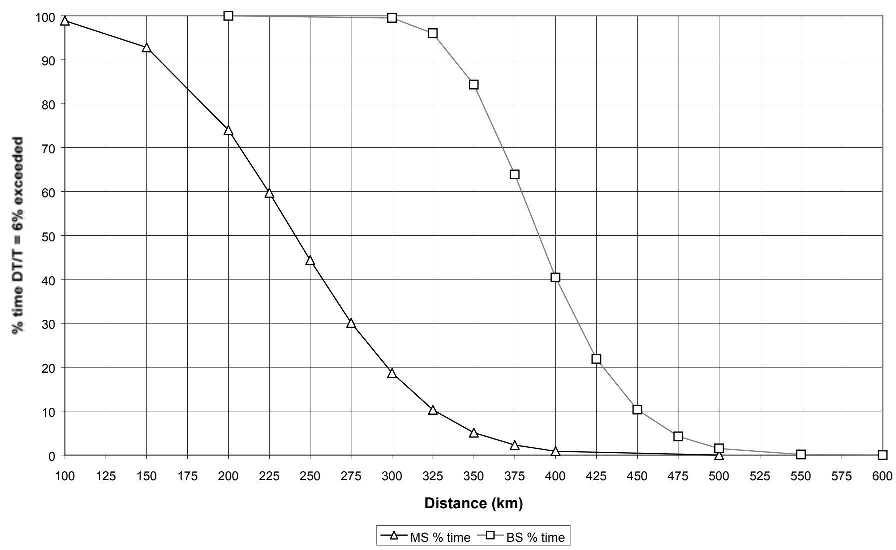


Figure B.4-2: Percentage of time that ΔT/T=6% is exceeded vs. distance

Further studies with updated parameters are required.

B.4.1.3 Adjacent band analysis (SRI-E, Path D, scenarios 17 to 20)

Co-located sharing considered the case where the S-IMT2000 and *FDD*/*TDD* systems were operating within the same geographic region but were separated in frequency. The interference levels vary depending upon the FDD/TDD environment and hence the interference received by an MES in each of the environments was considered separately. Each result comprises a plot of percentage of MES locations that a $\Delta T/T = 3\%$ at the MES is exceeded for various guardband sizes, as shown below.

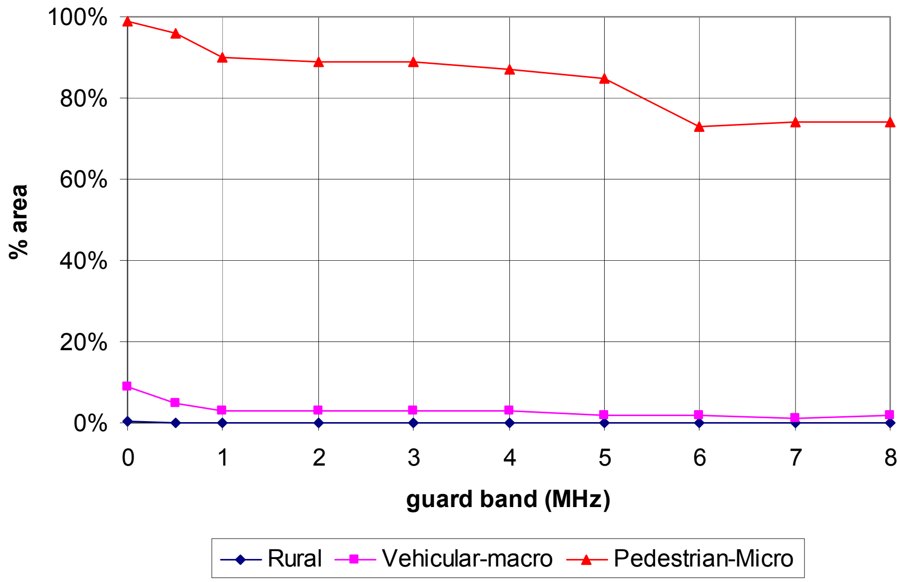


Figure B.4-3: Percentage of MES locations for which criterion is exceeded for interference MS (FDD) to MES for various environments (scenario 17)

In the rural and vehicular-macro environments, no guardband is necessary. In the pedestrian-micro environment, the necessary guardband exceeds 8 MHz.

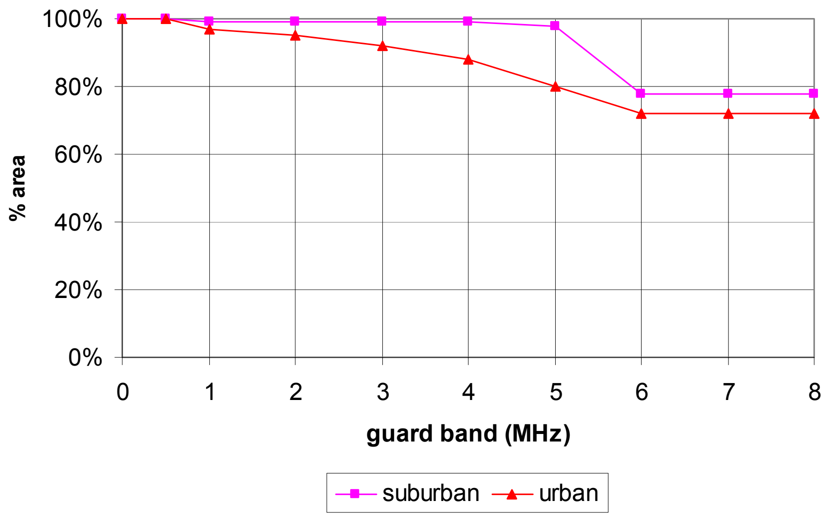


Figure B.4-4: Percentage of MES locations for which criterion is exceeded for interference MS (TDD) to MES for various environments (scenario 18)

In both environments, the interference criterion is exceeded for guardbands exceeding 8 MHz.

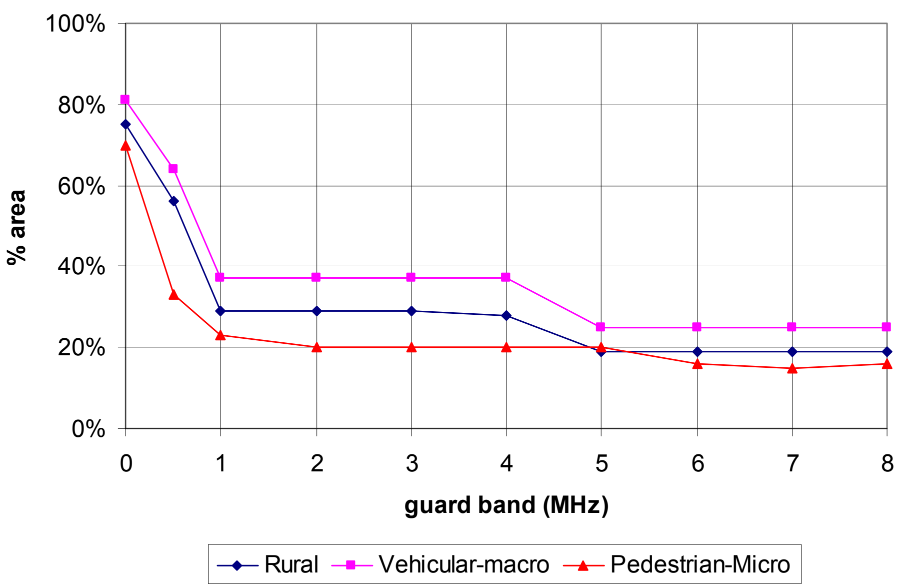


Figure B.4-5: Percentage of MES locations for which criterion is exceeded for interference BS (FDD) to MES for various environments (scenario 19)

The interference criterion is met for 20% locations with a guardband of 5 MHz in the rural environment and 6 MHz in the pedestrian-micro environment. In the vehicular-macro environment, the necessary guardband exceeds 8 MHz.

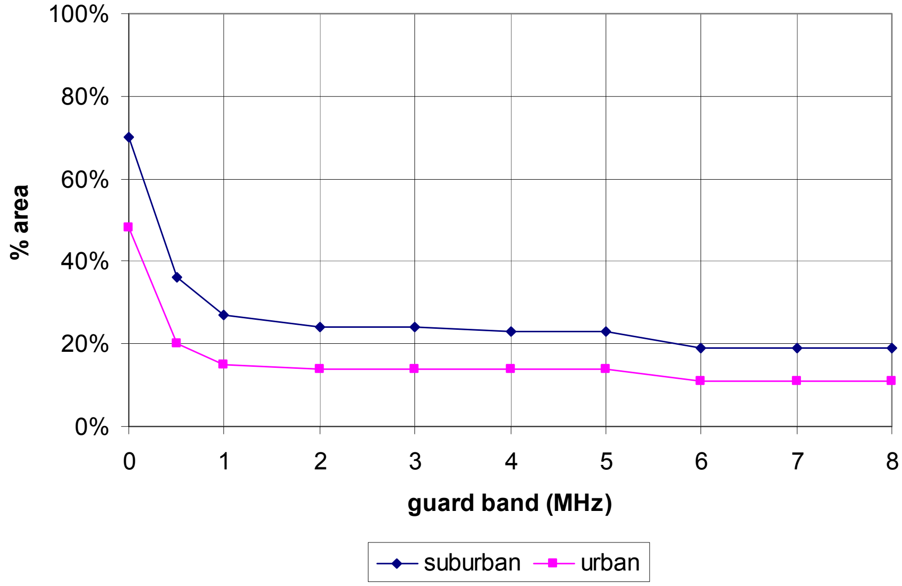


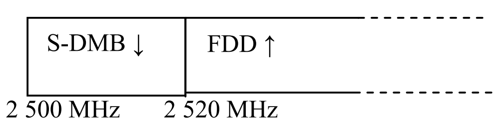
Figure B.4-6: Percentage of MES locations for which criterion is exceeded for interference BS (TDD) to MES for various environments (scenario 20)

In each of these four scenarios, large guardbands are required in particular environments. Hence these scenarios are examined further in section B.5

B.4.2 S-DMB

B.4.2.1 Scenarios 17 and 21: Interference from FDD UE uplink into S-DMB terminals

This case corresponds to a situation where *FDD* uplink operates in the lower part of the 2.5 GHz band, adjacent to the 2 500-2 520 MHz MSS allocation.



All the S-DMB terminals will be dual-mode, i.e. will implement T-IMT2000 and S-DMB capabilities. Due to filtering constraints, it is not practicable to implement in the same terminal Tx and Rx modules operating in the adjacent 5 MHz blocks. Even with a higher frequency separation (10 or 15 MHz), the situation would not improve significantly. Also, in Recommendation ITU-R M.1036-2, it is mentioned that the frequency separation between uplink and downlink frequency blocks should be at least 20-30 MHz, using foreseeable terminal duplexer and filtering technologies. As the IMT-2000 handheld terminals which implement the S-DMB capabilities will use the same RF front-end for S-DMB services as for terrestrial operation, a similar separation of 20-30 MHz between the upper edge of the MSS downlink allocation and the lower edge of the *FDD* uplink allocation is necessary.

B.4.2.2 Scenarios 18 and 22: Interference from TDD UE uplink into S-DMB terminals

Under this scenario, two cases need to be distinguished:

a) The S-DMB terminal implements TDD terrestrial uplink in the frequency block adjacent to the 2 500-2 520 MHz MSS band. As for the previous scenario, Tx and Rx bands would be adjacent, which is extremely difficult to implement. The compatibility cannot be ensured in this case.

b) The S-DMB terminal <u>does not</u> implement TDD capabilities in the upper adjacent frequency blocks to the 2 500-2 520 MHz MSS band, even though these blocks are identified for TDD. In this case, the required frequency separation can be derived from FDD/TDD coexistence studies in a similar case. Nevertheless, the BS-to-BS case analysed in the FDD/TDD studies, which is known to be the most problematic, will determine the required frequency carrier separation.

B.4.2.3 Scenarios 19, 20, 23, 24: Interference from BS FDD/TDD into S-DMB terminals

The S-DMB terminal may receive the wanted signal either directly from the satellite or from a terrestrial repeater. In this section both cases are envisaged, and depicted in the Figure below:

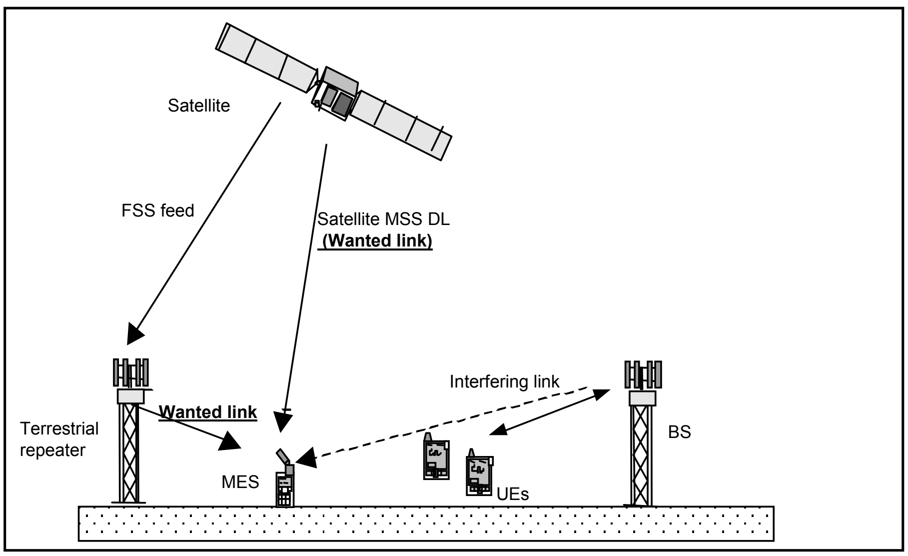


Figure B.4-7: Wanted and Interfering Paths (S-DMB terminal victim)

For the wanted link, the following bit rates are envisaged:

S-DMB terminal receive mode	Wanted Rx signal bit rate
From Satellite	64 kbit/s
	3 × 384 kbit/s
From Terrestrial Repeaters	3 × 384 kbit/s

Table B.4-1: Envisaged S-DMB downlink bit rates

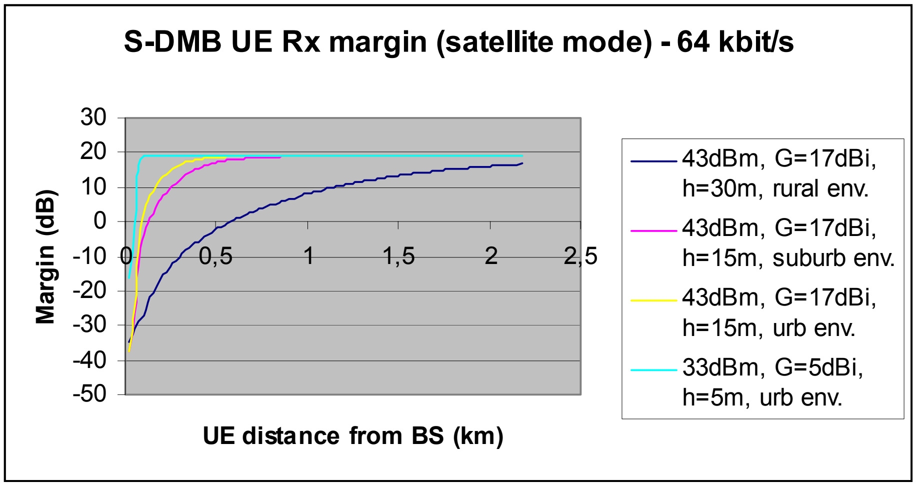
The S-DMB terminal is assumed to be a handheld terminal.
This scenario has been investigated with a classical C/(N+I) assessment based on static link budgets. Its purpose is to provide an order of magnitude of the problems which may be encountered.

The assumed C/(N+I) objective corresponds to outdoor reception for a FDD/TDD standardized pedestrian environment:

- C/(N + I) @ 64 kbit/s = –5.86 dB
- C/(N + I) @ 384 kbit/s = 3.77 dB

The Hata-COST 231 modified propagation model is used. The impact of the interference is calculated as a function of the distance between the wanted S-DMB user terminal (So called "S-DMB UE") and a single interfering base station.

Scenarios 19 and 20: S-DMB UE in Satellite reception mode
The following diagrams indicate the Rx margin in dB (relative to the objective C/(N+I)) at the S-DMB UE reception, for the 2 test bit rates proposed, and different interfering environments. A conventional 5 MHz carrier separation is assumed:



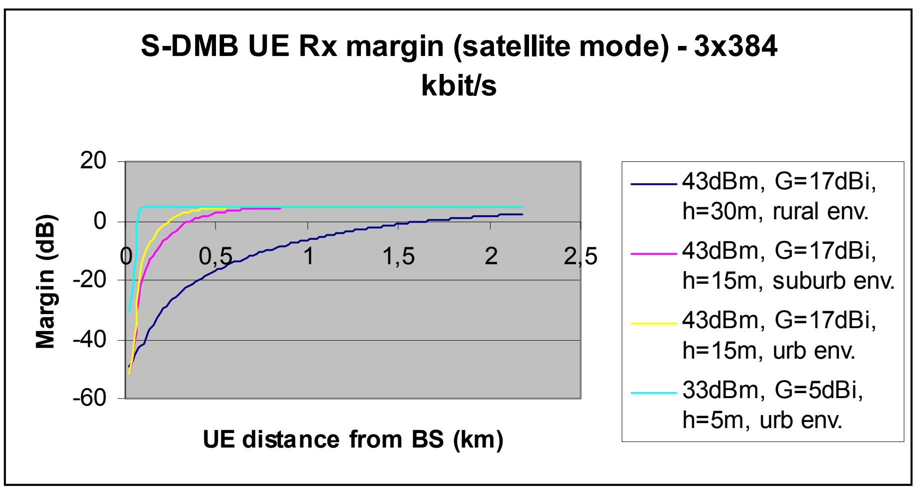


Table B.4-8: BS interference impact on S-DMB

The following Table gives the corresponding the separation distances (corresponding to 0 dB margin in the above Figures) for 5 MHz carrier spacing, and 10 MHz carrier spacing:

	Carrier separation	5 MHz		10 MHz	
	S-DMB downlink rate	64 kbit/s	3x384 kbit/s	64 kbit/s	3x384 kbit/s
Interfering BS (power, gain, height, environment)	43dBm, 17 dBi, 30m, rural	580	1650	310	860
	43dBm, 17 dBi, 15m, suburban	130	370	80	190
	43dBm, 17 dBi, 15m, urban	93	240	72	125
	33dBm, 5 dBi, 5 m, urban	51	70	42	58

Table B.4-2: BS interference radius (m) (victim: S-DMB terminal)

Assuming a terrestrial repeater cell radius of respectively 10 km, 2 km, 1 km and 315 m for the four environments envisaged in the above Table, the loss of coverage which results from BS interference is as follows:

	Carrier separation	5 MHz		10 MHz	
	S-DMB downlink rate	64 kbit/s	3x384 kbit/s	64 kbit/s	3x384 kbit/s
Interfering BS (power, gain, height, environment)	43dBm, 17 dBi, 30m, rural	0,34%	2,72%	0,10%	0,74%
	43dBm, 17 dBi, 15m, suburban	0,42%	3,42%	0,16%	0,90%
	43dBm, 17 dBi, 15m, urban	0,86%	5,76%	0,52%	1,56%
	33dBm, 5 dBi, 5 m, urban	2,62%	4,94%	1,78%	3,39%

Table B.4-3: BS interference area (percentage of cell area)

Comments on the results

The 64 kbit/s signal reception is interfered by the BS emission if the distance to the BS is lower than 130 m in suburban and 93 m in urban macro environment. In a rural environment, the separation distance increases to around 600 m. In urban Micro cell environment, the required separation distance from the interfering BS is around 50 m. These distances show that the service is possible with some degradation when the mobile approaches a base station operating in the adjacent 5 MHz frequency block. An extra 5 MHz spacing (10 MHz spacing) allows to slightly reduce the separation distances. As shown in the previous table, the loss of coverage being below 3% for 64 kbit/s signal, the standard 5 MHz carrier spacing is deemed sufficient.

The 1 Mbit/s signal (3x384 kbit/s) will suffer interference at relatively large distances from the BS: 1 650 m in rural macro environment, 370 m and 240 m in suburban and urban macro cells, and 70 m for urban micro cells. These distances are of the order of magnitude of the cell radius for the respective environments. Therefore, the 1 Mbit/s signal reception directly from the satellite cannot be properly ensured in such environments, and terrestrial repeaters will be necessary. In an interference-free environment, the reception margin is around 5 dB, which enables the reception of 1 Mbit/s signal in satellite line-of-sight conditions, or with limited shadowing.

Scenarios 23 and 24: S-DMB UE in Terrestrial Repeater reception mode

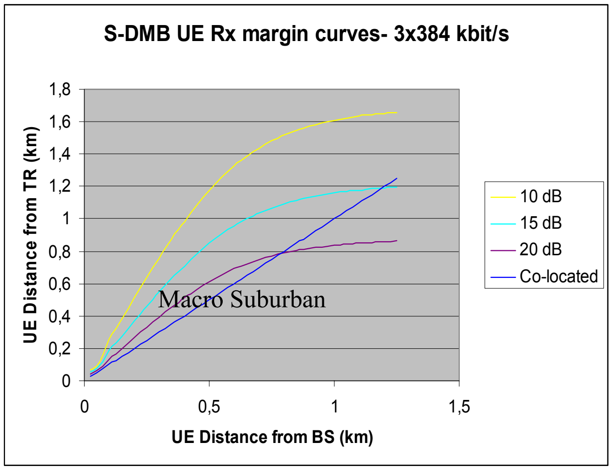
The interference assessment has been made for the 3 × 384 kbit/s stream, since this is the bit rate foreseen with a fully deployed S-DMB terrestrial repeater segment. The terrestrial repeater and the interfering BS are assumed to operate in the same environment (cell size/propagation conditions), and have the same antenna gain and antenna height.

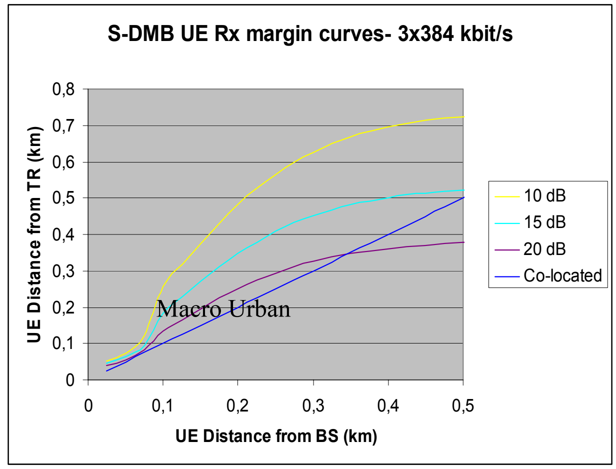
A standard 5 MHz carrier spacing is assumed.

The assumed values for BS and TR deployment are:

	Macro Suburban	Macro Urban	Micro Urban
BS and TR power (dBm)	43	43	33
BS and TR antenna gain (dBi)	17	17	6
BS and TR antenna height (m)	30	15	6

The C/(N+I) margin has been computed for various combinations of BS-UE (interfering link) distances and TR-UE (wanted link) distances, and result in the following curves:





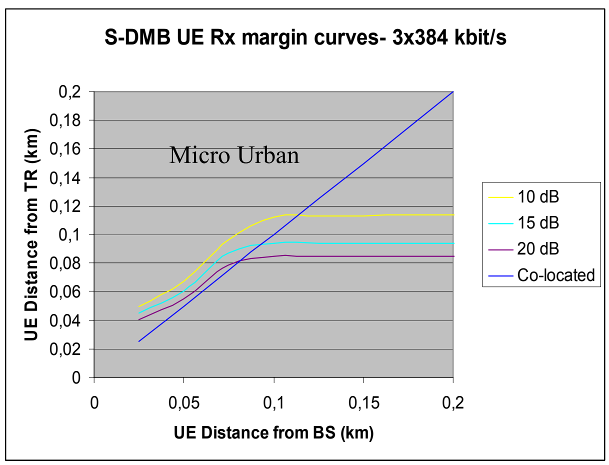


Table B.4-4: BS/TR assumptions

In the above Figures showing the $C/N + I$ margin, the curve "co-located" indicates the $y = x$ equation, and by intersection with the curves it is possible to read the margin in the case where the BS and the terrestrial repeater are co-located.

Comments on results

The above curves show the relationship between the distance to the terrestrial repeater and the minimum distance to the base station for a target Rx margin. When the TR and the BS are co-located, the curves show that it is possible to maintain a Rx margin above 15-20 dB (which is adequate for indoor penetration) for distances to the BS lower than around 1 km in suburban environment, 0.4 km in urban macro environment, and 100 m in urban micro environment, when the terrestrial repeater and the base stations are co-located.

These distances correspond approximately to operational cell radii for these environments. Therefore, the S-DMB terminal receiving from the terrestrial repeater will not experience harmful interference from the BS.

If the BS and TR are not co-located, the Rx margin decreases rapidly when the S-DMB terminal gets closer to the interfering BS. In order to maintain 15 to 20 dB margin, the distance to the BS has to be of the order of the distance to the terrestrial repeater. If BSs and TRs locations are independent, there will be large areas where the S-DMB terminal will be closer to the interfering BS, than to the TR. In such areas, the desired margin cannot be maintained.

As a conclusion, the co-location eases the adjacent channel co-existence for this scenario. Co-location could be ensured with the BS of the terrestrial operator using the S-DMB system. Co-location with the other operators can not be ensured in general, and we can expect that the S-DMB receiving terminal may experience harmful interference that may reduce its coverage.

B.5 Sensitivity analysis for the satellite radio interface-E (SRI-E)

A sensitivity analysis was undertaken to try and identify the system parameters that had the most impact on the interference levels. The results are presented in the following sub-sections. Some more optimistic assumptions have been considered in paths C and D in order to estimate how far the guardband may be reduced. Nevertheless, the appropriateness of the assumed parameter values in the sensitivity analysis new simulations results have not been agreed.

B.5.1 MSS DL Band

Path A
The baseline analysis indicated that adjacent channel sharing in the MSS DL to terrestrial direction would be possible without the use of additional guardbands. Therefore, no sensitivity analysis has been performed for path A co-located systems.

Path D
The baseline results for scenarios 17 to 19 (section B4.1.4) showed that large guardbands would be required with respect to MESs operating in some environments. For scenario 17, the necessary guardband exceeds 8 MHz in the pedestrian-micro environment whereas in the rural and vehicular-macro environments, no guardband is necessary. For scenario 18, the necessary guardband exceeds 8 MHz in each of the environments where TDD is anticipated. For scenario 19 a guardband exceeding 5 MHz is required in all environments. Finally, for scenario 20, a guardband of about 6 MHz is required in the suburban environment whereas a guardband of 0.5 MHz is required in the urban environment. For all these scenarios, more optimistic assumptions, which may be made regarding the parameter values and the effect of these on the results is examined.

The out-of-band emissions of the base station and UE transmitter will inevitably perform better than the mask given in the equipment standards. A factor of 3 dB is assumed for this. Further, the terrestrial system uses linear polarization whereas the satellite system uses circular polarization. A factor of 3 dB is assumed for this. Overall, an improvement of 6 dB may be considered and this leads to the following results for scenarios 17 to 19.

FIGURE B.5-1

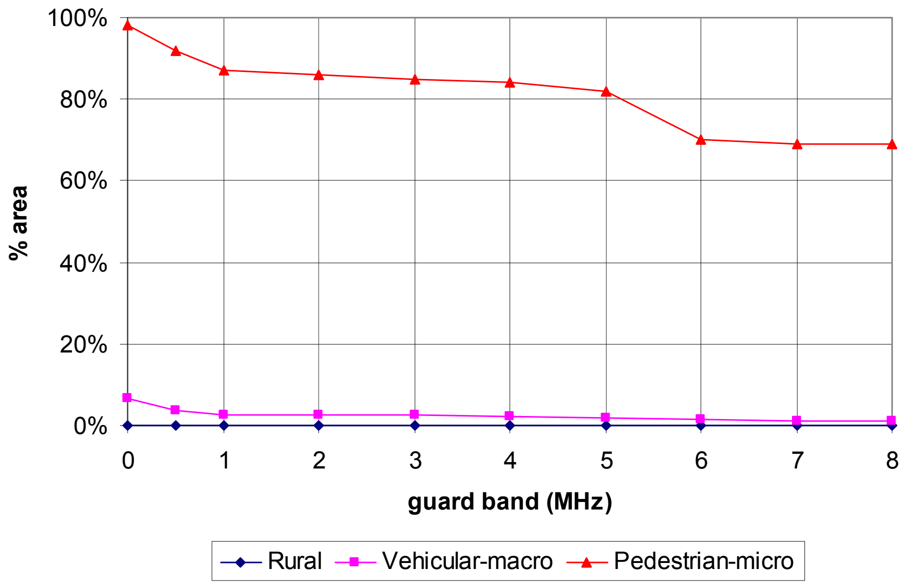


Table B.5-1: Improved results for scenario 17 (FDD UE interfering with MES)

For the rural and vehicular-macro environments, no guardband is necessary. In the pedestrian-micro environment, the criterion is exceeded by a considerable margin, even with a guardband of 8 MHz.

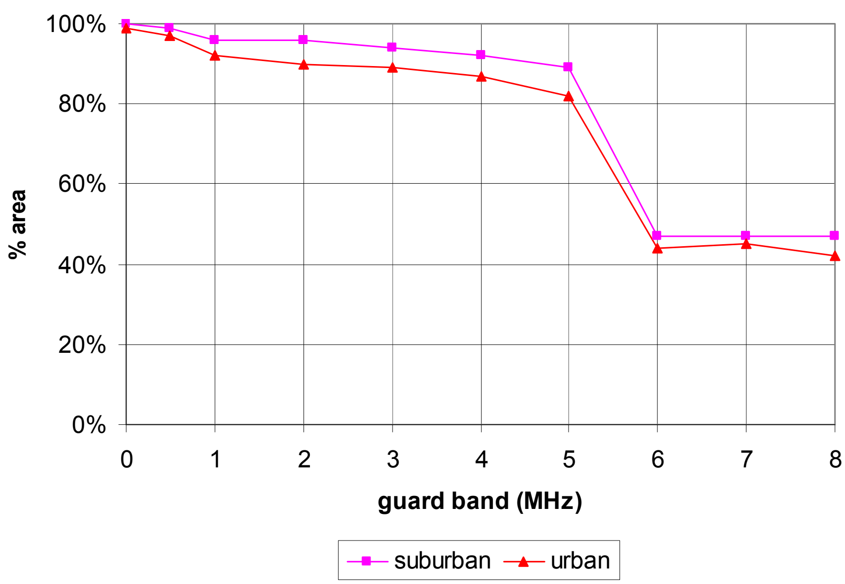


Table B.5-2: Improved results for scenario 18 (TDD UE interfering with MES)

In both environments, the necessary guardband exceeds 8 MHz.

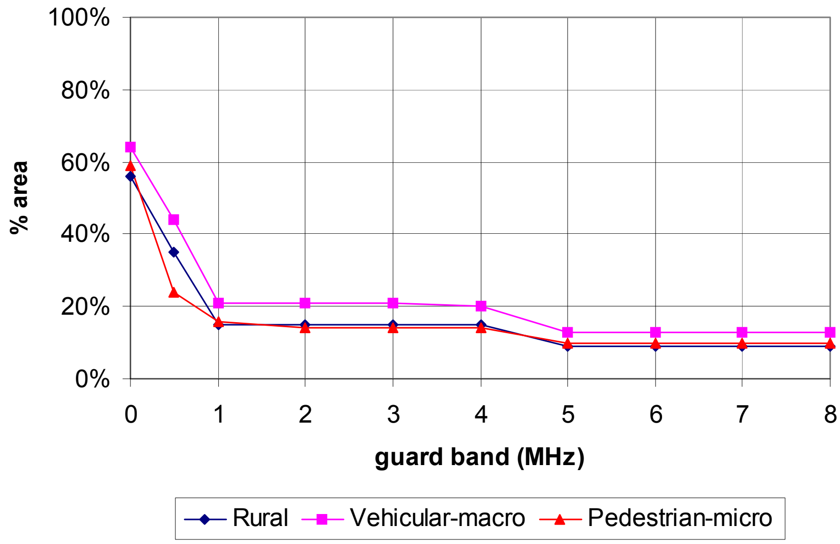


Table B.5-3: Improved results for scenario 19 (FDD BS interfering with MES)

For the rural and pedestrian-micro environments, the necessary guardband is about 0.75 MHz. For vehicular-macro case, the percentage of MES locations for which the ΔT/T criterion is exceeded is about 21% for a guardband of between 1 and 4 MHz. If this value is acceptable (in fact it slightly exceeds the baseline criterion of 20%), then the necessary guardband for this environment is 1 MHz.

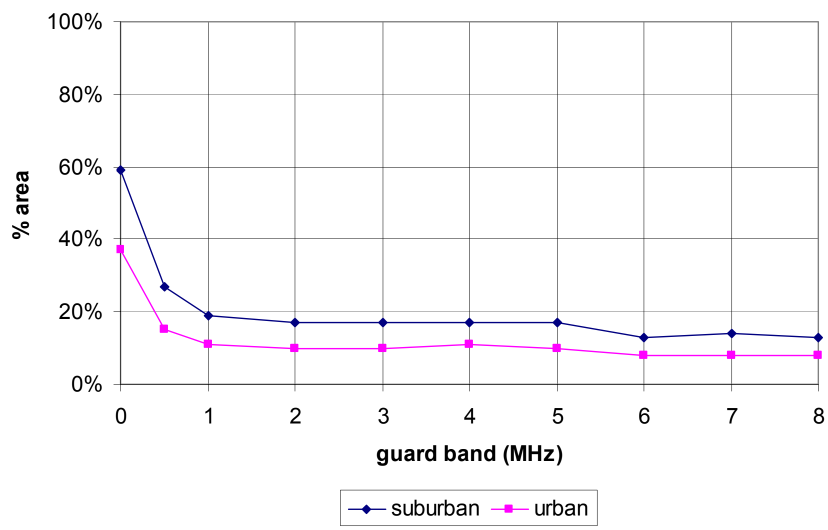


Table B.5-4: Improved results for scenario 20 (TDD BS interfering with MES)

In the suburban case, the necessary guardband is about 1 MHz and in the urban case, the necessary guardband is about 0.4 MHz.

B.5.2 MSS UL Band

Path B

The baseline analysis indicated that adjacent band operation in the MSS UL to terrestrial direction would be possible without the need for guardbands. Therefore, no sensitivity analysis has been performed for path B co-located systems.

Path C
The baseline results for scenario 15 (adjacent band interference from base stations into the MSS satellite), indicated that excessive interference would be caused, with a guardband exceeding 7 MHz. Due to this result, the input parameters have been examined to see where more optimistic assumptions can be made.

When considering aggregate interference from a large number of interferers spread over a large geographical area, the following variations from assumptions may be considered:

- The calculations assume that every base station transmits on the channel adjacent to (and second adjacent channel to) the satellite band on all cells and at a constant power (the "typical transmit power"). On average the transmit power may be at least 3 dB below this value.
- The calculations assume that the base station out-of-band emissions just meet the limits in the standard at each point of the frequency scale. In reality, there is some margin between the actual out-of-band emissions and the mask to allow for the tolerance of components used in manufacturing. Further, the limits are to be met under a range of environmental conditions and hence the equipment will perform better under more typical conditions. Finally, if the out-of-band emissions are close to the mask, it is often at a few specific points, rather than continuously throughout the defined frequency range. Overall, a benefit of about 5 dB may be assumed.
- The calculations assume that the base station antenna conforms exactly to the reference antenna pattern whereas in practice, the antenna may be expected to perform better, particular for the larger off-axis angles. Further, the baseline calculations do not include any terrain or building blockage between the base stations and the satellite. This could be significant for low elevation angles. Overall, a benefit of about 2 dB may be assumed for all elevation angles.
- The baseline calculations do not include any benefit from polarization isolation. (The terrestrial systems use linear, the MSS systems use circular). This may give a benefit of 3 dB.

In combination, a benefit of about 12-13 dB may be assumed from these factors. The following Figure shows the results for scenario 15 with a 12 dB benefit included. Results are shown for two example values of the minimum elevation to the satellite.

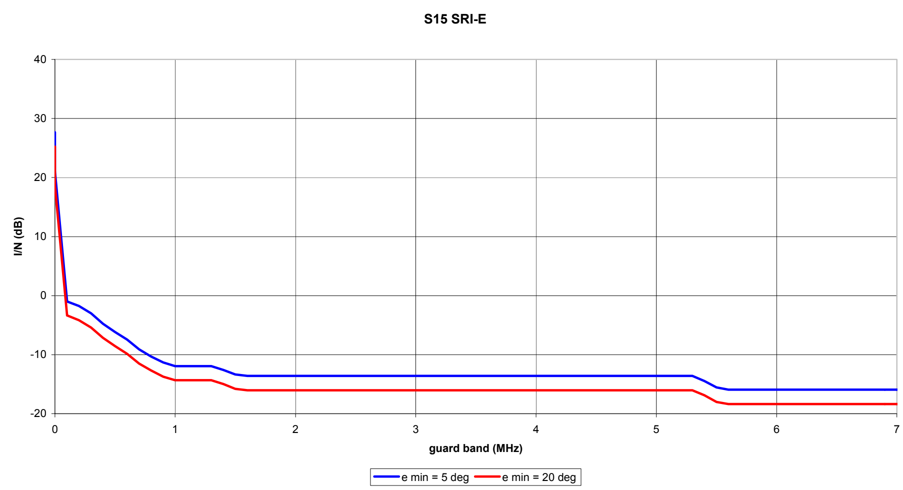


Table B.5-5: Improved results for SRI-E (scenario 15)

It can be seen that a guardband of 1.5 MHz leads to I/N values of –14 dB and –16 dB. Comparing this with the criterion for adjacent band interference (equivalent to I/N of –15 dB), it suggests that this guardband may be considered acceptable.

If we have a look at the ECC Report 65 results with these new baseline results, i.e. 12 dB of supplementary attenuation, the following Table gives the simulation results in the adjacent band:

Sat. Beam boresight	Interferences without guardbands	Interferences with 1 MHz guardband	Interferences with 2 MHz guardbands
10°E; 40°N	–193 (14% of ΔT/T)	–193.9	–194.9
10°E; 50°N	–194.3	–195.1	–196.1
10°E; 60°N	–196.5	–197.3	–198.3

Table B.5.1-1: Out of band interfering power density at satellite receiver (dBm/Hz) to compare to –185.78 dBm/Hz (ΔT/T = 3%)

In consequence, no guardband would then be required with that methodology.
Hence, it is shown that whatever the methodology, 1.5 MHz guardband would ensure efficient protection of SRI-E satellite receiver.

B.6 References in Annex B

[1] Report ITU-R M.2039 : Characteristics of terrestrial IMT2000 systems for frequency sharing / interference analyses, Geneva 2003.

[2] 3GPP 25.104 v530: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (FDD).

[3] 3GPP 25.942 v500: RF Systems scenarios.

[4] 3GPP 25.101 v530: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (FDD).

[5] 3GPP 25.102 v510: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (TDD).

[6] 3GPP 25.105 v510: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (TDD).

ANNEX C: DETAILED ANALYSYS OF RADIO ASTRONOMY

The band 2690-2700 MHz is allocated on a primary basis to Earth Exploration Satellites, Radio Astronomy and Space Research (passive) services in all Regions.

The number of radio astronomy stations, operating in this frequency band, is about 20 worldwide, and 10 in Europe (see table A.4-1).

The interference into Radio Astronomy stations from the following IMT-2000 system components are considered:

- terrestrial UMTS base and mobile stations.
- S-DMB and SRI-E mobile earth stations within satellite systems.

C.1 GENERAL CONSIDERATIONS ON INTERFERING SYSTEM COMPONENTS

General characteristics of IMT-2000 systems can be found in annexes A1, A2 and A3. The studies undertaken in preparation of this report have considered UMTS W-CDMA base stations with a maximum power of 43 dBm and a peak antenna gain of 14 dBi. Corresponding mobile terminals' EIRP is set to 24 dBm.

C.2 Interferer's OOB maximum power evaluation (averaging over the band 2690-2700 MHz)

The first terrestrial IMT-2000 adjacent channel OOB emissions in the band 2690-2700 MHz can be assessed using the OOB requirements contained in references [2], [3], [4]and [5] to Annex A. This latter Recommendation is valid also for the case of S-DMB MES emissions.
The recommendations for SRI-E are summarized in annex A.2.

The figure below illustrates the averaging process for the IMT-2000 maximum OOB power calculation in the band 2690-2700 MHz, here in the case where the IMT-2000 center frequency carrier is in the frequency channel immediately below 2690 MHz.

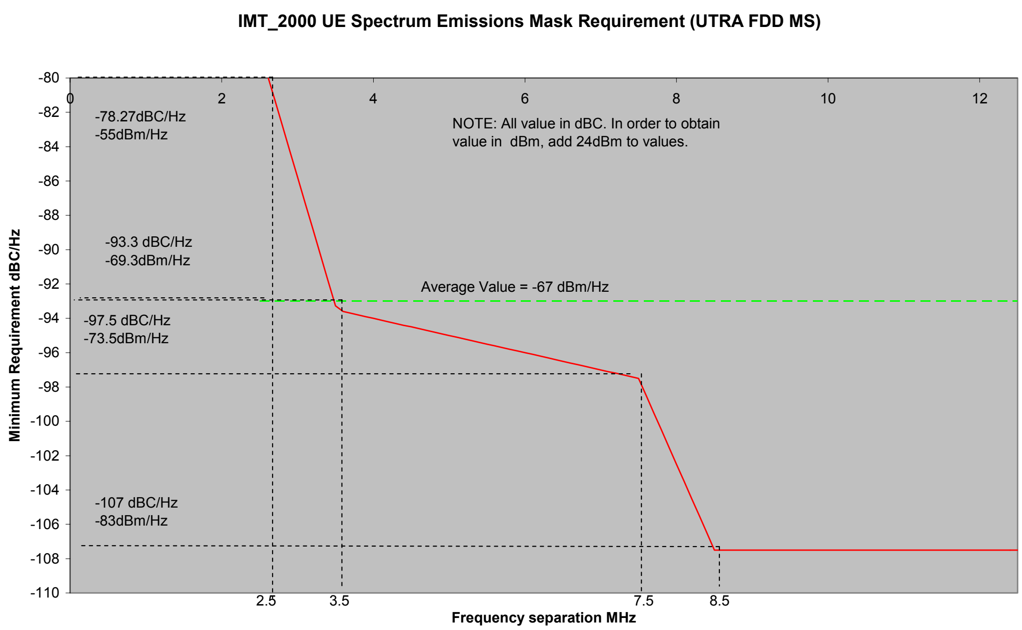


Figure C.2-1: IMT–2000 UE Spectrum Emissions Mask Requirement (UTRA FDD MS)

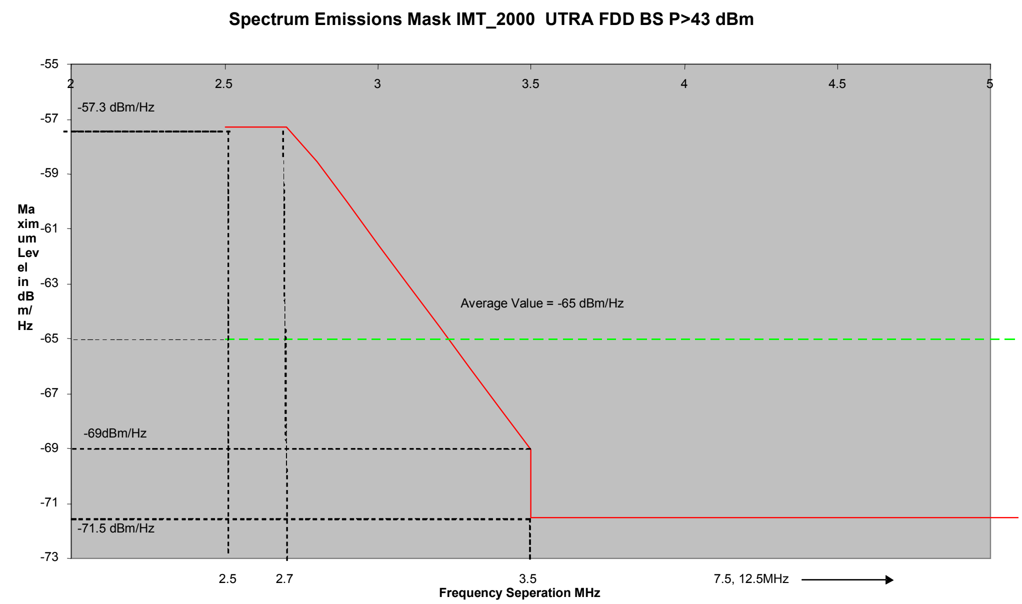


Figure C.2-2: Spectrum Emissions Mask IMT–2000 UTRA FDD BS P>43 dBm

As shown in the above figures, the average OBB emission values for the MS and BS are –67 dBm/Hz and –65 dBm/Hz respectively. For the S-DMB MES the figure for the MS also applies. An extra 6dB was subtracted from the average calculated values to allow for both terrain clutter attenuation and variations between the idealised envelope of the emission masks.

For the SRI-E MES the calculated value is -57.7 dBm/Hz. The extra 6dB would also be subtracted in this case

C.3 Coordination and exclusion zones considerations

Section C.2 provided the calculation process to evaluate the maximum IMT-2000 OOB emissions in the 2690-2700 MHz RAS frequency band.

Subsequent isolation calculations to meet the protection criterion, uses basically the equation :

Req. Isolation (dB) = Max.OOB power (dBm/Hz)+ IMTant.Gain (dBi)+ protection criterion (dBm/Hz).

The following table provides the required isolation between radio astronomy stations and IMT-2000 base, mobile and mobile earth stations under consideration in the studies :

Station type	Average OOB transmitter power (dBm/Hz)	Antenna gain (dBi)	Required isolation (dB, MCL value)
DS-CDMA FDD, BS (P=43dBm)*	-71.	+14	190
DS-CDMA FDD, MS (P=24dBm)*	-73	0	174
S-DMB, MES (P=24dBm)*	-73	0	174
SRI-E, (worst case azimuth, assuming 25 degree elevation angle to satellite)	-63.7	+8.2	192
SRI-E, (best case azimuths, for off axis angles >90 degrees)	-63.7	-5	178

(*) the maximum OOB emissions were obtained with maximum BS/MS/MES transmit power, it can be noted that typical BS/MS tx power are below this value (see Annex A1).

Table C.3-1: Required isolations between IMT-2000 system components and RA stations

Required isolation, or minimum coupling loss (MCL) in Table C.3-1 can be used to evaluate coordination and exclusion zones around a specific RA station, in accordance with ITU-R Recommendations.

The contours of coordination zones are typically to be used by the administrations to trigger a coordination process when an operator plans to set up an IMT-2000 base station in the coordination zone, or when the coordination zone is overlapping an IMT-2000 coverage zone (MS or SRI-E/S-DMB MES interferer case). Detailed discussions in this regard may result in exclusion zones, where any IMT-2000 emissions should be forbidden : the exclusion zone is likely to be smaller than the coordination zone.

C.4 References in Annex C

[1] Recommendation ITU-R RA.769-1: Protection criteria used for radioastronomical measurements .

[2] Recommendation ITU-R M.1343 : Essential technical requirements of mobile earth stations for non-geostationary mobile-satellite service systems in the bands 1-3 GHz .

[3] Recommendation ITU-R M.1480: Essential technical requirements of mobile earth stations of geostationary mobile-satellite systems that are implementing the global mobile personal communications by satellite (GMPCS) – memorandum of understanding arrangements in parts of the frequency band 1-3 GHz.

[4] ECC Doc. PT1(04)030: Study of co-ordination distances between terrestrial UMTS and Radio Astronomy (RAS).

[5] ECC Doc. PT1(04)003: Liaison statement to ECC PT 1 on UWB and protection criteria for the Radio Astronomy band 2690 – 2700 MHz.

ANNEX D: DETAILED ANALYSIS OF MMDS

D.1 Adjacent Channel Results

The assumption has been made that the 2.5GHz band will only be used in Ireland in urban areas for UMTS/IMT-2000 services while MMDS is predominantly used in rural areas. So in this study, adjacent channel sharing is considered in the cases where MMDS and UMTS/IMT-2000 FDD systems were operating in geographically separate locations.

Figure D.1 below is a representation of the two services operating in separate locations. An MMDS system can have cell sizes ranging from 16km to 40km radii, for these studies the 16km radius was chosen as it represents a worst case scenario with the MMDS transmitter closest to the UMTS cell.

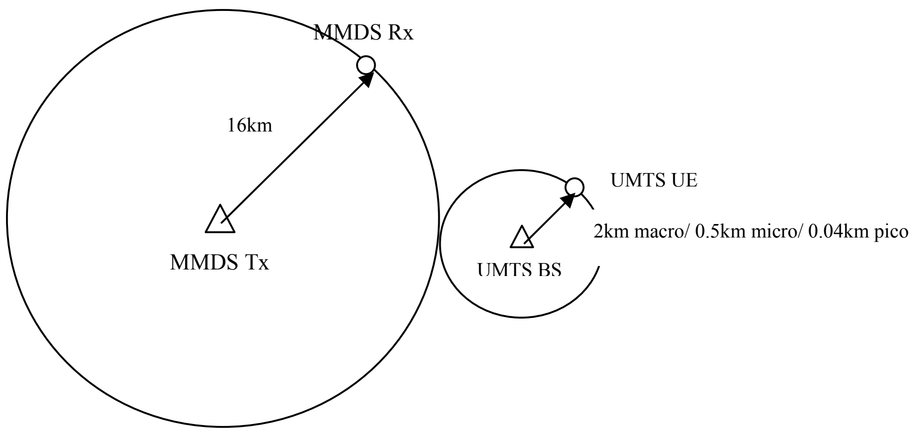


Figure D.1: Representation of an MMDS and UMTS systems service areas operating in geographically separate locations.

D.1.1 Interference Path E1

There is no interference measured from the UMTS UE transmitting into the MMDS receiver. This is because the MMDS receiver blocking response plus C/I ratio is greater than the power emitted from the UMTS UE.

D.1.2 Interference Path E2

Figure D1.2 shows the results of interference simulations from a UMTS base station into a MMDS receiver for macro cell deployment. It can be seen that for MMDS and UMTS systems to operate in geographically separated locations a guard band of 20 MHz is required between the two systems for the macro cell deployment scenario and at least 15 MHz is required between the two systems for the micro cell deployment scenarios. For pico cell deployment of UMTS no guard band is necessary due to the low power levels from the pico cell transmitters compared to the MMDS receiver blocking and wanted received signal the MMDS receiver.

There is no interference from a UMTS base station into a MMDS receiver for pico cell deployment.

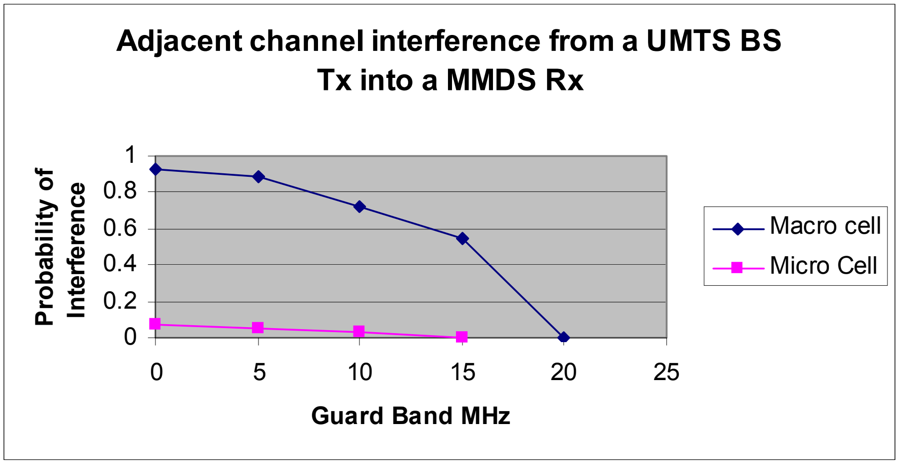


Figure D.1.2: Probability of adjacent channel interference from a UMTS base station Transmitter into a MMDS receiver

D.1.3 Interference path F1

Figure D.1.3 below shows the probability of interference from a MMDS transmitter into a UMTS base station receiver for macro cell deployment. It shows that a guard band of 15 MHz would be required to ensure no interference between the two systems. The SEAMCAT model did not show any interference into either a micro or pico cell from a MMDS transmitter. This is due to the lower antenna gain and height of the micro and pico cell receivers compared to the UMTS macro cell antenna.

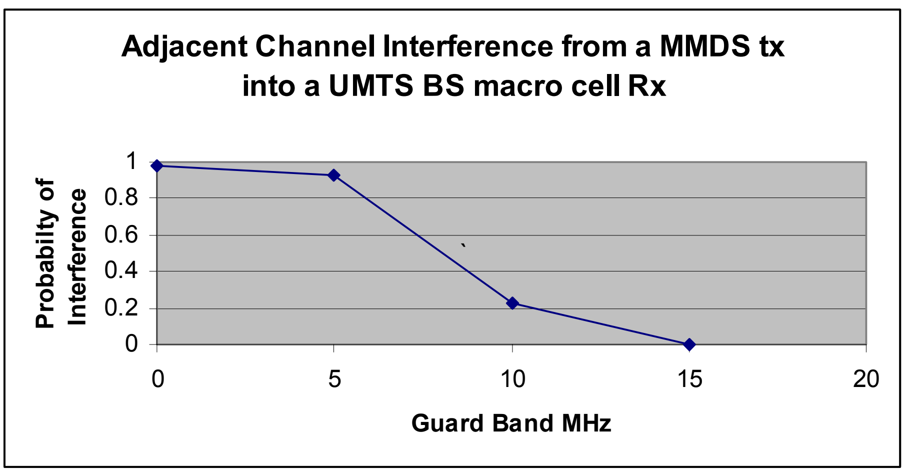


Figure D.1.3*:* Probability of adjacent channel interference from a MMDS transmitter into a UMTS base station receiver

D.1.4 Interference path F2

Figure D.1.4 below shows the interference from a MMDS transmitter into a UMTS UE. It indicates that a guard band of 10 MHz would be required to prevent interference between the two systems.

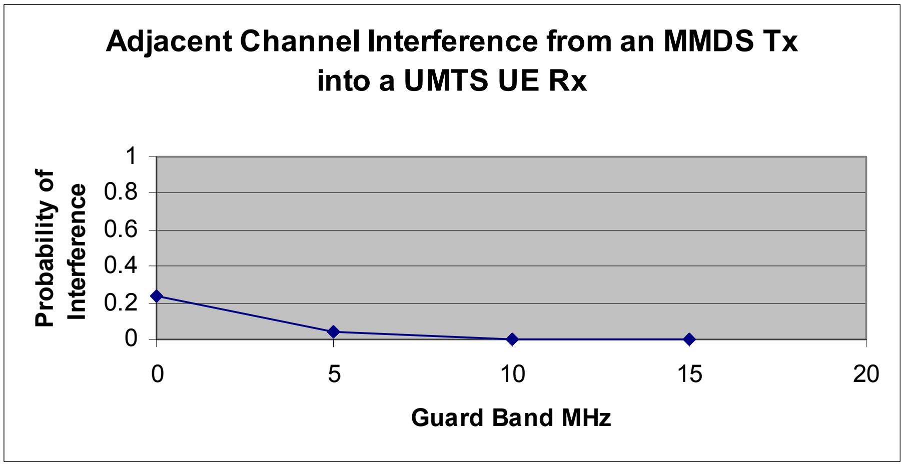


Figure D.1.4: Probability of adjacent channel interference from a MMDS transmitter into a UMTS UE receiver

D.2 Co-frequency Interference Results

The co-frequency simulations investigated the possibility of both MMDS and UMTS/IMT-2000 services sharing the whole of the 2520 – 2670 MHz band and relying mainly on geographical separation to facilitate co-frequency usage.

D.2.1 Interference Paths E1 and E2

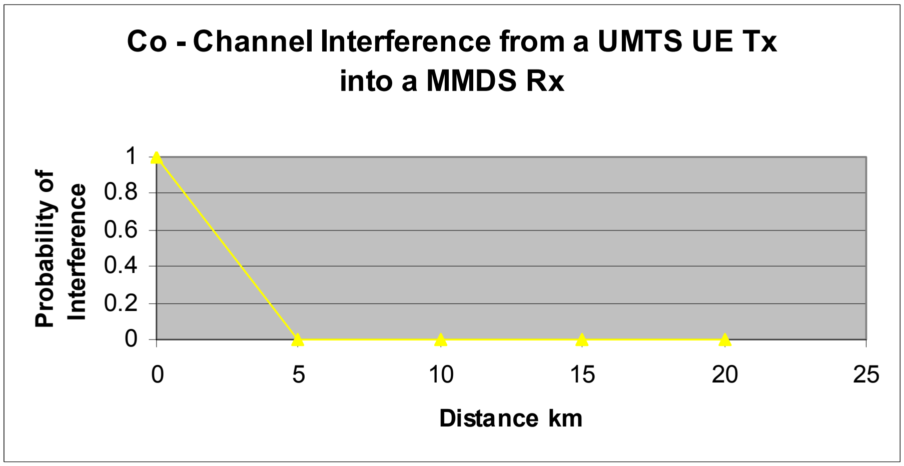


Figure D.2.1-1: Probability of co- channel interference from a UMTS UE transmitter into a MMDS receiver

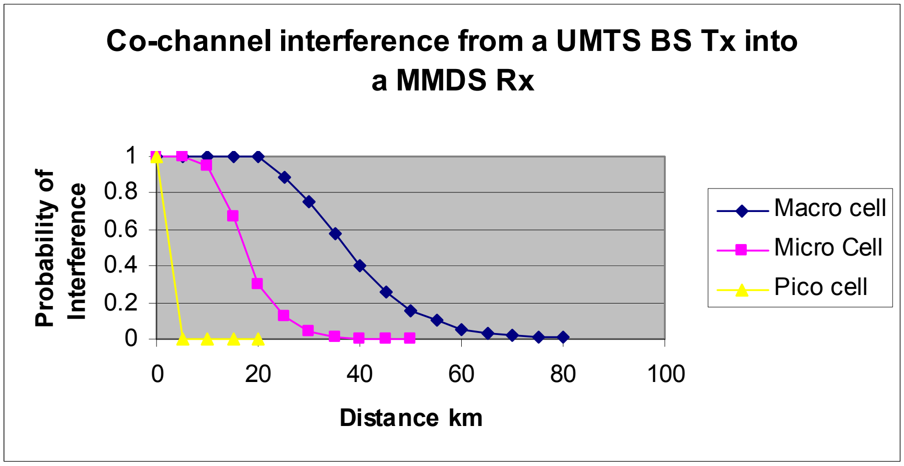


Figure D.2.1-2: Probability of co- channel interference from a UMTS base station transmitter into a MMDS receiver

D.2.2 Interference paths F1 and F2

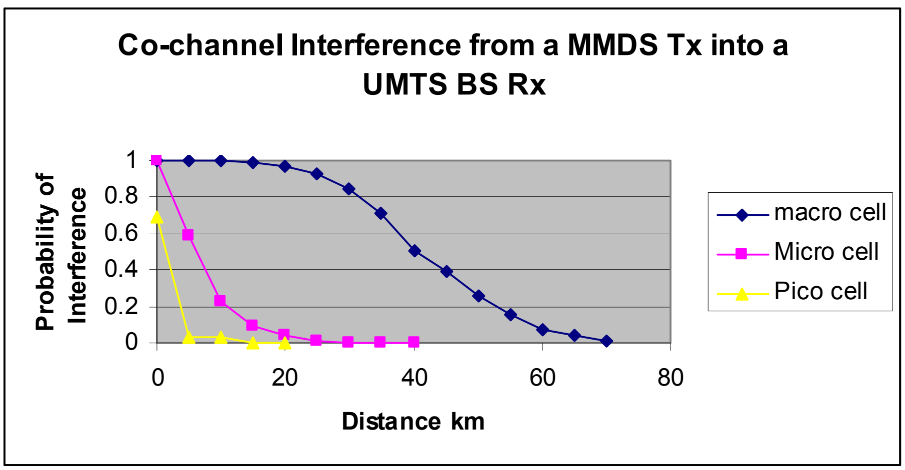


Figure D.2.2-1: Probability of co- channel interference from a MMDS transmitter into a UMTS base station

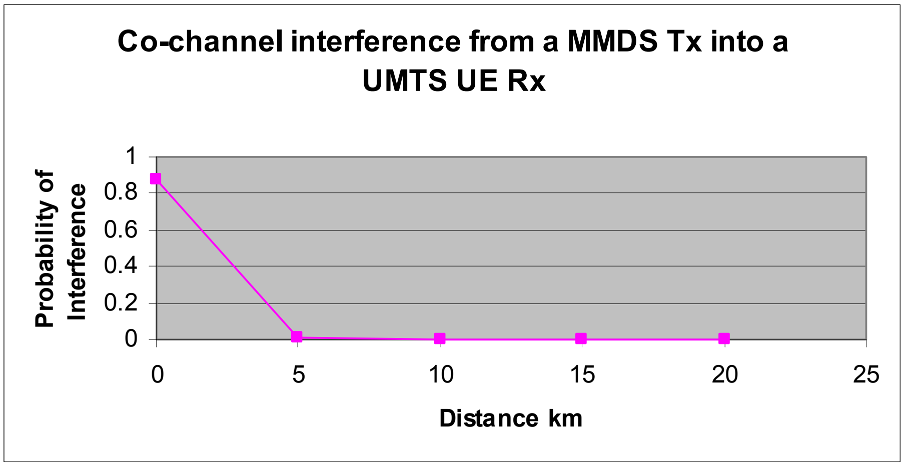


Figure D.2.2-2: Probability of co- channel interference from a MMDS Transmitter into a UMTS UE

The figures above show that in co-frequency scenarios the separation distances[12] required to prevent interference would be as follows:

- 5 km separation distance would be required to prevent interference from a UMTS UE transmitting into a MMDS receiver;
- 70 km separation distance between a UMTS base station transmitter and a MMDS receiver for macro cell deployment, 25km for micro cell deployment and 5 km for pico cell deployment;
- 70 km separation distance would be required between a MMDS transmitter and a UMTS base station receiver, 25 km for micro cell deployment and 5 km for pico cell deployment;
- 5 km separation distance would be required between a MMDS transmitter and a UMTS UE receiver.

[12] Separation distances in this case are the required distances between cell centres